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Prevalence of Second Mesiobuccal Canal in the Mesiobuccal Root of Maxillary Second Molars in a Libyan Subpopulation Using Cone-Beam Computed Tomography

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Abstract: ***Introduction: The permanent maxillary molars have greatest complexity, variation in the root canal system and a high percentage of treatment failure due to the impossibility of locating, instrumenting, and obturating the second mesiobuccal canal (MB2). The aim of this study was to determine the prevalence of MB2 canals in permanent maxillary second molar teeth using cone beam computed tomography (CBCT) and compare them by different age groups, gender, and side. Materials and Methods: In this retrospective cross-sectional study, The CBCT images of 184 patients (120 females and 64 males) between 13 and > 40 years old were including in this study. A total of 334 permanent maxillary second molars were analysed. Teeth with additional canals in their mesiobuccal roots (MB2) were identified. The Chi-squared test was used to compare the frequency of MB2 between genders, ages, sides. Results: MB2 canals in the mesiobuccal roots of maxillary second molars were detected in 302 of the 334 teeth, to give a tooth prevalence of 90.4%. The prevalence of MB2 canal was higher in males 95.7% than in females 87.7% with significant difference between the genders. No significant difference was found between sides and among the age groups. Prevalence of MB2 canals were more frequent as the bilateral (93.4%) than unilateral (6.6%). Conclusions: The percentage of MB2 was high. These results indicate that CBCT is an effective, high precision diagnostic tool for detecting (MB2) canal. To improve the prognosis of endodontic treatment, the clinician must pay more attention to the localization and treatment of this canal.***

Keywords: Maxillary second molar, second mesiobuccal canal, cone-beam computed tomography, Libyan subpopulation.

1. Introduction

Success in root canal treatment is dependent on a clinician's ability to locate, appropriate cleaning, shaping and filling of entire root canal system in all dimensions. [1] The main reason for endodontic failure is the presence of untreated canals therefore, it is important to have a complete knowledge of root canal anatomy and its variations prior to initiation of treatment. [2, 3]

The permanent maxillary molars have greatest complexity and variation in the root and root canal system. It is reported that the mesiobuccal (MB) root presents the greatest variation. The location of the secondary mesiobuccal canal (MB2) is quite complicated due to excessive dentine accumulation in the opening of the canal. [4, 5]

The previously reported variation in MB2 prevalence; Gilles & Reader., [6] reported 70.2%, Schwarze *et al*., [7] 95.8%, Reis *et al*., [8] 87.5%, Betancourt *et al*., [9] 48%, Fernandes *et al*., [10] 69% and Magat & Hakbilen., [11] reported 17.7%. This variation can be attributed to the different methods that were used by the researchers: study protocols (in vivo or in vitro), sample size, and techniques used in each study to identify canal configuration including histological sections [7], magnifying loupes [12], diaphanization [6], scanning electron microscope [7], microcomputed tomographic analysis [13, 14] endodontic surgical microscope [15], scanning electron microscope [7], periapical radiography [16] and cone beam computed tomography [8, 9, 17] this variation also could be associated with age, sex and ethnic difference of the study populations. [18]

Nowdays CBCT has become more widely used because it provides 3D images of the tooth structure with no destruction and enables a thorough morphological analysis of the external and internal of the root canal system. It provides more reliable diagnostics in the field of endodontics. CBCT scans can better visualize MB2 canals compared to other modalities such as digital radiography. [11, 19, 20]

The aim of this study was to determine the prevalence of MB2 canals in permanent maxillary second molar teeth using cone beam computed tomography (CBCT) and compare them by different age groups, gender, and side.

2. Materials and Methods

The study was granted the approval by Elaml dental center at Benghazi, Libya. In this retrospective cross-sectional study, a total of 230 CBCT images were randomly selected from the records of dental patients, who attended the Elaml dental center at Benghazi, Libya for dental treatment. We investigated CBCT images of 230 patients. However, only 184 CBCT images were evaluated because

of inclusion criteria. The CBCT images of 120 females and 64 males between 13 and > 40 years old were including in this study according to following inclusion criteria: Permanent maxillary second molars with fully erupted and matured apices. The exclusion criteria were: present metallic restoration, intra-radicular post or endodontic filling, rehabilitated using fixed prosthesis, canal calcification and maxillary molars with developmental anomalies.

CBCT images were obtained with a FONA X Pan 3D unit (Italy), using 85 KV and 10 mA: FOV 8.5 x 8.5 cm, voxel size 160 µm. A total of 334 permanent maxillary second molars were analysed using the CBCT machine software programme (DicomViewer) on the axial plane at 0.5 mm intervals and 1 mm thickness. The examination was made from the coronal to apical throughout the mesiobuccal root to detect the MB2 canal (figure 1). The CBCT images were analysed by two endodontists, experts in working with CBCT imaging. The data collected according to gender, age, side. To check the reliability of the CBCT images examination, a sample of 30 images was re-examined by the same examiners two weeks later and an agreement of 100% was obtained. Statistical analyses were performed using (SPSS 18.0, Chicago, USA). The Chi-squared test was used to compare the frequency of MB2 between genders, ages, sides. Differences were considered as significant when $P < 0.05$.

3. Results

Of the 230 CBCT images were examined, 184 fulfilled the selection criteria. There were 120 females (65.2%) and 64 males (34.8%) with three age groups 15-30, 31-40 & >40 years. The total number of maxillary second molars teeth examined was 334 (219 teeth for females and 115 teeth for males) of which 165 right maxillary second molars and 169 left maxillary second molars.

MB2 canals in the mesiobuccal roots of maxillary second molars were detected in 302 of the 334 teeth, to give a tooth prevalence of 90.4%. The prevalence of mb2 canal was higher in males 95.7% (110/115) than in females 87.7% (192/219) with significant difference between the genders ($P<0.05$). Table 1.

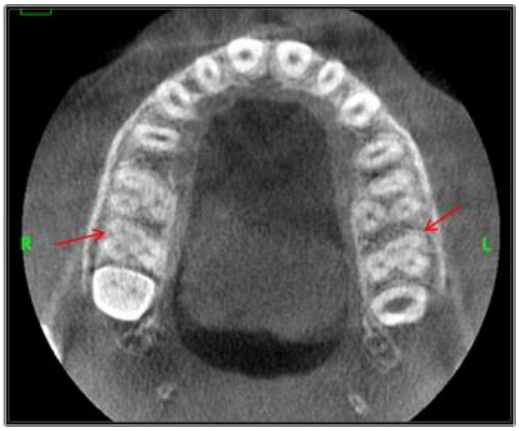

Figure 1: Axial view of CBCT shows two distinct canals in the mesiobuccal roots of the maxillary right and left second molar teeth.

According to the arch side the statistic study shows that, MB2 canals were more prevalent in the right maxillary second molars 90.9% (150/ 165) than in the left maxillary second molars 89.9% (152/169). No significant difference was found between the right and the left side ($P=0.8$, >0.05). (Table2). Prevalence of MB2 canals were more frequent as the bilateral (93.4%) than unilateral (6.6%). (Table3).

Regarding age, patient age was divided in to three groups and the results showed that the prevalence of the MB2 canal to be highest among 31-40 years (93.8%), followed by 15-30years (89.1%) and >40 years (88.9%). No significant difference was found among the age groups ($P=0.4$, >0.05). (Table 4).

Table 1: Prevalence of MB2 canal in the mesiobuccal root of the maxillary second molars according to gender

MB2 canal in maxillary second molar teeth	gender				Total	p
	Male		Female			
	No. of teeth	Percent	No. of teeth	Percent		
MB2 present	110	95.7%	192	87.7%	302 (90.4%)	0.01
MB2 absent	5	4.3%	27	12.3%	32 (9.6%)	
Total	115	100%	219	100%	334 (100%)	

Table 2: Prevalence of MB2 canal in the mesiobuccal root of the maxillary second molars according to arch side

MB2 canal in maxillary second molar teeth	Arch side				Total	P
	Right side		Left side			
	No. of teeth	Percent	No. of teeth	Percent		
MB2 present	150	90.9%	152	89.9%	302 (90.4%)	0.8
MB2 absent	15	9.1%	17	10.1%	32 (9.6%)	
Total	165	100%	169	100%	334 (100%)	

Table 3: Prevalence of MB2 canal in the mesiobuccal root of the maxillary second molars according to unilateral and bilateral

MB2 canal in maxillary second molar teeth	Gender				Total	
	Female		Male			
	No. of teeth	percent	No. of teeth	Percent	No. of teeth	Percent
Unilateral	7	8.1%	2	4%	9	6.6%
Bilateral	79	91.9%	48	96%	127	93.4%
Total	86	100%	50	100%	136	100%

Table 4: Prevalence of MB2 canal in the mesiobuccal root of the maxillary second molars according to age

MB2 canal in maxillary second molar teeth	Age (years)						Total	P
	15-30		31-40		>40			
	No. of teeth	percent	No. of teeth	Percent	No. of teeth	Percent		
MB2 present	123	89.1%	91	93.8%	88	88.9%	302 (90.4%)	0.4
MB2 absent	15	10.9%	6	6.2%	11	11.1%	32 (9.6%)	
Total	138	100%	97	100%	99	100%	334 (100%)	

4. Discussion

A comprehensive knowledge of root canal morphology and possible variations is a prerequisite for successful endodontic treatment. Anatomical variations should be examined both clinically and radiologically. [11] In the literature, the mesiobuccal root of maxillary permanent molars has generated more research and clinical investigation than any other root owing to its more complex root canal anatomy and common variations, especially regarding the prevalence of a second mesiobuccal canal (MB2). [5, 21] The presence of the MB2 canal should be considered before treatment. A high percentage of treatment failures in maxillary second molars is due to the impossibility of locating, instrumenting and obturating the MB2 canal located in the mesiobuccal root. [9]

There are many methods have been used and documented for the determination of MB2 presence both in vitro and in vivo, in vitro studies requires extraction of teeth often followed by sectioning, tooth clearing and root canal staining and microcomputed tomography (MCT) analysis these methods are more prone to expose the real internal morphology of the root canal but these methods not clinically useful. [6, 22, 23] Multiple periapical radiographs at different angles are the most commonly used method for detection of accessory canals in every day practice and periapical radiographs are essential for the endodontic preoperative diagnosis. Multiple periapical radiographs are required because a periapical radiographs is a two dimensional image of complex three dimensional anatomy. [24] Furthermore, the superposition of anatomical structures, excessive bone density of the zygomatic arch or impacted teeth especially in the maxilla often obscure canals this makes diagnosis of the initial canal anatomy difficult, especially for the mesiobuccal root of maxillary molars. [8, 24] Therefore, CBCT images can provide high resolution images in multiple planes while eliminating superimposition of surrounding structures. [24, 25, 26, 27] CBCT scan is the current gold standard for clinical assessment of internal morphology prior to initiation of root canal therapy. [11, 22] Moreover, CBCT is an effective and non-destructive tool to study the presence and location of the MB2 canal in vivo. [36, 41] CBCT became an effective adjunctive tool that aids in treatment planning, diagnosis, and follow-up in the field of endodontics. [28, 29, 30]

Abuabuara *et al*., [28] and Barton *et al*., [31] reported that the effectiveness of conventional periapical radiographs was low. Nattress and Martin, [32] noted that periapical radiograph alone were not reliable for detecting multiple canals. Matherne *et al*., [33] in a vitro study, reported that the superiority of CBCT over conventional radiographs in detecting the presence of accessory canals. Blattner et al., [27] in a vitro study, found CBCT to be a reliable method for the detection of the MB2 canal compared with the gold standard of physical sectioning of the specimen.

The present study used CBCT to evaluate the prevalence of MB2 in permanent maxillary second molars in Libyan subpopulation. Two hundred and thirty CBCT images were taken from the archive of Elaml dental center at Benghazi, Libya only 184 CBCT images were evaluated because of inclusion criteria. The prevalence of MB2 canals in maxillary second molars varied greatly in the literature ranged from 11.53% [34] to 95.8% [7]. The results obtained in this study revealed a prevalence of the MB2 canal in maxillary second molars 90.4% which is a percentage higher than the results reported in previous studies using the same diagnostic method (CBCT in vivo) in different populations such as (7.7% Taiwanese) [35] (15.1% Italian) [36], (17.7% Turkish) [11], (22% Chinese) [37], (23.2% polish) [38], (29.4% Thai) [4], (34.32% Brazilian) [39] (35.2% Malaysian) [40], (Spanish 41, 45%) [41] (Taiwanese 41.45%) [42] (42, 2% Korean) [25], (Iranian 43.40%) [43], (48% Chilean) [9], (60.1% Indian) [44] (57.94% Egyptian) [45] (49.35% Egyptian) [46], (Portuguese 43.56%) [47] and lower than the results of vitro studies reported by Bauman *et al*., [48] 92% based on (CBCT) in vitro, Schwarze *et al*., [7] 95.8% based on an operating microscope and Kulid and Peters, [49] 93.7% based on sectioning.

The differences in prevalence among these studies reveal the anatomical variability of the mesial root in maxillary molars which could be explained by the sample size, the observation technique and the patients` ethnicity [18, 37] and highly variable patient demographics another possible explanation for the different results could be CBCT parameter settings and manufacturer software difference, constant software developments and improvement of CBCT systems have greatly enhanced the resolution of images, especially when assessed on a computer screen. [10] The image resolution can affect the ability to detect MB2 canal. The reliability of detecting MB2 canals in CBCT scans has increased as the resolution has improved. Studies of different sample size can lead to different outcomes which effect the conclusions. [50].

The results obtained in the present study showed a significant association between the prevalence of the MB2 canal and gender ($P<0.05$). Male patients (95.7%) have a significantly higher prevalence of MB2 canals in second maxillary molars than females patients 87.7% these results are in agreement with previous studies [5, 9, 11, 17, 25, 30, 38, 40, 42, 50] but are in disagreement with a recent study by Mohara *et al*., [22] reported that female patients have significantly more MB2 canals in second maxillary molars than male patients. However, other previous studies results

have shown that there was no significant association between patient gender and MB2 prevalence. [4, 8, 10, 18, 37, 45, 51, 52] The lower detection rate of MB2 in females than in males was discussed in the literature and attributed to some factors like a higher demineralization rate and loss of bone mass, which is three times higher in females than in males this will prevent accurate detecting of the canal by computed tomography due to lack of contrast. [11]

Previous studies reported that the dimensions of maxillary molars are larger in males than in females. [53, 54, 55, 56, 57] Additionally, differential effects of the X and Y chromosomes on growth have been also used to explain why teeth dimensions of males, in both primary and permanent dentitions are larger than for females. The Y chromosome promotes both tooth crown enamel and dentine grow, while the X chromosome action seems to be restricted to enamel formation. [53, 58] Therefore, differential effect of the X and Y chromosomes explains gender dimorphism including the presence of larger molars in males and, possibly, an increasing in the number of root canals. [58]

Previous (meta-analysis) study demonstrated not only that males had higher odds of having MB2 canal than females in both maxillary molars, but also significant differences amongst geographic region. [58] Previous study reported that difference in the size of maxillary molars can be also found when comparing different geographic regions. The Australian aboriginals present the largest sized teeth, followed by the Africans, while Asians and Europeans have teeth with similar sizes. [59] Previous studies reported that the influence of the external anatomy on the inner morphology of teeth [60] it would be expected different proportions of MB2 root canals in maxillary molars depending on the geographic location and gender. For instance, Africans (Libyans) developed larger teeth and are also a geographic region associated with a higher proportion of MB2 canal in maxillary molars which confirms the conclusion of this study. Lower proportions of MB2 canal observed in Asians and Europeans might be correlated with a smaller tooth size when compared to Africans. [58]

In the present study, no significant difference was found in the distribution of the MB2 canal in relation to the position in the hemi-arch this result consistent with other studies [5, 9, 18, 25, 30, 37, 40, 45, 46] and in contrast with previous study reported that left molars tend to have a statistically significant higher prevalence of MB2. [50] Although tooth position had no influence on the incidence of an MB2 canal in the present study, the second molars showed a high tendency for the bilateral occurrence of an MB2 canal (93.4%). This means that if an MB2 canal exists on one side, clinicians must consider the possibility of two canals in the contralateral MB root and search for them when treating the contralateral maxillary second molars.

Regarding patient age, the findings of the studies in the literature based on CBCT scans shows different results related to the correlation between the prevalence of the MB2 canal and patient age. In the current study the results showed that the prevalence of the MB2 canal to be highest among patients aged 31-40 years (93.8%), followed by 15-30years (89.1%) and lowest >40 years (88.9%). Although, the differences among the age groups were not statistically significant (P=0.4, >0.05) this agrees with previous studies. [10, 25, 45]

Olczak and Pawlicka, [38] reported that a higher prevalence of MB2 in patients aged between 31-40 years than younger patients aged between 21-30 years. Wu *et al*., [61] reported that a higher prevalence of MB2 in patients aged 31-40 years compared to those older aged ≥51 years. Lee *et al*., [5] reported that a highest prevalence of MB2 in patients aged 10-20 years. Abarca *et al*., [18] reported that the presence of MB2 canal has tendency to increase with age with statistically significant association, which is different from what was observed by other authors MB2 prevalence is reduced with increasing age showing a statistically significant association. [5, 8, 37, 61] As dental structural changes occur with ageing. The most significant of these is continued deposition of secondary dentine leading to dentinal sclerosis and pulpal recession thus; canals become obliterated as there is a reduction in pulpal volume, making it difficult to locate the MB2 canal. [10] Abarca *et al*., [18] reported that the visualization of two canals in the MB root is complex in young patients, because in the formation of the MB2 canal, the septum that separates the two canals is of secondary dentin. Which means it works itself into position as the person ages. Therefore in many cases, they are categorized as one “ribbon shaped” canal and not as two canals. Therefore, clinicians should be made aware that MB2 canal can be present at any age.

5. Conclusions

The percentage of MB2 canal was high. These results indicate that CBCT is an effective, high precision diagnostic tool for detecting (MB2) canal in the mesiobuccal root of maxillary second molars. To improve the prognosis of endodontic treatment, the clinician must pay more attention to the localization and treatment of this canal.

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