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Variables That Affect the Ability to Find the Second Mesiobuccal Root Canals in Maxillary Molars

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Introduction: The study aimed to investigate the influence of various factors on the localization of the second mesiobuccal (MB2) canal in maxillary molars, a commonly missed canal during endodontic treatment. **Materials and Methods:** A comprehensive assessment of maxillary molars treated over three years with a dental operative microscope was conducted. Factors such as patient gender, age, tooth type, pulp status, pre-operative cone-beam computed tomography (CBCT), and treatment modality were examined. Statistical analyses included chi-square and multiple logistic regression. **Results:** Among 333 treated maxillary molars, the MB2 canal was identified in 60.1%. The prevalence of MB2 canals was significantly higher in the first molars (72.3%) compared to the second molars (40.2%; *P*=0.001). Multiple logistic regression models showed that gender, tooth type, and treatment modality emerged as significant determinants of MB2 canal localization: males [odds ratio 3.01(CI 95%:1.71-5.32), *P*<0.001], first molar tooth [odds ratio 4.26 (CI 95%:2.53-7.18), *P*<0.001] and secondary endodontic treatment [odds ratio 0.06 (CI 95%: 0.004-0.890), *P*<0.04]. **Conclusions:** Patient gender, tooth type, and treatment modality play pivotal roles in the identification of the MB2 canal. Additionally, the availability of pre-operative CBCT imaging was associated with a heightened ability to locate the MB2 canal.

Keywords: CBCT; Cone-beam Computed Tomography; Locating; Maxillary Molar; MB2 Canal; Retreatment

Introduction

One of the most essential points for successful endodontic treatment is to find, clean, disinfect and completely fill the entire root canal space. Maxillary molars have been reported to have a higher rate of failure of root canal treatment with persistent periapical radiolucencies due to missed root canals [1]. Among all roots of a maxillary molar, the mesio-buccal root is the most challenging and the chance of a root canal being missed during endodontic treatment is significantly higher. The second mesio-buccal [MB2] (or mesio-palatal) canal of maxillary molars is one of the most commonly missed root canals during root canal treatment. In addition, the MB2 canal is also very difficult to be negotiated [2] In a retrospective study, Khalighinejad *et al.* [3] evaluated the effect of using a dental operative microscope (DOM) on the outcome of primary endodontic treatment in maxillary first molars. They reported that when a DOM was not used, the prevalence of missed MB2 canals associated with periapical radiolucencies was significantly higher than when a DOM was used.

The prevalence of MB2 canals has been reported to range from 19.6 to 97.6% [4-7] and 13.8 to 94.7% for the first and second maxillary molars, respectively [8, 9]. Previous investigations have evaluated the prevalence of MB2 canal by either *ex-vivo* studies or clinical evaluations. *Ex-vivo* studies have used different methods such as dye penetration [10], tooth sectioning [11], scanning electron microscopy [12, 13], and cone-beam computed tomography (CBCT) [4, 14-16]. Some retrospective and prospective clinical studies have evaluated the prevalence of MB2 canals by using clinical aids and tools such as a DOM [3, 17] and CBCT [18]. Most *ex-vivo* studies have reported a higher prevalence of MB2 canals in maxillary molars compared to the clinical studies [19].

Some clinical studies have used data from postgraduate departments or data from specialist endodontic clinics. There are

several shortcomings in these studies such as a lack of data regarding the experience of the treatment providers with the DOM and CBCT that may affect their ability to locate the MB2 canal [3, 18]. In order to become familiar with the DOM, there is a steep learning curve and the experience of the treatment providers was not clear in studies that use DOM for detecting MB2 canals [20].

Therefore, the aim of this study was to evaluate the effect of several variables on finding MB2 canals in first and second maxillary molars that received endodontic treatment.

Materials and Methods

The protocol of this study was approved by the Ethics Committee of Kerman University of Medical Sciences (IR.KMU.REC.1401.027). In this study, all patients referred to a private practice limited to endodontics and who had maxillary molars with three separate roots in need of either primary or secondary (re-treatment) non-surgical endodontic treatment from June 2020 to September 2022 were included using census method. Teeth with no compromised periodontal involvement and no signs of a crack that were suitable for further restoration and that had received endodontic treatment performed under a DOM (Carl Zeiss, OPMI PICO, GmbH, Germany) were included.

Table 1. Bivariate analysis of various variables on locating MB2 canal in maxillary molars

Variables \ Locating MB2		Yes (%)	No (%)	*P*-value
Age	< 30	42 (68.9)	19 (31.9)	0.097
	30-49	112 (61.2)	71 (38.8)	
	≥ 50	46 (51.7)	43 (48.3)	
Gender	Male	78 (73.6)	28 (26.4)	0.001
	Female	122 (53.7)	105 (46.3)	
Tooth	1st molar	149 (72.3)	57 (27.7)	0.001
	2nd molar	51 (40.2)	76 (59.8)	
CBCT	Yes	71 (70.3)	30 (29.7)	0.012
	No	129 (55.6)	103 (44.4)	
Treatment type	Primary	144 (54.8)	119 (45.2)	0.001
	Secondary	56 (80.0)	14 (20.0)	
Access	MO	61 (49.2)	63 (50.8)	0.011
	DO	42 (61.8)	26 (38.2)	
	OC	92 (68.1)	43 (31.9)	
	MOD	5 (83.8)	1 (16.7)	
Pulp status	Pulpitis	108 (52.7)	97 (47.3)	0.001
	Necrosis	36 (63.2)	21 (36.8)	
	Retreatment	56 (78.9)	15 (21.1)	

Maxillary molars that had fused roots or were non-restorable were excluded from this study. The following variables and their effects on locating the MB2 canals were evaluated: gender, age, type of tooth, pulp status, availability of a pre-operative CBCT, type of endodontic treatment (primary or secondary), and the location of caries. In addition, the reason for ordering the CBCT was investigated. All data were analyzed by chi-square test as well as multiple logistic regression model. The significance level was set as ≤0.05. Multiple logistic regression model was used to analyze the association between independent variables such as age, gender, presence of pre-operative CBCT, location of caries and corresponding access cavity, type of endodontic treatment, type of tooth, and pulp status to locate the MB2 canals. The Hosmer-Lemeshow goodness-of-fit test showed that the overall goodness-of-fit of the model was satisfactory (*P*=0.849).

Results

From a total of 349 first and second maxillary molars, 333 teeth met the inclusion criteria. The Chi-square test showed that, all variables (*i.e.*, age, gender, pre-operative CBCT, type of tooth, type of endodontic treatment, location of caries and corresponding access cavity, and the form of access cavity preparation) had a significant impact on locating the MB2 canals (*P*<0.05) (Table 1). Based on the multiple logistic regression model, there was a significant correlation between locating the MB2 canal with male patients, first maxillary molars, and secondary endodontic treatment (Table 2).

Table 2. The multiple logistic regression model on the effect of various variables on locating MB2 canal in maxillary molars

Variables		Odds ratio (95% CI)	*P*-value
Age	< 30	1.62 (0.74-3.56)	0.23
	30-49	1.49 (0.83-2.66)	0.18
	≥ 50	Reference	-
Gender	Male Female	3.01 (1.71-5.32)	<0.001
Tooth	1st molar 2nd molar	4.26 (2.53-7.18)	<0.001
CBCT	Yes No	1.45 (0.77-2.77)	0.25
Treatment	Primary Secondary	0.06 (0.004-0.890)	0.04
Location of caries and corresponding access cavity	Distal Occlusal Mesial & distal Mesial	0.37 (0.03-3.69) 0.60 (0.60-6.21) 0.55 (0.06-5.40) Reference	0.40 0.67 0.61 -
Pulp	Retreatment Necrosis Pulpitis	2.18 (0.27-1.09) 0.10 (0.01-1.43) Reference	0.08 0.0.09 -

In this study, 30.3% (n=101) of the patients had CBCT images taken prior to the endodontic treatment or completing the procedure. The majority of these CBCT images (n=60, 59.41%) had been previously ordered by either the treating practitioner or other treatment providers for other reasons such as to determine the prognosis of treatment of another tooth, assessment of pain with no apparent origin, prior to placement of an implant, to assess an impacted molar, to assess a pathologic radiolucency, and diagnosis of a vertical root fracture (VRF) (Table 3). These CBCT images had been previously arranged and were available on the desktop computer of the office and they were used during either primary or secondary endodontic treatment. In addition, one CBCT image had been ordered during the treatment (Table 3). In the case of ordering a CBCT prior to the endodontic treatment, the majority of these teeth (n=38, 92.68%) required secondary endodontic treatment.

The number of patients that had a CBCT and received secondary endodontic treatment was significantly higher compared to the number of patients who received primary endodontic treatment (P<0.001). In addition, when the CBCT was taken in advance of the treatment, a significantly higher number of MB2 canals were located in patients who received secondary endodontic treatment compared to the primary endodontic treatment (P=0.004). However, pre-operative CBCT had no significant effect on locating the MB2 canals in the maxillary first molars compared to the maxillary second molars (P=0.903) (Table 4).

Discussion

The results of this clinical study show that variables such as gender, pre-operative CBCT, type of tooth, type of endodontic treatment, and the location of caries and corresponding access cavity had significant effects on locating MB2 canals (P<0.05).

Table 3. Reasons of ordering CBCT for the patients

Reasons \ Number	Number	Percent (%)
Prior to the endodontic treatment of maxillary molars	41	40.59
For treating another tooth	34	33.66
Unrecognized reason of pain	3	2.97
Vertical root fracture	4	3.96
Implant	11	10.90
Impacted tooth	2	1.98
Outcome of previous treatment	1	0.99
Pathologic radiolucent lesion	1	0.99
Intraoperative reason	2	1.98
Unknown	2	1.98
Total	101	100

A multi-center worldwide study using CBCT confirmed a wide range of prevalence of MB2 canals in different geographical locations [4]. In that study, Belgium reported the highest prevalence of MB2 canals (97.6%), whereas Venezuela reported the lowest prevalence of MB2 canals (48.0%) [4]. Results of the present study indicated that 72.3% and 40.2% of the maxillary first and second molars had MB2 canals, respectively. The prevalence of MB2 canals in this study was in accordance with previous investigations that have reported maxillary first molars had significantly more MB2 canals compared to the maxillary second molars [21, 22].

In this study, about one third of the patients had CBCT images, and a combination of using a DOM and CBCT resulted in the location of more MB2 canals compared to clinical studies that have only used magnification [23]. However, in this study the percentage of MB2 canals was lower compared to the Parker *et al.* study [24] that also used a combination of a DOM and CBCT. The difference between geographical locations, and hence probable racial differences of the patients, may be the reason for the different percentages in the two studies.

There is some controversy regarding the use of CBCT for locating MB2 canals [25]. It has been shown that when the MB2 canal was not seen in CBCT images, there was still a chance that the canal could be found by clinical searching with troughing [24]. In endodontic treatment of maxillary molars, DOM and troughing are the two main methods used to locate most MB2 canals [24]. If a DOM and troughing are not successful, then a CBCT could help practitioners to locate about half of the missed canals that were not located during the first attempt before examining the CBCT images [24]. Manigandan *et al.* [26] reported that a high number of MB2 canals (90%) could be found by using a DOM and selective troughing of the dentin. Using CBCT in their study only improved the location of MB2 canals from 90% to 93%. Therefore, the routine pre-operative use of CBCT for all maxillary molars cannot be recommended [15, 24].

Table 4. Variables in treated teeth with and without a CBCT at the time of treatment

Variables \ CBCT		Yes (%)	No (%)	*P*-Value
Treatment	Primary	48 (18.25)	215 (81.75)	<0.001
	Secondary	53 (75.71)	17 (25.29)	
Tooth	1st molar	62 (30.1)	144 (69.9)	0.903
	2nd molar	39 (30.7)	88 (69.3)	
Locating the MB2 canal in patients who had a CBCT	Primary treatment	27 (56.2)	21 (43.8)	0.004
	Secondary treatment	44 (83.0)	9 (17.0)	
Ordering CBCT prior to the endodontic treatment		40 (40.59)	60 (58.41)	-

Studebaker *et al* [18] reported that 5.6% of the patients treated by postgraduate endodontic students as well as faculty clinicians had a CBCT prior to commencing endodontic treatment. However, in this study only 30.3% of the patients had a CBCT prior to the treatment. The difference might be due to the different regulations in different countries. In the United States of America, either a dental practitioner or an endodontist can install and use CBCT in his/her office. However, based on regulations in Iran, only oral and maxillofacial radiologists have the legal right to install and operate CBCT machines. Therefore, patients may be given a Dicom file of their CBCT images on a compact disk that they can keep for themselves. This may be an advantage for a dental practitioner since he/she would receive information from a CBCT image that had been previously ordered for other reasons and the patient may provide them at the examination visit. In this study, the patients' CBCT images were either taken for an endodontic reason or from the patients records where a CBCT image had been taken for other reasons such as for treatment of another tooth, searching for the reason of pain that had no obvious origin, detecting a vertical root fracture of another tooth, ordered by another dental practitioner such as for extracting an impacted tooth, placing an implant, *etc*. (Table 3). The current regulation in Iran may have a drawback since endodontists may not be able to take a CBCT during endodontic treatment when necessary and will have to refer their patient to the oral and maxillofacial radiology clinics for an intra-operative CBCT image. However, Table 3 shows that the majority of the patients had CBCT images that were taken for other reasons. Therefore, in fact, only 41 patients (12.31%) out of 333 patients were referred for CBCT images prior to the treatment for assessment of the maxillary molars that needed endodontic treatment. Most of these patients (n=38, 92.7%) needed secondary endodontic treatment and others were sent for CBCT images for other reasons such as being suspicious about the presence of a mishap or extension of a periapical radiolucency. The position statements of the American Association of Endodontists (AAE) and the European Society of Endodontology (ESE) do not recommend the routine use of CBCT images when treating maxillary molars [27, 28]. However, based on a practitioner's judgement, in case of complicated root canal morphology, the possibility of a mishap and missed root canals, no apparent reason for failure of previous endodontic treatment, and the need for more information that could not be obtained from two-dimensional radiographs, a CBCT image should be ordered.

In this study, males had a significantly higher prevalence of MB2 canals compared to females (P=0.001). Several studies have reported that the prevalence of MB2 canals is higher in males [4, 5, 21, 26, 29, 30], although several other studies have reported no significant difference between genders [22, 31-33]. Different study methodologies as well as geographical locations may affect the reported prevalence of MB2 canals [4, 19] even though most studies have used CBCT to evaluate the prevalence of MB2 canals [4, 5, 21, 22, 29-31, 33].

The type of treatment had a significant impact on locating the MB2 canals (P=0.001). This was in accordance with Wolcott *et al*. [23] who reported significantly more MB2 canals in maxillary first molars during secondary endodontic treatment compared to primary treatment. However, for the second molars, the type of treatment had no significant impact on locating the MB2 canals.

It has been shown that the use of a DOM can increase the ability of a dental practitioner to locate MB2 canal [34]. However, one of the shortcomings of previous clinical investigations was that they did not mention the experience of the practitioners working with the DOM. As the amount of experience can affect the ability to locate MB2 canals in maxillary molars [35], only cases that were treated after three years of routine use of a DOM for root canal treatment were included in this study in order to prevent the effects of the learning curve on locating the MB2 canals.

One may argue that the size of the field of view (FOV) may have an influence on detecting MB2 canals. The results of a study showed that the size of FOV has no significant effect on detecting MB2 canals; however, the smaller field of view may results in determining more accurate root canal configuration in mesiobuccal roots of maxillary molars [7]. It has been shown that the CBCT's voxel size has had an important effect on detecting MB2 canals. Bauman *et al*. [36] reported that a voxel size equal to or less than 0.2 mm could significantly improve the ability of detecting MB2 canals in maxillary molars. One of the limitations of this study was that the CBCT images were not always ordered for the purpose of locating the MB2 canals as they may have been ordered for other reasons. However, Aung and Myint [37] stated that using CBCT images for detecting MB2 canals may result in higher false positive outcomes due to the context bias. "Context bias is the liability of an observer of an index test to think test findings to be positive more commonly in settings with higher disease prevalence, and they may overestimate the sensitivity of the test". They suggested that considering CBCT's only for detecting the MB2 canals may result in an overestimation of the prevalence of this canal [37].

In this study, the MB2 canal was located in 83% of teeth in need of secondary endodontic treatment in patients that had a CBCT scan before commencing the treatment. This does not necessarily mean the prevalence of the MB2 canal is higher, but it shows that more maxillary molars with missed MB2 canal needed secondary endodontic treatment.

The location of caries may have some effects on locating MB2 canals in maxillary molars. In theory, when the location of caries is in the distal part of a tooth, the practitioner may be conservative when preparing the access cavity to locate the MB2 canal and not remove sound and intact tooth structure in the mesial part of the tooth. However, when the caries is in the mesial part of the tooth, the practitioner may think there is greater visibility and no need to be concerned about tooth structure. The results of the present study showed that direct access cavity preparation through the occlusal surface resulted in finding significantly higher MB2 canals compared to when the caries was located in the mesial of the tooth. Therefore, restoring tooth structure in the mesial and distal parts of the tooth following full caries excavation may not affect a practitioner's ability to locate MB2 canals. A hypothesis for why fewer MB2 canals are found when there is mesial caries might be that the formation of more dentin on the pulp chamber floor makes it more difficult to locate this canal.

It is important to note that in bivariate analysis each variable of tooth type, gender, type of treatment, placement of caries, and presence of CBCT may have a significant impact on detecting MB2 canals; however, when a multiple logistic regression model was used only three variables of the gender, tooth type, and treatment types have significant impact on detecting MB2 (Table 2).

Conclusion

In conclusion, the results of the present study indicate that maxillary first molars, male patients, and secondary endodontic treatment were more likely with locating significantly more MB2 canals in maxillary molars.

Conflict of Interest: 'None declared'.

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