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Canal Configuration of the Mesiobuccal Root of Maxillary Molars

Üst Molar Dişlerin Meziobukkal Kök Kanal Morfolojilerinin Klinik Olarak İncelenmesi

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ABSTRACT

Aim: The purpose of this study was to determine the canal morphology and the percent of second mesiobuccal canals (MB2s) in conventionally treated and retreated maxillary first, second, and third molars that could be routinely located in different age groups.

Subjects and Method: The teeth examined were 202 first molars (83 men, 118 women; age range, 18-68 years), 129 second molars (60 men, 69 women; age range, 18-77 years), and 15 third molars (7 men, 8 women; age range, 30-61 years) treated over a 4-yr period of time by 1 endodontist. The results were recorded on a computer program and all the proportions were analyzed by using chi-square (likelihood ratio) test and two proportions z-test. All levels of significance were set at $p<0.05$.

Results: The prevalence of MB2s decreased from first to third molars (70.2%, 31.7%, 14.3%, respectively); type II (2 treatable canals that joined) and type III (2 treatable canals with 2 separate apical foramina) canal configurations were the most common. The prevalence of MB2s in first molars was significantly higher than in teeth having undergone root canal treatment in both second ($p<0.05$) and third molars ($p<0.05$). There were significant differences in the occurrence of MB2s between patients ≤ 50 years old and patients > 50 years in both first and second molars ($p<0.05$).

ÖZET

Amaç: Bu çalışmanın amacı kök kanal tedavisi uygulanmış ve/veya kanal tedavisi tekrarlanmış farklı yaş gruplarındaki bireylere ait üst birinci, ikinci ve üçüncü molar dişlerde rutinde mevcut olabilecek ikinci meziobukkal kanalların (MB2s) kök kanal morfolojilerini ve klinikte görülme sıklıklarını incelemektir.

Bireyler ve Yöntem: Kök kanal tedavisi uygulanmış dişlerin 202 adedi birinci molar (83 erkek, 118 kadın; yaş ortalaması, 18-68), 129 adedi ikinci molar (60 erkek, 69 kadın; yaş ortalaması, 18-77), 15 adedi üçüncü molar (7 erkek, 8 kadın; yaş ortalaması, 30-61) olup, bu dişlerin tedavileri bir endodontist tarafından 4 yıllık bir periyot boyunca gerçekleştirildi. Elde edilen veriler bir bilgisayar programına aktarıldı, ki-kare (likelihood ratio) testi ve oranların karşılaştırılması için z testi kullanılarak istatistiksel analiz gerçekleştirildi. Önemlilik düzeyi $p<0.05$ olarak alındı.

Bulgular: MB2s'nın görülme sıklığı birinci molarlardan üçüncü molarlara doğru azalarak seyrettiği görüldü (sırasıyla, 70.2%, 31.7%, 14.3%); tip II (2 ayrı kök kanalının kök ucunda birleştiği kök kanal anatomisi) ve tip III (2 ayrı kök kanalının ayrı sonlandığı kök kanal anatomisi) kanal morfolojileri en sık gözlenen morfolojiler olarak belirlendi. Birinci molar dişlerde görülen MB2s sıklığı ikinci molar ($p<0.05$) ve üçüncü molar ($p<0.05$) dişlerde görülenden anlamlı olarak

Conclusion: A significant proportion of maxillary first molars had two canals in the mesiobuccal root (70.2%) and that the occurrence of two canals decreased significantly with the increasing age in both first and second molars.

KEYWORDS
Maxillary molars, root canal morphology, second mesiobuccal canal

daha yüksek bulundu. Birinci ve ikinci molar dişlerde görülen MB2s oranı, yaş grupları açısından 50'den küçük ve 50'den büyük olan bireyler arasında belirgin farklar bulundu ($p<0.05$).

Sonuç: Üst çenede yer alan birinci molar dişlerin büyük bir çoğunluğunun meziobukkal köklerinde iki kanal yer almaktadır (% 70.2) ve bu oran yaş artışı ile birlikte gerek üst birinci molar dişlerde gerekse üst ikinci molar dişlerde belirgin olarak azalmaktadır.

ANAHTAR KELİMELER
Maksiller molar dişler, kök kanal morfolojisi,ikinci meziobukkal kanal

INTRODUCTION

The aim of endodontic treatment is the chemomechanical cleansing of the root canal and its hermetic obturation with an inert material[1]. It is generally accepted that the major cause of the failure of root canal therapy is the clinician's inability to recognize and adequately treat all the canals of the root canal system[1-3]. A clear understanding of human root canal anatomy is a prerequisite for performing conventional endodontic procedures. The anatomic complexities of the root canal have been highlighted in the literature, and the need for clinicians to understand probable aberrations has been emphasized[4,5].

The morphology of canal systems in maxillary molars has been evaluated in many studies. In particular, the complexity of the mesiobuccal (MB) roots of the first and second maxillary molars, which was first noted by Hess and Zurcher[6], later became the focus of more detailed and repeated investigations after the publication of a study by Weine *et al.*[2] These studies demonstrated that most maxillary first molars and a considerable percent of second molars have an additional MB root canal (MB2), which is also referred to as a *mesiolingual canal* or a *mesiopalatal canal*[7]. Since these studies, several more studies of the root canal anatomy of maxillary molars have shown that the frequency of MB2s ranges from 10% to 95%[1,3-5,8,9]. The prevalence of MB2s varies with the method used in the study (ie, the sectioning of extracted teeth, the injection of dye, the study of radiographs, the surgical techniques used, the use of light microscopy or scanning microscopy, microcomputed tomography, and whether the clinical study is retrospective or prospective)[4,8,10-15]. A study by Pomeranz and Fishelberg[3] revealed a large discrepancy between clinical and laboratory results with regard to the incidence of MB2s. Although in vitro studies[12,16] also have demonstrated that the incidence of MB2s is high, there is no consensus on the number of MB2s that are amenable to endodontic treatment.

To categorize the root canal system in each root, Weine[17] described 4 different configurations: type I (a single canal from the pulp chamber to the apex), type II (2 separate canals that leave the chamber but merge short of the apex to form a single canal), type III (2 separate canals that leave the chamber and exit the root in separate foramina), and type IV (1 canal that leaves the chamber but divides short of the apex into 2 separate and distinct canals with separate foramina). The purpose of our study was to determine

the canal morphology and the percent of maxillary molar MB2s in different age groups that could be identified clinically.

SUBJECTS AND METHOD

From October 2000 to January 2004, 1535 teeth were endodontically treated and retreated by 1 endodontist at the Department of Endodontics at the Başkent University Faculty of Dentistry. Of the teeth treated, 202 were maxillary first molars, 129 were maxillary second molars, and 15 were maxillary third molars. Access preparations were routinely modified to a rhomboid shape. Most of the content of the pulp chamber and canal systems was removed, and the canal was irrigated with a 2.5% sodium hypochlorite solution. The floor of the pulp chamber was searched with a sharp explorer and/or a small round burr between the MB and the palatal canal. After negotiating the canal with fine files (especially size 6, 8, or 10 in MB2s), we measured the working length with an electronic apex locator (Root ZX; J. Morita Corp, Tokyo, Japan) and/or radiographs. Root canal preparations were performed with either a step-back technique using stainless steel files or with a crown-down technique using rotary NiTi instruments. Root canal fillings were performed via a cold lateral condensation technique. Most root canal treatments were completed in 1 or 2 appointments.

Patient data (name, pulp status [vital, necrotic, retreatment], diagnosis, age, sex, tooth number, number and morphology of the root canal, type of sealer, obturation technique, and final restoration) were recorded on a personal computer and analyzed with Microsoft Office Excel 2003 software (Microsoft Corp., Redmond, WA, USA). The findings of this retrospective study were obtained from those records; however, some of the documentation forms were excluded because the data were incomplete. In the Tables, incomplete information is referred to as "Unrecorded."

The root canal morphology of the MB was classified according to the method of Weine *et al.*[2]. The MB root was noted as having 2 treatable canals with 2 separate apical foramina (type III) when 2 separate files or gutta-percha points could be placed and seen at the radiographic working length. The MB root was classified as having 2 treatable canals that joined (type II) when 2 files or gutta-percha points could be seen on the radiograph to join. This was confirmed clinically when a file in 1 canal impeded the placement of a file in the other canal or when a gutta-percha point placed at the working length in 1 canal could be scored by a file placed in the other canal[14]. In a clinical setting, a sterile absorbent point was inserted into the MB2 canal to determine whether it joined with the MB. If the fluid level in the other canal decreased in volume when an absorbent point was inserted, that canal was considered to have joined with the MB. If the level did not change in volume when an absorbent point was inserted, the canals were classified as separate.

Data were analyzed by using chi-square (likelihood ratio) test and two proportions z-test. All levels of significance were set at $p<0.05$.

RESULTS

Of the 202 maxillary first molars investigated (83 men and 118 women; age range, 18-68 years), 56 teeth had 3 root canals (29.8%) and 132 had MB2s (70.2%), 38 of which were type II (Figure 1); 27 were type III (Figure 2); and 2 were type IV (Tables 1 and 2). Of the 129 maxillary second molars investigated (60 men and 69 women; age range, 18-77 years), 4 teeth had 1 root canal (3.2%) (Figure 3), 10 teeth had 2 root canals (8.1%), 70 teeth had 3 root canals (57%), and 39 teeth had MB2s (31.7%) (Table I). Of the 39 teeth that had MB2s, 7 were type II (Figure 4), 9 were type III (Figure 5), and 1 was type IV (Table II). Of the 15 maxillary third molars investigated (7 men and 8 women; age range, 30-61 years), 3 teeth had 1 root canal (21.4%) (Figure 6), 3 teeth had 2 root canals (21.4%), 6 teeth had 3 root canals (42.9%), and 2 teeth had MB2s (14.3%) (Table I).

FIGURE 1

A root canal configuration in a mesiobuccal root of maxillary right first molar. Two orifices with separate canals that merge short of the apex to form a single root canal with one foramen (type II).

FIGURE 2

A root canal configuration in a mesiobuccal root of maxillary right first molar. Two orifices with separate canals showing two distinct foramina (type III).

TABLE I

Frequencies and percents of canals treated in maxillary molars

Teeth	Total no. of Teeth Treated	No. Unrecorded Teeth	No. Recorded Teeth	1 Canal (%)	2 Canals (%)	3 Canals (%)	4 Canals (%)
First molars	202	14	188	0	0	56 (29.8)	132 (70.2)[a]
Second molars	129	6	123	4 (3.2)	10 (8.1)	70 (57)	39 (31.7)[b]
Third molars	15	1	14	3 (21.4)	3 (21.4)	6 (42.9)	2 (14.3)[b]

[a,b:] *Differences between groups identified with the same superscript symbol were not statistically significant (p>0.05).*

TABLE II

Distribution and percents of mesiobuccal roots in the 4 types of root canals in maxillary first and second molars

Teeth	Total M B2s	No. Unrecorded M B2s	No. Recorded M B2s	Type I (%)	Type II (%)	Type III (%)	Type IV (%)
First molars (n: 188)	132 (70.2)	65	67 (35.6)	56 (29.8)	38 (20.2)	27 (14.3)	2 (1.1)
Second molars (n: 123)	39 (31.7)	22	17 (13.8)	70 (57)	7 (5.7)	9 (7.3)	1 (0.8)

[*] *MB2, Additional mesiobuccal root canal.*

Chi-square (likelihood ratio) analysis proved a significant relationship ($p<0.001$) for number of canals and maxillary molars. Two proportions z-test showed that the prevalence of MB2s in first molars was significantly higher than in root canal treated teeth in both second ($p<0.05$) and third molars ($p<0.05$). The prevalence of MB2s was also higher in second molars compared to third molars, but this difference was not significant ($p>0.05$) (Table I).

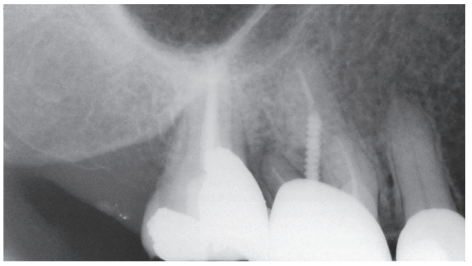

FIGURE 3

A root canal configuration of a single canal from the pulp chamber to the apex in maxillary right second molar.

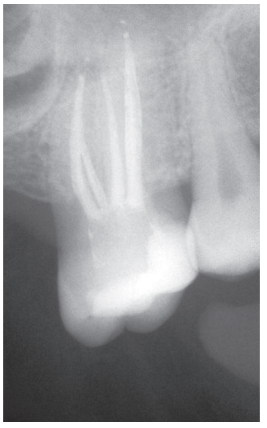

FIGURE 4

A root canal configuration in a mesiobuccal root of maxillary left second molar. Two orifices with separate canals that merge short of the apex to form a single root canal with one foramen (type II).

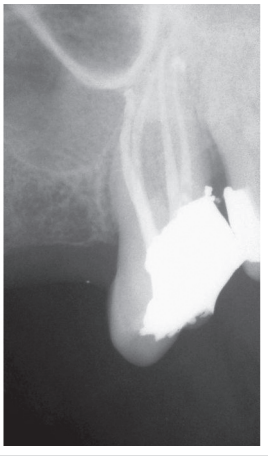

FIGURE 5

A root canal configuration in a mesiobuccal root of maxillary right second molar. Two orifices with separate canals showing two distinct foramina (type III).

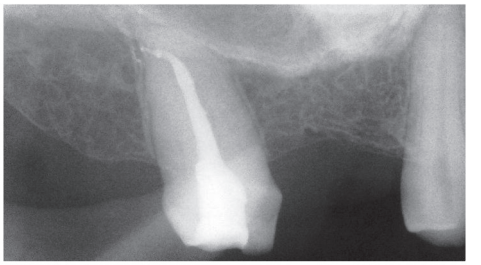

FIGURE 6

A root canal configuration of a single canal from the pulp chamber to the apex in maxillary right third molar.

Table III and Table IV summarize the frequencies and percents of canals treated in maxillary first and second molars according to age disparity. For first molars, 41 of 159 (25.8%) teeth from patients ≤ 50 years old had 1 treatable canal in the MB root, whereas 15 of 29 (51.7%) teeth from patients > 50 years old had 1 treatable canal in the MB root. The corresponding values for second molars were 42 of 86 (48.8%) and 28 of 37 (75.7%). There was an inverse relationship between age and the prevalence of MB2s in both first and second molars. Chi-square (likelihood ratio) analysis proved a significant relationship for number of canals and age groups for both first ($p<0.05$) and second ($p<0.01$) molars. Two proportions z-test showed that there were significant differences in occurrence of MB2s between patients ≤ 50 years old and patients > 50 years in both tooth morphotypes ($p<0.05$).

The 23 MB2s of the maxillary first molars, the 20 MB2s of the maxillary second molars, and the sole MB2 of the maxillary third molar were identified as a fourth canal. However, these were not used in the calculation of the percent of MB2s in the root canal morphology of the MB because we were able to simply instrument that canal to a depth of 3 to 4 mm after troughing with a sharp explorer between the MB and palatal canals. Furthermore, some forms of root canal morphology that could not be classified as any of the types ranging from I to IV were not recorded, despite the number of total canals

TABLE III

Frequencies and percents of canals treated in maxillary first molars according to age disparity

Patient Age (y)	Total No. of Teeth Treated	No. Unrecorded Teeth	No. Recorded Teeth	3 Canals (%)	4 Canals (%)
18-30	103	9	94	25 (26.6)	69 (73.4)[a]
21-50	69	4	65	16 (24.6)	49 (75.4)[a]
51-68	30	1	29	15 (51.7)	14 (48.3)[b]
Total	202	14	188	56 (29.8)	132 (70.2)

[a,b:] *Differences between groups identified with the same superscript symbol were not statistically significant (p>0.05).*

TABLE IV

Frequencies and percents of canals treated in maxillary second molars according to age disparity

Patient Age (y)	Total No. of Teeth Treated	No. Unrecorded Teeth	No. Recorded Teeth	1 Canals (%)	2 Canals (%)	3 Canals (%)	4 Canals (%)
18-30	35	1	34	0	2 (5.9)	19 (55.9)	13 (38.2)[a]
31-50	54	2	52	2 (3.8)	4 (7.8)	23 (44.2)	23 (44.2)[a]
51-77	40	3	37	2 (5.4)	4 (10.8)	28 (75.7)	3 (8.1)[b]
Total	129	6	123	4 (3.2)	10 (8.1)	70 (57)	39 (31.7)

[a,b:] *Differences between groups identified with the same superscript symbol were not statistically significant (p>0.05).*

present. In addition, the teeth with an unclassified root canal morphology were not used to calculate the percent of MB roots in the root canal anatomy of the maxillary molars studied.

DISCUSSION

The morphology of canal systems in maxillary molars varies by definition according to the method and criteria used to detect it. In vitro studies show more fourth canals than do in vivo studies. Our findings are similar to those of studies that have reported the presence of MB2s ranging from 61.8% to 73.2%[8,13] for maxillary first molars and from 22.7% to 50.7%[8,11] for maxillary second molars in vivo. However, Sempira and Hartwell[9] reported that 33.1% of maxillary first molars and 24.3% of second molars had a negotiable MB2 in vivo, but those authors' criteria were more stringent than ours. If the separate orifices were initially located but blended into a single canal coronally during instrumentation, Sempira and Hartwell[9] did not consider the orifice to be a separate canal. However, the authors of most studies support our view, in which a second canal is considered to be present if separate orifices or canals were identified initially. Second canals were not considered to be present if the canals remained separate after instrumentation.

Most researchers have stated that magnification, especially that supplied by an operation microscope, enhances the likelihood of finding an MB2 in maxillary molars[8,18,19]. Gorduysus *et*

al.[18] reported that the negotiation of an MB2 was enhanced from 69% to 80% when an operation microscope was used. However, Sempira and Hartwell[9] stated that the use of a microscope did not significantly increase the number of MB2s they identified, but did greatly enhance visibility. Also, it increased their level of confidence when using rotary burrs and ultrasonic tips to remove the secondary calcific deposits that covered many of the canal orifices.

Our finding that older patients had 1 treatable canal in the MB root more frequently than did younger patients supports the findings of other authors[12-14]. Gilles and Reader[12] stated that although it is probable that canals become smaller with age, it is unlikely that they disappear completely. Therefore, it is likely that many more MB2s exist than can be treated clinically, and that many of the type I canals in our study were in fact type II or III canals.

In clinical practice, locating an MB2 canal is challenging. These canals usually originate on the lingual side and slightly distal to the main MB but occasionally share the orifice with the MB. An MB2 is not always visible after access cavity preparation as it is often smaller and covered by calcifications[4]. The protocol used in recent clinical studies[8,14] to locate an MB2 (namely, finding rhomboid-shaped access cavities and removing the mesial dentinal protuberance overlying the canal orifice with burrs or ultrasonic instruments used under magnification) seems the most successful. Clinicians must be sure to create an adequate access cavity that does not weaken the coronal tooth structure. In older patients, the MB2 usually has a tortuous path and is more likely to be calcified and untreatable[12-14,20]. This could result in treatment failure and may explain the relatively high frequency of surgical retreatment performed on the MB root of maxillary first molars[21].

Differences in root canal types are important. Type II canals can join close to the coronal orifice or near the apex. If they join near the orifice, success is possible, even if 1 canal is missing. Conversely, if the canals join near the apex and 1 of the canals has not been properly cleaned, then the chance of failure increases because of the retention of organic tissue and microorganisms. Furthermore, when a root is surgically resected, an MB2 can be exposed. Even if it has been identified and sealed with a root-end filling, an untreated canal could contribute to failure because of microleakage. However, type III canals present the most difficult challenge because they exit in 2 foramina. Therefore, although a certain chance of failure is to be expected in type III canals, clinicians should develop the skills necessary to locate, clean, and shape the entire root canal system to produce a more predictable and favorable prognosis. Perhaps if more clinicians had a better knowledge of the internal morphology of the canals and better methods for accessing them (eg, by using proper illumination from a headlamp and magnification with an operation microscope), the likelihood of finding and successfully treating MB2s would increase. However, the most important factor in finding MB2s is the clinician's awareness that these extra canals exist. When a maxillary molar is treated, finding an additional canal in the MB root should be expected until radiographs and clinical examinations indicate the contrary[16].

CONCLUSION

A significant proportion of maxillary first molars had two canals in the mesiobuccal root (70.2%) and that the occurrence of two canals decreased significantly with increasing age in both first and second molars.

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