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Evaluation of Root Canal Configuration of Permanent Maxillary Molar Teeth in a Turkish Subpopulation: A Cone-Beam Computed Tomographic Study

Bir Türk Alt Popülasyonunda Kalıcı Üst Azı Dişlerinin Kök Kanal Konfigürasyonunun Değerlendirilmesi: Konik Işınlı Bilgisayarlı Tomografi Çalışması

[1]Erhan ERKAN, [2]Keziban OLCAY, [1]Tan Fırat EYÜBOĞLU, [3]Elif ŞENER, [1]Mustafa GÜNDOĞAR

[1]Department of Endodontics, Scholl of Dentistry, Istanbul Medipol University, Istanbul, Türkiye
[2]Department of Endodontics, Scholl of Dentistry Istanbul University-Cerrahpaşa, Istanbul, Türkiye
[3]Department of Oral and Maxillofacial Radiology, School of Dentistry, Ege University, Izmir, Türkiye

Erhan Erkan: https://orcid.org/0000-0003-2631-3286
Keziban Olcay: https://orcid.org/0000-0002-2168-710X
Tan Fırat Eyüboğlu: https://orcid.org/0000-0002-0308-9579
Elif Şener: https://orcid.org/0000-0003-1402-9392
Mustafa Gündoğar: https://orcid.org/0000-0001-8656-7101

ABSTRACT

Objective: Maxillary molars may be challenging for root canal treatment due to their complex canal anatomy and additional root canals, especially in the mesiobuccal root. The current study aimed to investigate the prevalence of root and root canal numbers of maxillary molar in a selected Turkish population.

Materials and Methods: A total of 905 first and second maxillary molars were evaluated using cone-beam computed tomography (CBCT) images. The number of roots and canals was recorded and the mesiobuccal canal was further evaluated with the Vertucci classification.

Results: A total of 394 teeth had a second mesiobuccal (MB2) canal (43.5%). While 90.4% of all maxillary molars had three roots, 44% had four root canals. The most common root canal anatomy of mesiobuccal root canals was Type II (42.6%) followed by Type IV (31.5%) and Type III (22.1%).

Conclusions: It is clear that the second mesial root canal in permanent maxillary molars should be carefully searched for the long-term success of root canal treatments. It is seen that CBCT sections will be beneficial in diagnosis and treatment in better understanding the anatomical structure of the teeth and determining possible anatomical deviations.

Keywords: Cone-beam CT, root canal morphology, maxillary molar

ÖZ

Amaç: Üst çene azı dişleri, karmaşık kök kanal anatomisi ve özellikle mezial kökteki ek kök kanal sayıları nedeniyle endodontik tedaviyi zorlaştırabilir. Bu nedenle başarılı bir kanal tedavisi için üst çene azı dişlerinin anatomik özelliklerinin analiz edilmesi gerekmektedir. Bu çalışmanın amacı, seçilmiş bir Türk nüfusunda üst çene azı dişlerinin kök ve kök kanal sayılarının prevalansını araştırmaktır.

Materyal ve Metot: Konik ışınlı bilgisayarlı tomografi (KIBT) kullanılarak toplam 905 birinci ve ikinci kalıcı üst azı dişi değerlendirildi. Kök ve kök kanal sayıları kaydedilerek mezyobukkal meziobukkal kök kanalı Vertucci sınıflamasına göre değerlendirildi.

Bulgular: Toplam 394 üst azıda ikinci bir mezial (MB2) kök kanalı (% 43,5) vardı. Tüm üst büyük azı dişlerinin % 90,4' ünde üç adet kök varken, %44'ünde ise 4 kök kanalı vardı. Mezial kök kanallarının en yaygın kök kanal anatomisi Tip II (% 42,6) iken, bunu Tip IV (% 31,5) ve Tip III (% 22,1) takip etti.

Sonuç: Üst daimi azı dişlerindeki ikinci mezial kök kanalının, kanal tedavilerinin uzun dönem başarısı için dikkatlice aranmasında büyük fayda olduğu açıktır. Dişlerinin anatomik yapısının daha iyi anlaşılmasında ve olası anatomik sapmaların belirlenmesinde KIBT kesitlerinin teşhis ve tedaviye oldukça yardımcı olacağı görülmektedir.

Anahtar Kelimeler: Konik ışınlı BT, kök kanal morfolojisi, üst azı dişi

Sorumlu Yazar / Corresponding Author:
Erhan Erkan
Department of Endodontics, Faculty of Dentistry, Istanbul Medipol University, Medipol Mega Dental Hospital, TEM Avrupa Otoyolu Göztepe Çıkışı No: 1, 34214, Bağcılar Istanbul, Türkiye.
Tel: +90 532 362 70 53
E-mail: eerkan@medipol.edu.tr

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INTRODUCTION

Complete shaping, proper irrigation, and hermetic root canal filling are essential to promote successful root canal therapy. On the other hand, untouched dentin surfaces in the root canal may cause endodontic failure.[1] All root canals must be optimally shaped, irrigated, and obturated hermetically for a successful long-term prognosis of root canal treatment.[2]

Endodontic failures occur mainly in permanent maxillary molars due to their complex root and canal anatomy.[1-3] The most common reason for endodontic failure is missing root canals, especially the second mesiobuccal root canal (MB2).[4] An missing MB2 canal may contain residual microorganisms resulting in post-operative pain and re-infection of the periapical area.[5,6] According to previous studies, permanent maxillary molars generally show the formation of three roots and four canals.[7] Many researchers have also shown different morphological root canal types.[7-11]

Studies evaluating the root canal complex of teeth have used various techniques, such as canal staining and clearing, radiographic examination, and physical sectioning.[12-18] Although clearing and physical sectioning techniques are the best way to analyze root canal anatomy, they are invasive modalities indicated only for extracted teeth. According to position statements of the American Academy of Oral and Maxillofacial Radiology and the American Association of Endodontics, an intraoral radiograph is accepted as a standard pattern of the imaging modality of endodontic diagnosis.[19] Nevertheless, superimpositions observed on two-dimensional images cannot fully reflect the root canal complex, especially in the presence of complex anatomy as expected in molar teeth.[8]

Axial, coronal, and sagittal CBCT sections can clarify the enamel, dentin, and alveolar bone, so the clinicians realize the unique anatomy of the root canal complex without superimposition.[5,6] CBCT has been considered a unique device in detecting the presence of an MB2 canal in the mesial root of maxillary molars.[20] It has also been confirmed that the accuracy of the detection of MB2 with CBCT imaging is more specific than with conventional radiographs and dental magnification devices.[21-23]

Our study aims to help clinicians in the long-term success of root canal treatment by examining the root canal anatomy of permanent maxillary molars, which were reviewed on pre-existing recorded CBCT images in the university clinic, and to create references for academics interested in the subject. Our findings also will compare with the same studies in the literature.

MATERIALS AND METHODS

Ethics Committee Approval: The present study was planned following the principles of the Declaration of Helsinki at all stages and approved by the Ethical Board of the university committee. (Date: 11/01/2022, decision no: E-10840098-772.02-193).

Patient Selection: CBCT images were obtained from the patients for diagnostic purposes by reading and signing the informed consent form. Nine hundred-five maxillary molars were examined from the patients' CBCT images taken between 2000 and 2017 in the Faculty of Dentistry.

Study Protocol: CBCT was taken using the i-CAT17–19 (Imaging Sciences Int., Inc., USA) imaging device following a scanning protocol in line with the company's recommendations with a voxel size of 0.25 mm. All volumes were acquired at 120 kVp

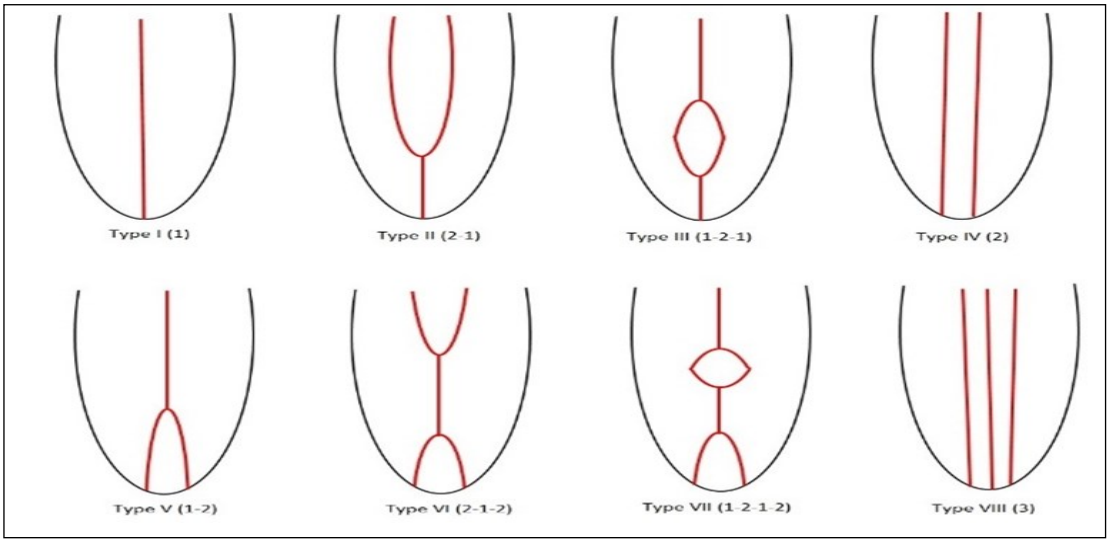

Figure 1: Vertucci's classification of canal morphology.

and 20.27 mAs using a 16 cm × 11 cm field of view.

Data Collection: The images of a routine dental procedure were taken for the preoperative planning of surgical operations and endodontic diagnosis. The age and gender of the patients were also recorded.

Study Design: The inclusion criteria of the study were complete root formation of all teeth without dental restoration and no periapical lesions. In addition, the images that could not be evaluated due to digital image errors were not included in the investigation.

The root canals were studied by an oral radiologist and two endodontists with at least ten years of experience. To calibrate the observers, 10 of the obtained data were randomly selected and examined by two endodontists twice at 10-day intervals. In disagreements, an oral radiology specialist made the final decision. The root canal anatomy of the mesial root was classified due to Vertucci's classification (Figure 1):

Statistical Analysis: The data obtained from the study were analyzed by IBM SPSS Statistics v. 22 software (IBM SPSS, Türkiye). In comparing qualitative data, the chi-square and Fisher-Freeman-Halton exact tests were used with descriptive statistical methods (mean, standard deviation, frequency) and were evaluated at $p < 0.05$. Cohen's kappa coefficient for the interobserver agreement was determined as 0.75.

RESULTS

The study was completed with 905 teeth (339 male, 566 female) with an age range of 16-81 (37 ± 13.88) years. The number of maxillary first molars was 406 (44.9%), and that of second molars was 499 (55.1%). Three hundred ninety-four maxillary molars had an MB2 canal (43.5%). The majority of the teeth (90.4%) had three roots. In addition, 52.3% of the teeth had three root canals, and 44% had four (Table 1).

Table 1: The presence of MB2, and the number of root and root canals.

Maxillary Molar Teeth		**n (%)**
Gender	Male	339 (37.4)
	Female	566 (62.6)
Age	First molar	406 (44.9)
	Second molar	499 (55.1)
	≤20	66 (0.72)
	21 – 30	281 (31.04)
	31 - 40	252 (27.62)
	41 - 50	140 (15.46)
	51 - 60	96 (10.6)
	≥61	70 (7.73)
Presence of MB2	Yes	394 (43.5)
	No	511 (56.5)
Number of Roots	1	29 (3.2)
	2	46 (5.08)
	3	818 (90.3)
	4	12 (1.32)
Number of Root Canals	1	11 (1.21)
	2	23 (2.54)
	3	473 (52.26)
	4	398 (43.97)

Table 2: The prevalence of MB2 canals in maxillary first and second molars by gender.

MB2 Root Canal		**Present n (%)**	**Absent n (%)**	**p**
Gender	Male	167 (49.3)	172 (50.7)	0.007*
	Female	227 (40.1)	339 (59.9)	

Table 3: Association of the presence of MB2 canals in maxillary molars by gender and age groups.

MB2 Root Canal			Present n (%)	Absent n (%)	p
First Molar	Age	≤20	28 (82.4)	6 (17.6)	0.043*
		21-30	73 (57.5)	54 (42.5)	
		31-40	80 (74.1)	28 (25.9)	
		41-50	38 (66.7)	19 (33.3)	
		51-60	27 (64.3)	15 (35.7)	
		≥61	26 (68.4)	12 (31.6)	
Second Molar	Gender	Male	64 (33.3)	128 (66.7)	0.000*
		Female	58 (18.9)	249 (81.1)	

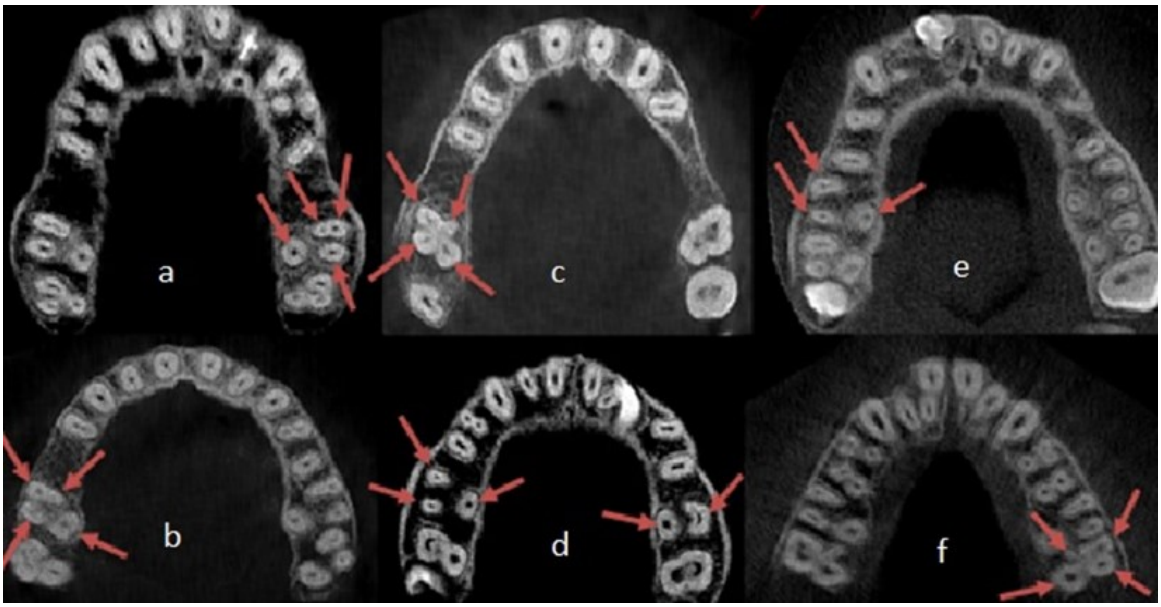

Figure 2: CBCT images of different root canal system morphologies on maxillary molars. a,b,c – four root canals formation, d,e – three and two root canals formation, f – four root canals with additional root formation of permanent maxillary molars.

The prevalence of MB2 canals in males (49.3%) was significantly higher than in females (40.1%) (Table 2), both maxillary first and second molars.

The presence of MB2 also was found to be higher in patients under 20 years (82.4%) compared to the other age groups at maxillary firsts. In contrast, there was no difference in maxillary second molars (Table 3).

When the mesial root canals were evaluated, the most common classification was Type II (42.6%), followed by Type IV (31.5%) and Type III (22.1%). There was a statistical difference between the number of roots of the first and second maxillary molar teeth. While 97.8% of the first molar teeth had three roots, 84.4% of the second molar teeth had three roots. In addition, 7.8% of the second molar teeth had two roots, and 5.6% had one root. Concerning the number of root canals, 66.5% of the first maxillary molar teeth had four root canals, and 68.3% of the second molars had three root canals (Figure 2).

DISCUSSION AND CONCLUSION

Knowledge of the unique root canal anatomy and the MB2 canal is considered a challenge for successfully treating maxillary molars. Locating and cleaning MB2 is essential for a better long-term prognosis.[4,24-27] The presence of MB2 in our study was 43.5% among all maxillary molar teeth. The results of previous studies on this subject vary considerably.

The highest incidences of MB2 were reported by Martins et al.[16] (95.2%), Pèrez-Heredia et al.[24] (86.2%), and Zhang et al.[6] (85.4%). The high percentage findings of a researcher also include Khademi et al.[21] (79.2%). In addition, our findings were similar to Razumova et al.[18] (59.8%). A study reported the lowest incidence rate as 36.3%, when examined worldwide.[27] In another study from Turkey, the same rate was reported by Aydın[25] as 65.27%.

The differences between results may be caused not only by the racial/ethnic diversity of populations but

also by methodological differences in the studies, such as the diagnostic criteria and techniques used, sample size, evaluation methods, and age range. The different CBCT devices with various exposure parameters may also affect the results. Our findings showed that the incidence of MB2 was higher in young patients, especially those under 20 years. Zhang et al.[6] stated that the calcification of root canals and secondary or tertiary dentin formation decreased the detection of MB2 canal access. Therefore, we strongly recommend that clinicians carefully detect MB2 canals, especially in young patients.

In the study, most molar teeth had three roots (90.4%), while 5.1% had two, 3.2% had one, and 1.3% had four. Our results also were similar to other studies regarding the number of roots. The literature also shows that molars have three root canals in more than 90% of individuals.[16-18,21,25,-27]

Regarding the maxillary molars' root canal number, the three-rooted configuration had the highest frequency (52.3%), while 44% had four canals, 2.5% had two, and 1.2% had one root. When the upper molars were evaluated separately, 66.5% of the first molars had four root canals, and 68.3% of the second molars had three. However, 4.2% of the second molars had two root canals. Al Shalabi et al.[28] evaluating an Irish population, reported that 78% of the maxillary first molars had four roots, the highest reported in the literature. To objectively evaluate the differences in these results, we strongly recommend conducting large-scale global studies to evaluate the effect of geographical and ethnic conditions.[26,27]

Many studies in vitro and in vivo investigate the presence of additional root canals at mesiobuccal root in maxillary molars. Results vary considerably, with a higher incidence of MB2 detected in those using in vitro analyses, in which techniques such as clearing technique and sectioning have been utilized to visualize the root canal system.[8] Although microcomputed tomography (μCT) is now accepted as a perfect way to study root canal morphology, and it can only be performed on extracted teeth.[27] CBCT is a powerful tool that can dissect the root canal system in slices of any desired thickness without damaging the tooth.[6] However, despite being the most reliable tool to evaluate the canal anatomy of molars in in-vivo studies, it should be kept in mind that CBCT should only be undertaken in cases where conventional imaging systems do not yield adequate information on root canal anatomy.

According to the findings of our study, the incidence of the MB2 canals was 43.2%, which was significantly higher in males. Three root canals were observed in 66.5% of the maxillary first molars, and 15.7% of the second maxillary molars. When the mesial roots were evaluated according to the Vertucci classification, Type II (42.6%), Type IV (31.5%), and Type III (22.1%), canal formations were significantly more common. There was a difference between the root numbers of the first and second maxillary molars statistically ($p < 0.05$). While 97.8% of the first molars had three roots, 84.4% of the second molars had three. Four-rooted maxillary molars were scarce among the first (0.2%) and second (2.2%).

CBCT is currently used in diagnosing and treating tooth resorption, pathological lesions, detection of perforations, and treatment planning. In addition, CBCT imaging with small voxel sizes before the root canal treatment is strongly recommended if it's possible for an excellent long-term prognosis and treatment quality. Because high-resolution images to be taken at different voxel intervals are more valuable for endodontic diagnosis. However, the method is more expensive than conventional radiographs, and patients receive more radiation.

In conclusion, our results concerning the root anatomy provide comprehensive information about the root canal complex of the Turkish subpopulation and present data that can be compared to other populations.

Ethics Committee Approval: The current study was affirmed by the Ethical Board of the university (Date: 11/01/2022, Decision No: E-10840098-772.02-193). International declarations, guidelines, etc., completed the present study.

Conflict of Interest: No conflict of interest was declared by the authors.

Author Contributions: Concept – EE, KO, TFE; Supervision – EŞ, MG; Materials, Data Collection and Processing – EE, KO, MG; Analysis and Interpretation, and Writing – EE, EŞ, MG.

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