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Prevalence of middle mesial root canal in mandibular molars in an Iranian population: A micro-computed tomography study

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ABSTRACT

Background: Knowledge about the anatomic variations of the root canal system and their prevalence is necessary for clinicians to ideally clean the root canal system. The anatomic complexity of the root canal system is one of the reasons for its inadequate debridement, resulting in residual microorganisms and root canal treatment failure. The present study aimed to evaluate the prevalence of middle mesial root canals in mandibular molars in an Iranian population.

Materials and Methods: The samples in the present descriptive/cross-sectional study consisted of mandibular first and second molars (n = 100, with 50 first and 50 s molars). A convenient sampling method was used to collect samples. The teeth were mounted in gypsum and scanned using a micro-computed tomography unit. The images were reconstructed with software, and the relevant checklist was completed by the observers. The data were analyzed with SPSS v26 using the Chi-squared test at a significance level of $P < 0.05$.

Results: The prevalence of the middle mesial root canal in the present study was 36% for mandibular first molars and 22% for mandibular second molars, with an overall prevalence of 29%. The prevalence of the middle mesial root canal was not significantly different between the first and second mandibular molars ($P = 0.12$). The mean distance between the mesiobuccal and mesiolingual root canal orifices in the teeth with a middle mesial root canal was significantly higher than in those without the middle mesial root canal ($P < 0.001$). In addition, there was no significant difference in the prevalence of the middle mesial root canal between the teeth with and without the second distal root canal ($P = 0.89$).

Conclusion: The prevalence of the middle mesial root canal in the studied population was 29%, which is significant clinically. In addition, the mean distance between the mesiobuccal and mesiolingual root canal orifices in teeth with a middle mesial root canal was higher than that in teeth without this root canal.

Key Words: Mandible, micro-computed tomography scan, molar, root canals, X-ray

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INTRODUCTION

Successful root canal treatment depends on the thorough debridement of the whole root canal space.[1]

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The anatomic complexity of the root canal systems is one of the etiologic factors for its inadequate debridement, resulting in root canal treatment failure due to residual microorganisms.[2] In addition, there is a strong correlation between apical periodontitis and un-debrided root canals.[3] Therefore, thorough knowledge of root canal anatomy is essential for successful root canal treatment.[4]

The mesial root of mandibular molars has a complex anatomy, and a high percentage of communication has been reported between the mesiobuccal and mesiolingual root canals.[5] A separate middle mesial root canal in mandibular molars was reported for the first time by Vertucci and Williams[6] and Barker *et al*.[7] It was then explained by Pomeranz *et al*.[8] in an *in vitro* study on its prevalence, classification, and clinical treatment. The prevalence of the middle mesial root canal has been reported from 0.26% to 53.8% in different studies, depending on the technique used.[9,10] In addition, the prevalence of a double middle mesial canal was reported at 3.3% in one study.[11]

Considering the importance of thorough knowledge about the internal anatomy of mandibular molars by dental practitioners, the limited studies in this field on the Iranian population, especially using the Micro-computed tomography (micro-CT) technique, and the discrepancies in the results of previous studies in this field, the present study was undertaken to:

1. Evaluate the prevalence and morphology of the middle mesial root canal in mandibular first and second molars in an Iranian population using the micro-CT technique
2. Compare the mean distance between the orifices of mesiobuccal and mesiolingual root canals in teeth with and without the middle mesial root canal
3. Compare the frequency percentages of the second distal root canals between the teeth with and without a middle mesial root canal.

MATERIALS AND METHODS

In this cross-sectional descriptive study, the number of samples for each mandibular molar was calculated at $n = 50$. The teeth were collected from eight dental clinics in Isfahan Province, and extracted for reasons other than that for the present study. The age and gender of the samples were unknown. Mandibular molars with a C-shape root canal configuration, calcified root canals, and fused roots were excluded. The samples were disinfected in 1% sodium hypochlorite solution (Golrang, Tehran, Iran) for 10 min and mounted in gypsum (Pardis, Semnan, Iran) in groups of three.

The samples were scanned using a micro-CT unit (LOTUS inVivo, Behin Negareh Co., Tehran, Iran) at kVp = 80, mA = 100, and 40-µm cross-section thickness in 28 min to achieve the best image quality. The images were reconstructed using the LOTUS inVivo-REC software.

The following checklist was completed by two observers, including an endodontist and an oral and maxillofacial radiologist:

1. The presence or absence of a middle mesial root canal in each sample
2. The distance between the orifices of the mesiobuccal and mesiolingual root canals in the axial cross-section on the pulp chamber floor in each sample
3. The presence or absence of the second root canal in the distal root in each sample
4. The morphology of the middle mesial root canal based on the Pomeranz *et al*. classification:[8]
   a. Fin: When the instrument could freely move between the mesiobuccal and mesiolingual root canals
   b. Confluent: When the middle mesial root canal had a separate orifice but joined one of the mesiobuccal or mesiolingual root canals in the apical third
   c. Independent: When the middle mesial root canal had a separate orifice and ended at a separate apical foramen.

When there was disagreement between the two observers, a third observer (an endodontist) was asked to help reach a final agreement. Kappa coefficient was used to evaluate the inter-observer reliability. The distance between the mesiobuccal and mesiolingual root canal orifices was measured in the axial view on the pulp chamber floor with the Image J (Wayne Rasband, USA) software using the ruler tool. The data were analyzed with SPSS v26 (IBM, Armonk, NY, USA). The prevalence of the middle mesial root canal was compared between the first and second molars using the Chi-squared test. The independent *t*-test was used to evaluate the distance between the mesiobuccal and mesiolingual root canal orifices in the presence and absence of the middle mesial root canal. In addition, the Chi-squared test was used to evaluate the relationship between the

presence and absence of a middle mesial root canal and the prevalence of a second distal root canal in the studied population. Statistical significance was set at $P < 0.05$.

RESULTS

The correlation coefficient (kappa) between the observers was 0.71. The prevalence of the middle mesial root canal for mandibular first and second molars was 36% and 22%, respectively, with an overall prevalence of 29%. The prevalence of the middle mesial root canal was not significantly different between the mandibular first and second molars ($P = 0.12$). In addition, one case of double middle mesial root canal was detected in one mandibular first molar [Figures 1 and 2].

Figure 1: The micro-computed tomography axial cross-section of a mandibular molar with a middle mesial root canal.

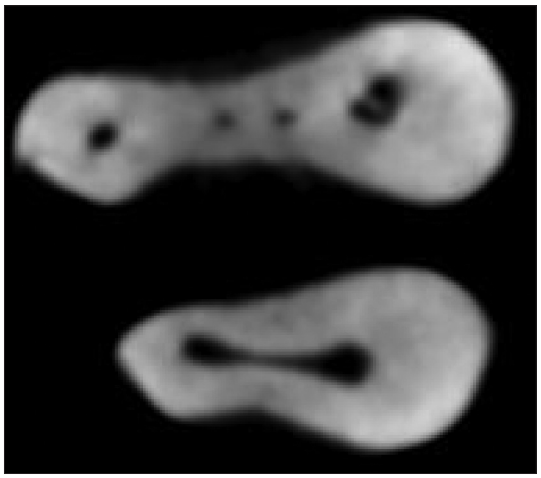

Figure 2: The micro-computed tomography axial cross-section of a mandibular first molar with a double middle mesial root canal.

Concerning the morphology of the middle mesial root canal, the percentages of confluent, fin, and independent root canal configurations were 78.9%, 15.6%, and 5.5%, respectively [Table 1].

The mean distance between the mesiobuccal and mesiolingual root canal orifices in teeth with a middle mesial root canal was 3.60 ± 0.24 mm, and 3.19 ± 0.30 mm in teeth without the middle mesial root canal. This was significantly greater between the two canal orifices in teeth with a middle mesial root canal ($P < 0.001$).

The prevalence of the middle mesial root canal in teeth with the second distal root canal was 28%, and 29.3% in teeth without the second distal root canal, with no significant difference ($P = 0.89$).

DISCUSSION

Knowledge about the morphology of the root canal system significantly affects root canal treatment outcomes.[12] Therefore, before undertaking root canal treatment, the clinician should have adequate knowledge about the pulp morphology of the tooth in question.[13] Inadequate cleaning or obturation of a part of the root canal system results in partial elimination of the irritants, resulting in treatment failure and perpetuation of symptoms and signs of the patient.[14]

The prevalence of the middle mesial root canal has been reported in 0.26%–53.8% of the cases in different studies. These findings have been achieved using the cone-beam computed tomography (CBCT) technique and dental microscopes. Different prevalence rates have been reported for the middle mesial root canal in European, Asian, African, North American, and South American populations.[9,11] Versiani *et al.*[15] evaluated the middle mesial root canal using the micro-CT technique, reporting a higher prevalence in the Brazilian population than in the Turkish population. Wang *et al.*[16] studied a Chinese population using the CBCT technique, reporting a 2.6% prevalence for the middle mesial root canal. Azim *et al.*[17] used the

Table 1: The percentages of different morphologies of the middle mesial root canal for each tooth type

Tooth type	Fin (%)	Confluent (%)	Independent (%)
First molar	22.2	66.7	11.1
Second molar	9.1	90.9	0
Total	15.6	78.9	5.5

guided troughing technique to study a North American population and reported the presence of middle mesial root canal in 46% of the samples. Navarro *et al*.[18] used electron microscopy to study the morphology of mandibular first molars in an European population, reporting a 12% prevalence for middle mesial root canal. Hosseini *et al*.[19] studied 200 mandibular first molars in an Iranian population using the CBCT technique, reporting middle mesial root canals in 9% of the samples. In addition, Hasheminia *et al*.[20] studied 768 CBCT images of mandibular first molars in an Iranian population and reported a prevalence of 3.13% for the middle mesial root canal, with one-third of the cases being separate root canals extending from the root canal orifice to the root apex.

Initial studies only reported the independent morphological type.[6,21] However, after the introduction of the Pomeranz *et al*. classification,[8] other morphological types were evaluated and reported. de Pablo *et al*.[22] reported a similar prevalence for the independent and confluent types in the apical third. Pomeranz *et al*.[8] showed a higher rate for the fin morphological type than the confluent. The most common morphology for the middle mesial root canal has been reported to be confluent.[11] Fabra-Campos[23] reported that the incidence of confluent configuration was higher than fin or independent configurations. According to Versiani *et al*.,[15] the confluent configuration can be with or without an isthmus connecting to the main root canals (mesiobuccal or mesiolingual) from mid-root to the apex. They reported that the most common morphology was the confluent type. de Toubes *et al*.[24] indicated that 54% of middle mesial root canals merge with the mesiobuccal canal and 38% merge with the mesiolingual canal.

New technologies, including dental microscopes and loupes, allow higher magnifications possible and provide better access to the root canal.[25] In addition, 3D imaging techniques such as CBCT have been suggested as a reliable method to evaluate extra root canals and unusual morphologies.[26] A comparison of different techniques used in different morphological studies showed that the most commonly used technique is the *in vitro* clearing technique.[11,27,28] However, recent studies have mostly used 3D techniques such as CBCT and micro-CT.[4,29] The micro-CT technique was developed in the early 1980s. This technique allows the possible use of a sample for different tests without destroying its structure.[30] A recent study showed that the findings provided by the micro-CT technique are similar to histologic findings.[31] In addition, this technique can be used in anatomic studies for quantitative measurements of hard tissues such as enamel, dentin, or bone or changes after root canal instrumentation.[32]

Micro-CT was used in the present study due to its high accuracy in identifying the middle mesial root canal and its morphology. It is a non-invasive and repeatable technique. It can be used to evaluate fine anatomic structures and 3D reconstruction due to its high spatial resolution and small voxel sizes. It provides more detailed data than the clearing, sectioning, and digital radiography techniques.[15] However, it cannot be applied clinically due to its high cost, long exposure time, and high radiation dose.[30]

Several studies using the CBCT technique have reported a lower prevalence of the middle mesial root canal than the present study.[15,33] This can be attributed to differences in the populations studied and the lower efficacy of the CBCT technique in identifying and evaluating fine anatomic structures due to insufficient spatial resolution, artifacts due to metallic objects, and higher slice thickness. CBCT images have a higher content of scattered radiation due to the cone shape of the X-ray beam and a flat detector panel. A larger width of the X-ray in the CBCT technique results in non-homogeneous distribution of the X-ray intensity in different areas. In addition, the penetration of X-ray through solid structures increases the mean energy of the X-ray bundles, resulting in beam hardening.[34]

In the present study, the distance between the mesiobuccal and mesiolingual root canal orifices was measured and compared. This helps clinicians estimate the possibility of the presence of a middle mesial root canal by considering the distance between the two mesial root canals. The present study showed that, unlike the study by Weinberg *et al*.,[33] the distance between the orifice of the two main mesial root canals in teeth with a middle mesial root canal was significantly higher than the teeth without the middle mesial root canal. The difference in results between these two studies might be due to the differences in populations, the imaging technique used and the greater number of samples in the present study. In addition, the present study showed no significant difference in the prevalence of the middle mesial root canal between teeth with and without the second distal root canal, which was consistent with two previous studies.[8,35] However, Sherwani *et al*.[36] reported a higher prevalence of middle mesial

root canals in mandibular first molars with two distal root canals than those with one distal root canal. This difference might be attributed to differences in populations, the study procedures and a larger sample size in Sherwani *et al*. study.

The middle mesial root canal can be located equidistant from the main canals or it can be closer to one of the main canals. Sherwani *et al*.,[36] in an Indian population, reported that most of the middle mesial root canals were located at the center of the main canals. In contrast, in Karapinar-Kazandag *et al*.[37] study, a higher number of middle mesial root canals were closer to one of the main canals. de Toubes *et al*.[24] observed that the majority of the middle mesial root canals were located closer to the mesiobuccal canal. However, Nosrat *et al*.,[35] in a North American population, reported that most of the middle mesial root canals were identified closer to the mesiolingual canal.

A number of studies have reported a higher rate for the prevalence of middle mesial root canals in mandibular second molars.[17,37] Nevertheless, many previous studies have reported a higher prevalence for the middle mesial root canal in mandibular first molars compared to second molars, which is consistent with the present study.[29,38]

All in all, to gain access to the middle mesial root canal in mandibular molars, the area between the mesiobuccal and mesiolingual root canals should be carefully searched with hand instruments or ultrasonic tools using magnification by dental loupes or microscopes. First, the pulp chamber root and wall irregularities should be removed for proper visualization and access. Then, a 1–2 mm-deep fissure should be created with low taper ultrasonic tips or a round bur with a long shank under magnification with a dental microscope to locate the middle mesial root canal orifice. However, in some cases, it is not possible to gain access to the middle mesial root canal in the coronal third, and advancing for more than 2 mm weakens the root in the danger zone and increases the risk of iatrogenic perforation of the root.

CONCLUSION

According to the results of the present study, the overall prevalence of the middle mesial root canal in mandibular first and second molars in an Iranian population was 29%. In addition, the mean distance between the orifice of the mesiobuccal and mesiolingual root canals in teeth with a middle mesial root canal was higher than in teeth without this root canal.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

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