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ORIGINAL RESEARCH ARTICLE

The Prevalence of Radix Paramolaris and Entomolaris in Mandibular Molar Teeth: A Retrospective Study

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Abstract

Purpose: This study aims to analyze the frequency of radix paramolaris (RP) and radix entomolaris (RE) in the mandibular first and second molars using cone-beam computed tomography (CBCT).
Materials & Methods: The CBCT images of 400 patients at the ages of 14 to 66 were included in the study. On the included images, two maxillofacial radiologists simultaneously examined the presence of RP and RE by using axial CBCT cross-sections from the crown down to apical.
Results: The prevalence of at least one RE or RP was 9% (36/400). RP was found in 1.25% (n = 20) of the teeth. Of these, two cases were bilateral, and 16 unilaterally occurred. RE was detected in 2.38% (n = 38) of the teeth, with 11 bilateral and 16 unilateral cases. The prevalence of at least one RE or RP was 10.7% (16/149) for males and 8% (20/251) for females. No statistical sex-related and side-related difference ($p > 0.05$) was detected for the prevalence of RP and RE.
Conclusion: The study confirms a 9% prevalence of at least one root variation (RP or RE) in permanent mandibular molars in a Turkish subpopulation. Clinicians need to be aware of such anatomical variations in the number of roots since they can complicate root canal treatments and tooth extractions.

Key words: cone-beam CT; mandibular molar; root canal morphology; radix entomolaris; radix paramolaris

Introduction

Clinicians' knowledge of variations in tooth anatomy provides essential support for diagnosis and treatment. The determination of variations in tooth roots is one of the most fundamental factors affecting the success of endodontic treatment.[1] Due to broad variations in tooth anatomy, the prognosis of endodontic treatment is influenced by the anatomy and morphology of the root canal system.[2] Necrotic tissue residues remaining inside root canals due to failure in determining extra roots and root canals may lead to periapical pathologies.[3] Therefore, having full knowledge of root and root canal anatomy and their possible anatomical variations will help reduce endodontic failure caused by incomplete debridement and obturation.[4]

The mandibular molars usually have two roots, including one in the mesial and one in the distal.[5,6] The presence of a third extra root is a significant anatomical variation. The third root in mandibular molar is found in two forms: Radix paramolaris (RP) and Radix entomolaris (RE).[7] An extra root located on the distolingual position of the mandibular molar is called RE, and the mesiobuccally located one is termed RP.[7,8] There are also reports in the literature where mandibular first and second molars with four roots have been encountered. These reports have described four-rooted mandibular first and second molars consisting of two mesial and two distal roots, where each one of the four roots has an independent root canal.[9,10]

These variations in distal root anatomy can be identified by careful examination of angled radiographic images.[3] In their study, Slowley mentioned the difficulty of determining extra canals and roots.[3] Conventional and digital two-dimensional imaging techniques used in evaluating root morphology may be insufficient in determining the presence of extra roots. Cone-beam computerized tomography (CBCT) imaging is an advanced technique that allows excellent three-dimensional images of dental hard tissues

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and osseous structures. CBCT scans provide three-dimensional information, they demonstrate the radiology of roots, pulp chambers, and pulp canals more accurately than other two-dimensional radiography techniques. [11]

In line with this information, our study examined root variations in mandibular first and second molars by utilizing CBCT data. This study aims to reveal the frequency of root variations and to compare different root morphologies in mandibular first and second molars with the literature.

Materials and Methods

The Institutional Review Board of ankara University Faculty of Dentistry approved the protocol of this retrospective study (No: 36290600/54/2021). This study retrospectively analyzed CBCT records of approximately 1500 patients who applied for various reasons during the 2017-2020 period. Images in which crown-root anatomy could not be observed fully and clearly, teeth with any periapical pathology causing root resorption, teeth with root canal treatment, crown-bridge prostheses and, CBCT images were unclear and impaired were excluded from the analysis. Patients aged 14 years and older who had bilaterally erupted first and second molar with completely developed root were included the study. A total of 400 cases were evaluated. The images included in the study were reviewed by two maxillofacial radiologists simultaneously with consensus.

Presence of RP and RE; examined from the crown down to apical using axial CBCT sections(Figure 1-2) and 3D reconstruction (Figure 3-4). All exposure parameters for the images obtained are presented in Table 1.

All images were generatedwith the Promax 3D Max (Planmeca, Helsinki, Finland) CBCT device. The images were evaluated in a dimly lit room on a 15-inch Toshiba Qosmio monitor (Toshiba, Tokyo, Japan) set at a resolution of 1920 × 1080 and a color depth 32-bit.

Descriptive statistics were calculated. Statistical analysis was performed with SPSS software (ver.20, IBM SPSS Inc., New York, NY, USA). The chi-squared test was used for comparisons of categorical variables. A level of $p < 0.05$ was accepted as statistically significant.

Results

A total of 400 patients (251 female and 149 male) between the ages of 14 to 66 (mean age: 25.95) were included in the study. The prevalence of at least one RE or RP was 9% (36/400). RP was found in 1.25% (n = 20) of the teeth. Of these, two cases were bilateral, and 16 unilaterally occurred. RE was detected in 2.38% (n = 38) of the teeth, with 11 bilateral and 16 unilateral cases. While there were 5 teeth observed to have 4 roots including both RE and RP, 1 of these teeth was a first molar, and 4 were second molars. These four-rooted teeth were categorized in both the RE and RP classes in the statistical analysis. The prevalence of at least one RE or RP was 10.7% (16/149) for males and 8% (20/251) for females. A chi-squared test was performed to examine the relationship between sex and third root variation type. There was no statistically significant difference between third root variations and sex ($p = 0.35$) Table 2.

When RP and RE were assessed according to the teeth type, the relationship between tooth type (first molar or second molar) and root variation type was statistically significant ($p < 0.0001$) The frequency distribution of the number of teeth according to tooth type was presented in Table 3. RP has been seen more in mandibular second molars, whereas RE was more common in mandibular first molars. REs were most frequently detected on the right side of the mandible, while RPs were most commonly found on the left side. However, no significant side-related difference was detected ($p = 0.27$). The results were presented in detail in Table 4.

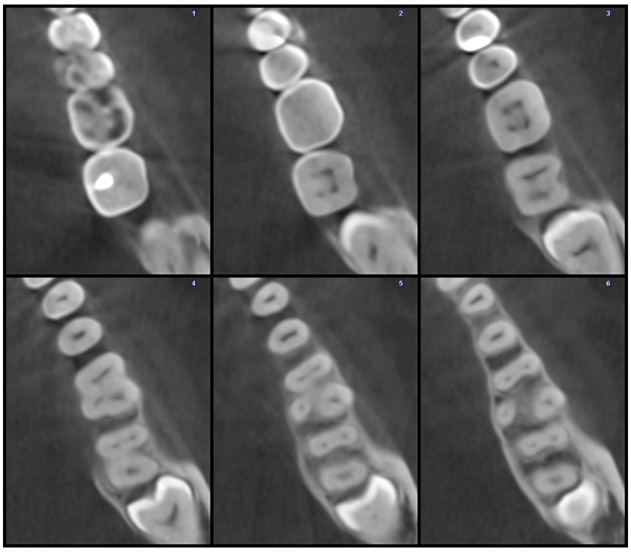

Figure 1. Radix entomolaris in the left mandibular first molar, axial CBCT section

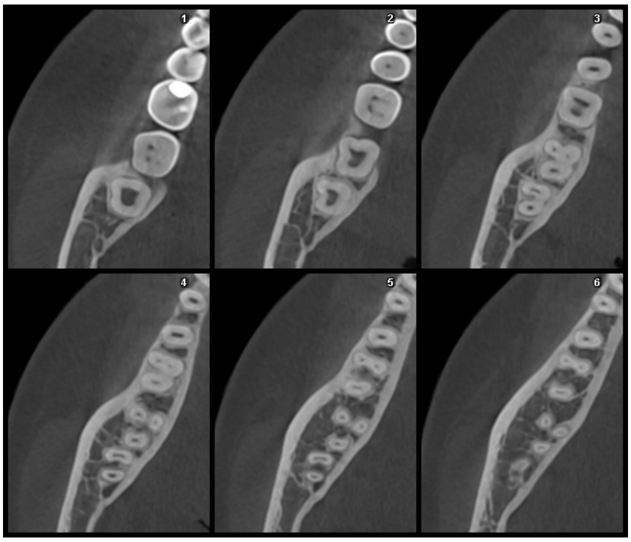

Figure 2. Radix paramolaris in the right mandibular second molar, axial CBCT section

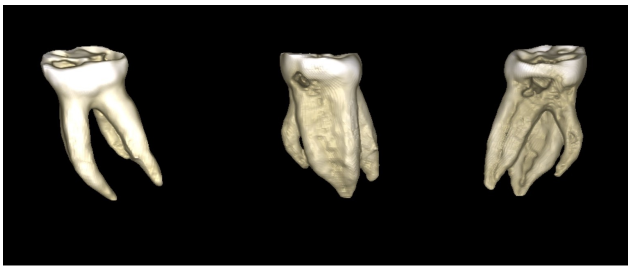

Figure 3. 3D volume reconstruction of the tooth with radix entomolaris (buccal,mesial and distal view)

The unilateral and bilateral distribution of root variations (RP or RE) was presented in Table 5. ($p = 0.032$). Accordingly, unilateral occurrence of both RE and RP was found more frequently. In addition, when RE and RP are compared with each other, RE tends to be more bilateral than RP, and this difference was statistically significant.

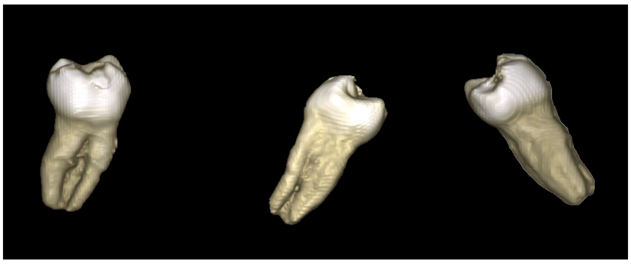

Figure 4. 3D volume reconstruction of the tooth with radix paramolaris (buccal,mesial and distal view)

Table 1. Minimum and maximum exposure parameters.

Parameters	Minimum	Maximum
FOV*	130 x 55 mm	230 x 260 mm
kVp	96 kVp	96 kVp
mA	10 mA	10 mA
s	12.002 s	9.161 s
DAP*	1098 mGyxcm2	2224 mGyxcm2

*FOV: Field of View *DAP: Dose Area Product

Table 2. Frequency distribution and percentage of the root variations according to sex in mandibular permanent molars

Sex	Molars with additional roots N (%)	Radix Paramolaris n (%)	Radix Entomolaris n (%)
Female	20 (8%)	11 (1.1%)	16 (1.6%)
Male	16 (10.7%)	9 (1.5%)	22 (3.7%)
Total	36 (9%)	20 (1.25%)	38 (2.38%)

N; number of patients, n; number of teeth, %; frequency

Table 3. Frequency distribution and percentage of the number of teeth according to tooth type in mandibular permanent molars

Teeth Type	Radix Paramolaris n (%)	Radix Entomolaris n (%)	Both RP and RE n (%)
First molar	1 (6.7%)	26 (78.8%) *	1 (20%)
Second molar	14 (93.3%) *	7 (21.2%)	4 (80%)
Total	15 (100%)	33 (100%)	5 (100%)

* Statistically significant differences ($p < 0.0001$)by Chi-square test n number of teeth, % frequency,

Table 4. Distribution of root variation according to side

	Radix Paramolaris n (%)	Radix Entomolaris n (%)
Right	8 (40%)	21 (55.2%)
Left	12 (60%)	17 (44.8%)
Total	20 (100%)	38 (100%)

n number of teeth, % frequency

Discussion

It is thought that there may be a relationship between the prevalence of RE and the geographic location of a particular population. Still its etiology has not yet been fully elucidated.[12] The fact that the prevalence of this variation is low (1-5%) in Europe, Africa, and Caucasia populations and high (5-40%) in Mongolia, Chinese, Eskimo or Native American populations may suggest that race-related factors are effective on dental morphology.[13,19] Its prevalence in the white (Caucasian) population has been reported to vary between 3.4% and 4.2%.[20] Few studies have reported the prevalence of RP. These studies reported that the incidence of radix paramolaris in mandibular molars is low and almost rare.[16,21] There seems to be much less attention paid to determining the incidence of RP compared to RE, mainly because the incidence of RP is low or rare.[21,22] Several other studies have determined the prevalence of 3 roots in mandibular molars without specifying root type (RE or RP).[18] Besides, in studies reporting the prevalence of root variations in mandibular molar in the Turkish population, this prevalence has been reported as 2.06-4.6% in the mandibular first molars and 2.1-3.45% in the mandibular second molars.[14,23,24](Table 6) In our study, we examined the prevalence of three-rooted mandibular permanent molars in Turkish individuals by utilizing CBCT images. The number of teeth found to have RE or RP was 58, or 3.625%. This result is compatible with previous studies in Turkish populations in the literature.

Table 5. Number and percentage of patient with additional roots in mandibular first and second molars by unilateral and bilateral status

	Radix Paramolaris n (%)	Patients with Radix Entomolaris n (%)
Bilateral	2 (11.1%)	11 (40.7%) *
Unilateral	16 (88.9%) *	16 (59.3%)
Total	18 (100%)	27 (100%)

* Statistically significant differences ($p < 0.05$) by Chi-square test n number of patient, % frequency

The presence of supernumerary roots can be detected with two-dimensional periapical radiography images obtained with different angles. This way, the superposition of the distobuccal root, which is larger can be prevented.[25] However, the fact that the root anatomy has a complex structure makes it challenging to distinguish supernumerary roots in the 2-dimensional images of a 3-dimensional structure.[26] CBCT provides observers with the opportunity of a more accurate observation by eliminating superpositions as opposed to the case of other two-dimensional imaging methods.[27] In addition to this, Souza-Flamini et al.[28] stated that micro-CT could be used in obtaining a large set of morphometric data in the assessment of 3-rooted mandibular molar teeth. However, micro-CT has disadvantages such as the small number of teeth that can be examined, high cost, high radiation dose, and long evaluation time.

In the study by Shemesh et al.[15] examined the prevalence of 3 and 4 roots in mandibular molar in Israeli population. The researchers reported the bilateral prevalence of 3-rooted teeth as 26%. In the same study, bilaterally present RE and RP rates were 34.8% and 17.4%, respectively. In some studies, the prevalence of bilaterally RE varied in the range of 50-67%.[29,30] However, Suyambukesan and Peruma reported no observation of the bilateral occurrence of RE.[31] In our study, while RP was found bilaterally in 11.1% (2/18) of the patients, RE was found bilaterally in 40.7% (11/27) of the patients. According to the data obtained in our study, when RE and RP were compared with each other, the tendency of RE to be bilateral compared to RP and the tendency of RP to be unilateral compared to RE were significantly higher.

In the literature, the prevalence of RE in mandibular first molars has been reported between 3% and 40% in different populations.[32] In mandibular second molars, the prevalence of RE is much lower.[22] Moreover, it was reported that the prevalence of RP is higher in mandibular second molars than in mandibular first molars.[22] In a study by Felsypremila et al.[16] they examined 299 mandibular first molars and 322 mandibular second molars by CBCT. The prevalence of RE was found as 5% and 0.9% in mandibular first and second molars, respectively. In the same study, the prevalence of RP was

Table 6. Prevalence of three-rooted mandibular molars in different ethnic groups.

			First molars		Second molars	
Population	Year	Method	Teeth, n	Three rooted, n(%)	Teeth, n	Three rooted, n(%)
Taiwanese [8]	2009	CBCT	246	63(%25.61)		
North Indian [12]	2017	Periapical	1000	83(%8.3)		
Iranian [13]	2017	CBCT	386	12(%3.10)		
Turkish [14]	2013	CBCT	173	8(%4.6)	235	5(%2.1)
Israeli [15]	2015	CBCT	1229	32(%2.6)	1465	26(%1.78)
Indian [16]	2015	CBCT	299	17(%5.7)	322	8(%2.5)
Chinese [17]	1988	Extracted teeth	100	15(%15)		
Taiwanese [18]	2007	Periapical	166	35(%21.09)		

0.7% in the mandibular first molars and 1.5% in the mandibular second molars. Martins et al.[33] found the prevalence of third roots as 2.2% and 2.7% in mandibular first molars and second molars. They reported that RE was significantly more frequent in mandibular first molars. Similarly, 15 RPs were detected, and 14 of these (1.75%) were in the mandibular second molars, whereas 33 REs were found, and 26 of these (3.25%) were in the mandibular first molars in this study. However, the third root prevalence was higher in this study, which was found as 3.6% in both mandibular first and second molars. In contrast, some studies reported that RP was more frequent in mandibular first molars.[21,34]

The study conducted on periapical and panoramic radiographic images by Rozylo et al.[35] found no significant difference between the prevalence of third root variations based on their localization on the right and left sides. In contrast, de Moor et al.[32] reported that the prevalence of RE on the left side was higher than on the right side. Some studies on Hispanic, Taiwanese, and Chinese populations have provided data demonstrating a higher prevalence of third root variations on the right side of the mandible.[8,17,29,36] In this study, there was no significant difference between the numbers of both RP and RE according to sides.

It is not very likely to talk about a relationship between sex and the prevalence of third root variations. Some previous studies have reported that sex did not affect the prevalence of third root variations.[8,13,15,18,32] Similarly, there was no significant relationship between the prevalence of RP or RE and sex.

There are several limitations in this study. Since it is a retrospective study, clinical data are not included. Root morphologies in the mandibular molars were determined only by CBCT imaging. More accurate results can be obtained from clinical and CBCT examinationsafter of teeth extraction with indications for extraction. Micro-CT imaging can provide many morphometric data to evaluate three-rooted mandibular molars. However, all methods have their advantages-disadvantages, and limitations.

Conclusion

Consequently, while the prevalence and type of third root variations differ between different populations, RE is seen more frequently in mandibular first molar teeth, and RP is seen more frequently in mandibular second molar teeth. The prevalence of RE in mandibular molar teeth is higher than that of RP. Clinicians should be aware of these unusual root morphologies in mandibular molars. Knowing the differences in root morphology before invasive procedures such as root canal treatment and extraction will prevent possible mistakes and increase the success rate of treatments.

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Author Contributions

Study Idea / Hypothesis: M.H.K. Study Design: H.E. Data Collection: S.T.G., M.O., E.S. Literature Review: M.H.K., H.E., S.T.G., M.O. Analysis and / or Interpretation of Results: H.E., H.P.O. Article Writing: M.O., S.T.G. Critical Review: M.H.K., H.P.O

Conflict of Interest

Authors declare that they have no conflict of interest.

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