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Prevalence of radix entomolaris and radix paramolaris in mandibular first and second molars in a Turkish population

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Abstract

Aim: This retrospective study determined the prevalence and distribution of extra roots (radix entomolaris [RE] and radix paramolaris [RP]) in mandibular first and second molars in a southeastern Anatolian Turkish population using cone-beam computed tomography (CBCT).

Methodology: A total of 2010 mandibular first and second molars from the archived CBCT images of 662 patients (325 males, 337 females) were evaluated for the associations of RE and RP with sex, side, molar type, and unilateral/bilateral presence. Fisher's exact test was used for categorical comparisons and McNemar's exact test for the paired right-left comparison at patient level; prevalences are reported with Wilson score 95% confidence intervals, and the 24 pairwise post-hoc comparisons were corrected for multiplicity by the Holm procedure.

Results: An extra root was detected in 3.7% of the examined teeth (75/2010, 95% CI 3.0-4.7%) and 9.5% of the patients (63/662, 95% CI 7.5-12.0%). Prevalence did not differ significantly by sex (8.9% [29/325] in males versus 10.1% [34/337] in females, $p = 0.61$), side (McNemar exact $p = 0.16$), or unilateral/bilateral presence ($p = 1.00$). Although the overall per-tooth prevalence was similar in first and second molars (3.9% versus 3.6%, $p = 0.73$), the distribution of root type among the 75 affected teeth differed significantly (Fisher exact $p = 0.002$). RP was the most frequent type in both first (1.95%, 19/974) and second (3.09%, 32/1036) molars but exceeded RE significantly only in the second molars (RE 4/1036, $p < 0.001$; first molars RE 14/974, $p = 0.49$). Among the affected teeth, RP was relatively more common in the second molars (Holm-adjusted $p = 0.025$), whereas the excess of RE in the first molars did not survive correction for multiple testing (Holm-adjusted $p = 0.26$).

Conclusion: The presence of extra roots in mandibular molars within the Turkish population is a key variation for access cavity preparation in endodontics. The different distributions of these roots between the first and second molars emphasize the need for a thorough pre-treatment radiographic assessment.

Keywords: Cone-beam computed tomography, root canal anatomy, prevalence, tooth abnormalities, radix entomolaris, radix paramolaris

Introduction

The success and long-term prognosis of endodontic therapy fundamentally depend on a comprehensive understanding of the root canal system. Recognizing the intricate anatomical and morphological variations within teeth is crucial, as failure to identify and treat anomalies such as supernumerary roots or additional canals can lead to persistent periapical infections, ultimately resulting in treatment failure and tooth loss. Consequently, a clinician's profound knowledge of both typical dental morphology and its potential deviations is indispensable for achieving effective treatment outcomes (1).

Mandibular molars typically present with two roots—one mesial and one distal—which together house three root canals (2). However, the presence of a third root is a notable anatomical variation influenced by factors such as ethnic background and individual genetic predispositions (3). This supernumerary root was first documented by Carabelli in 1844 (4). Subsequently, in 1915, Bolk coined the term radix entomolaris (RE) to describe an additional root located on the distolingual aspect of the tooth (5). In contrast, an extra root found on the buccal or mesiobuccal surface is termed radix paramolaris (RP) (6).

It is well-established that these morphological variations are associated with a range of factors, including the patient's age, sex, ethnicity, and even geographic origin (7). Correspondingly, research across diverse populations has demonstrated significant variability in the prevalence of these third roots. For instance, a third distolingual root has been reported in 13% of mandibular first molars in a Thai population (8), and three roots in 2.06% of first molars and 3.45% of second molars in a Turkish cohort (9), while a low frequency of three-rooted molars has been reported in a Brazilian population (10). These structural discrepancies have direct clinical implications, as they can complicate disinfection procedures by providing niches for microbial persistence within the root canal system.

From a clinical standpoint, the presence of supernumerary roots holds significant implications for both periodontal and endodontic management. The formation of an additional furcation area by RE or RP can enhance dental biofilm accumulation, thereby increasing the risk of localized periodontal disease (11). Moreover, these extra roots often present endodontic challenges; for example, REs are frequently shorter and more acutely curved than primary roots and may be either separate from or fused to other roots, necessitating meticulous treatment planning and execution (12, 13).

Various diagnostic modalities have been employed to visualize root and canal morphology, including conventional radiography (14, 15), in vitro studies (16), computed tomography (CT) (17), and cone-beam computed tomography (CBCT) (9, 18). Among these, CBCT is widely recognized in the literature for providing superior accuracy in the assessment of the root canal system. Its primary advantage lies in the ability to generate three-dimensional reconstructions, which can be viewed in the sagittal, axial, and coronal planes, allowing for detailed cross-sectional analysis that is not possible with two-dimensional imaging (9, 18).

The inherent anatomical complexity of root canal systems presents a formidable clinical challenge to achieving the biological goals of endodontics, namely, thorough debridement and disinfection. A lack of awareness regarding morphological variations, compounded by the limitations of conventional diagnostic imaging, can lead to misdiagnosis or oversight of these structures. Consequently, untreated extra roots and canals often result in persistent infections and treatment failure. Subsequent retreatments may introduce iatrogenic complications, including excessive removal of the tooth structure, which predisposes the tooth to fracture and eventual extraction.

Therefore, the objective of the present study was to utilize CBCT to determine the prevalence of RE and RP in the mandibular first and second molars in a Turkish subpopulation. This investigation also aimed to comprehensively analyze the association of these variations with patient sex, arch side (right/left), unilateral versus bilateral occurrence, and molar type (first versus second). This study was designed to test the following four null hypotheses:

- **H_{01}:** There will be no significant difference in the distribution of extra root presence and types (RE and RP) between the sexes.
- **H_{02}:** The prevalence of extra roots will not differ significantly based on tooth type (#36, #37, #46, #47) or molar type (first and second molars).
- **H_{03}:** There will be no significant difference in the distribution of extra roots between the right and left sides.
- **H_{04}:** Unilateral and bilateral distributions of extra roots will not show a significant difference with respect to sex or tooth type.

Materials and Methods

Ethical approval

This study was conducted as a retrospective analysis of cone-beam computed tomography (CBCT) images obtained between 2018 and 2025 from the archival database of the Department of Oral and Maxillofacial Radiology at the Faculty of Dentistry, Dicle University. This study exclusively utilized pre-existing clinical data, and no new images were acquired from patients. A standard informed consent form had been obtained from all patients prior to their original CBCT examinations. The entire research protocol adhered to the principles outlined in the Declaration of Helsinki of 1964 and its subsequent amendments. Formal approval was granted by the Local Ethics Committee of the Faculty of Dentistry, Dicle University (Protocol No: 2025-39).

Sample size calculation

An a priori power analysis was performed using G*Power software (version 3.1.9.7; Heinrich Heine University, Düsseldorf, Germany) to determine the required sample size. Based on the prevalence rates of RE and RP reported in a previous study (19), the calculation indicated that a minimum of 1494 teeth would be required to achieve a statistical power of 95% (1−β) with a significance level (α) set at 0.05.

Retrospective image acquisition

All CBCT scans were acquired using an I-CAT Vision system (Imaging Sciences International, Hatfield, PA, USA). The standardized exposure parameters were 120 kVp and 5 mA, with a scan duration of 8.9 seconds. The scans captured a 16 × 13 cm field of view and were reconstructed into axial slices with a thickness of 0.3 mm and an isotropic voxel size. The resulting image data were archived in the Digital Imaging and Communications in Medicine (DICOM) format.

Inclusion and exclusion criteria

The selection of images for this study was governed by the following criteria.

The inclusion criterion was the presence of at least one fully erupted mandibular first or second molar on CBCT scans.

Exclusion criteria: Images were excluded if the teeth exhibited immature root apices, any form of root resorption, root fractures, or the presence of metallic restorations that could compromise the image quality. Furthermore, scans with significant artifacts that obscured the anatomical details were also excluded. The presence of systemic diseases, oral pathologies (such as caries or periodontitis), or a history of dental procedures did not constitute grounds for exclusion, provided that the root's structural integrity was intact and the overall image clarity was not reduced.

Image examination and evaluation

An initial pool of 1050 CBCT scans was screened, from which 662 patients (325 males, 337 females) who met the inclusion criteria were selected. This yielded a final sample of 2010 mandibular molar teeth for analysis (493 first molars (#36), 510 second molars (#37), 481 first molars (#46), and 526 second molars (#47)). Two experienced endodontists independently evaluated the CBCT images, examining the coronal, sagittal, and axial planes to identify anatomical features from the pulp chamber floor to the root apex (Figs. 1 and 2). Any discrepancies in their findings were resolved by consulting a third endodontist to reach a final consensus. For each tooth, the presence or absence of an extra root was recorded, and if present, it was classified as either RE or RP. These morphological findings were then correlated with variables including patient sex, tooth location, molar type (first/second), and unilateral or bilateral presentation for statistical analysis.

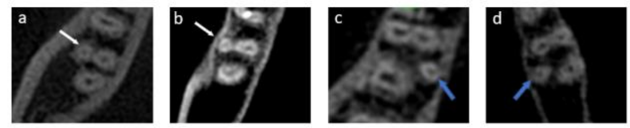

Figure 1. Axial CBCT images of three-rooted mandibular molars; (a-b) RP in the left mandibular second molar (white arrows), (c-d) RE in mandibular first molars (blue arrows).

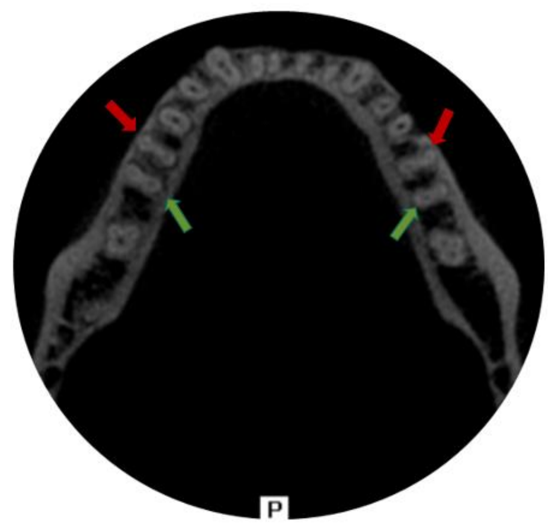

Figure 2. Axial CBCT image of the mandible showing bilateral mandibular molars with extra roots; RP in the mandibular first molars (red arrows) and RE in the mandibular first molars (green arrows).

Statistical analysis

All collected data were statistically analyzed using SPSS 25.0 software (IBM Inc., Armonk, NY, USA). Descriptive statistics are reported as frequencies (n) and percentages (%). The chi-square test of association was used to compare proportions between groups; when an expected cell count was below five, Fisher's exact test was used instead. A p value < 0.05 was considered statistically significant, and exact p values are reported throughout. All prevalences are accompanied by 95% confidence intervals calculated using the Wilson score method, and each percentage is identified as either a per-tooth or a per-patient value. Because the right and left sides are paired within patients, side comparisons were performed at the patient level using McNemar's exact test. The 24 pairwise post hoc contrasts denoted by superscript letters in Tables 2 and 3 were adjusted for multiple comparisons using the Holm step-down procedure.

Results

Out of the 2010 mandibular molar teeth analyzed, a supernumerary root was identified in 75 teeth, corresponding to an overall per-tooth prevalence of 3.7% (75/2010, 95% CI 3.0-4.7%). At the patient level, 63 of the 662 patients were affected (9.5%, 95% CI 7.5-12.0%). The remaining 1935 teeth (96.3%) exhibited a normal root configuration. No statistically significant association was found between the presence of extra roots and patient sex; they were observed in 40 teeth from 34 female patients (53.3% of affected teeth) and 35 teeth from 29 male patients (46.7% of affected teeth). At the patient level, the prevalence of an extra root was 10.1% in females (34/337, 95% CI 7.3-13.8%) and 8.9% in males (29/325, 95% CI 6.3-12.5%), a non-significant difference (x^2 = 0.26, df = 1, p = 0.61; Fisher's exact p = 0.69). Similarly, among the 75 teeth that had an extra root, the distribution of the specific root types (RE, RE/RP, and RP) did not differ significantly between the sexes (Table 1) (Fisher's exact p = 0.099).

A significant association was found between the type of extra root and the molar class (first vs. second) among the 75 affected teeth (Fisher's exact p = 0.002) (Table 2); the overall per-tooth prevalence of an extra root, however, did not differ between first molars (3.9%, 38/974, 95% CI 2.9-5.3%) and second molars (3.6%, 37/1036, 95% CI 2.6-4.9%) (Fisher's exact p = 0.73). The most frequently observed supernumerary root in both first molars (1.95%, 19/974, 95% CI 1.25-3.03%) and second molars (3.09%, 32/1036, 95% CI 2.20-4.33%) was RP; RP was significantly more frequent than RE in the second molars (32 versus 4 teeth, p < 0.001) but not in the first molars (19 versus 14 teeth, p = 0.49). When examining the distribution within each root type, RE was predominantly found in the first molars (77.8% of all RE cases), as was the combined RE/RP variant (83.3% of cases). Conversely, RP was more commonly identified in the second molars (62.7% of all RP cases). After Holm correction across the 24 pairwise post hoc contrasts of Tables 2 and 3, the shift of RP towards the second molars remained significant (adjusted p = 0.025), whereas the corresponding concentration of RE in the first molars did not (unadjusted p = 0.014, adjusted p = 0.26); on the at-risk denominators of 974 first and 1036 second molars neither contrast is significant after adjustment (RE unadjusted p = 0.016, RP unadjusted p = 0.12).

Further analysis by specific tooth number revealed significant differences in the distribution of root type among the affected teeth (Fisher's exact p = 0.018) (Table 3), although the per-tooth prevalence of an extra root did not differ between the four tooth positions (4.7% for #36, 3.9% for #37, 3.1% for #46 and 3.2% for #47; Fisher's exact p = 0.56). Among the teeth that had an extra root, the proportion classified as RE was lower in tooth #37 (5%) than in tooth #36 (39.1%), but this difference did not survive Holm correction for the 24 pairwise comparisons (unadjusted p = 0.011, adjusted p = 0.23), and no significant differences were observed among teeth #36, #46 (33.3%), and #47 (17.6%) (all adjusted p = 1.00). The occurrence of RE/RP did not vary significantly across tooth types (all unadjusted p ≥ 0.18, all adjusted p = 1.00). The proportion classified as RP was significantly higher in tooth #37 (95%) than in tooth #36 (47.8%) (unadjusted p = 0.0009, Holm-adjusted p = 0.020); the difference from tooth #46 (53.3%) was nominally significant but did not survive correction (unadjusted p = 0.011, adjusted p = 0.23), and the proportion did not differ from that in tooth #47 (76.5%) (p = 0.16). All of the figures quoted in this paragraph are percentages of the affected teeth at each tooth position. Expressed as a proportion of all teeth examined, the prevalence of RE was 1.83% (9/493, 95% CI 0.96-3.43%) in tooth #36, 0.20% (1/510, 95% CI 0.03-1.10%) in tooth #37, 1.04% (5/481, 95% CI 0.44-2.41%) in tooth #46 and 0.57% (3/526, 95% CI 0.19-1.66%) in tooth #47, and the corresponding prevalence of RP was 2.23% (11/493, 95% CI 1.25-3.95%), 3.73% (19/510, 95% CI 2.40-5.75%), 1.66% (8/481, 95% CI 0.85-3.25%) and 2.47% (13/526, 95% CI 1.45-4.18%); on these at-risk denominators none of the 21 pairwise contrasts between tooth positions is significant after Holm correction.

Regarding anatomical location, the presence of extra roots did not differ significantly between the right and left sides of the mandible (Table 4). At patient level 32 patients had an affected tooth on the right side and 43 on the left; the paired 2 × 2 table reconstructed from Tables 4 and 5 (12 patients affected on both sides, 20 on the right only, 31 on the left only and 599 on neither) gives McNemar's exact p = 0.16, with p = 0.17 for the first molars (#36 versus #46) and p = 0.69 for the second molars (#37 versus #47). The per-tooth prevalences were 3.2% on the right (32/1007, 95% CI 2.3-4.5%) and 4.3% on the left (43/1003, 95% CI 3.2-5.7%). In the patient-level analysis, the occurrence of bilateral extra roots was not significantly different between the first and second molars (Table 5) (Fisher's exact p = 1.00). Finally, neither the unilateral nor bilateral presentation of supernumerary roots showed a significant association with tooth type or sex (Tables 5-6) (Fisher's exact p = 1.00 for both). Twelve of the 63 affected patients had bilateral involvement (19.0%, 95% CI 11.2-30.4%), corresponding to 1.81% of all 662 patients (95% CI 1.04-3.14%).

Table 1. Distribution and frequency [n (%)] of mandibular first and second molars exhibiting RE, RE/RP, and RP among the 75 teeth with an extra root, stratified by sex. Percentages are row percentages. The distribution of root type did not differ between the sexes (Fisher's exact p = 0.099).

Sex	RE	RE/RP	RP	Total
Male	5 (14.3)	2 (5.7)	28 (80)	35 (100)
Female	13 (32.5)	4 (10)	23 (57.5)	40 (100)
Total	18 (24)	6 (8)	51 (68)	75 (100)

Fisher's exact test
Abbreviations: RE, radix entomolaris; RP, radix paramolaris; RE/RP, co-occurrence of RE and RP

Table 2. Comparison of the presence and type of extra roots in first and second molars [n (%)]. Row percentages use the number of teeth examined (974 first and 1036 second molars) and column percentages use the column totals. The per-tooth prevalence of any extra root was 3.9% (38/974, 95% CI 2.9-5.3%) in first molars and 3.6% (37/1036, 95% CI 2.6-4.9%) in second molars (Fisher's exact p = 0.73), while the distribution of root type among the 75 affected teeth differed between the two molar types (Fisher's exact p = 0.002).

	RE	RE/RP	RP	Absent	Total
First molar					
n	14^{Aa}	5^{Aa}	19^{Aa}	936	974
% (row)	1.4	0.5	2.0	96.1	100
% (column)	77.8	83.3	37.3	48.4	48.5
Second molar					
n	4^{Aa}	1^{Aa}	32^{Ab}	999	1036
% (row)	0.4	0.1	3.1	96.4	100
% (column)	22.2	16.7	62.7	51.6	51.5

Fisher's exact test (2 × 4 table including the Absent column, p = 0.007; 2 × 3 table restricted to the 75 affected teeth, p = 0.002); the chi-square test was not used because an expected count was below five. Lowercase letters a-b compare first with second molars within the same column, and uppercase letters A-B compare the root types with one another; values sharing a letter did not differ. Both sets of comparisons were made among the 75 affected teeth, and all p values are adjusted for the 24 pairwise post hoc contrasts of Tables 2 and 3 by the Holm procedure. Only the RP contrast between first and second molars remains significant (adjusted p = 0.025); the letters previously shown for RE between molar types (adjusted p = 0.26) and for RE versus RP (adjusted p = 0.12) have been withdrawn.
Abbreviations: RE, radix entomolaris; RP, radix paramolaris; RE/RP, co-occurrence of RE and RP

Table 3. Distribution of RE, RE/RP, and RP presence by tooth number [n (%)]. Percentages are column percentages calculated within the affected teeth at each tooth position; they are not prevalences among all teeth examined (n = 493 for #36, 510 for #37, 481 for #46 and 526 for #47). The per-tooth prevalence of any extra root was 4.7% (23/493, 95% CI 3.1-6.9%) for #36, 3.9% (20/510, 95% CI 2.6-6.0%) for #37, 3.1% (15/481, 95% CI 1.9-5.1%) for #46 and 3.2% (17/526, 95% CI 2.0-5.1%) for #47, and did not differ between the four positions (Fisher's exact p = 0.56).

Extra root	36	37	46	47	Total
RE	9^{a} (39.1)	1^{a} (5)	5^{a} (33.3)	3^{a} (17.6)	18 (24)
RE/RP	3^{a} (13)	0^{a} (0)	2^{a} (13.3)	1^{a} (5.9)	6 (8)
RP	11^{a} (47.8)	19^{b} (95)	$8^{a,b}$ (53.3)	$13^{a,b}$ (76.5)	51 (68)
Total	23 (100)	20 (100)	15 (100)	17 (100)	75 (100)

Fisher's exact test (3 × 4 table, p = 0.018). Superscript letters a-b compare the four tooth positions within the same row, that is, the proportion of the affected teeth at each position that was of the given root type; positions sharing a letter did not differ. All p values are adjusted for the 24 pairwise post hoc contrasts of Tables 2 and 3 by the Holm procedure. Only the RP contrast between tooth #36 and tooth #37 remains significant (adjusted p = 0.020); the letters previously shown for RE between #36 and #37 (adjusted p = 0.23) and for RP between #37 and #46 (adjusted p = 0.23) have been withdrawn. On the at-risk denominators (493, 510, 481 and 526 teeth) none of the 21 pairwise contrasts is significant after adjustment.
Abbreviations: RE, radix entomolaris; RP, radix paramolaris; RE/RP, co-occurrence of RE and RP

Table 4. Right- and left-sided distribution of RE, RE/RP, and RP among the 75 teeth with an extra root [n (%)]. Percentages are column percentages. The distribution of root type did not differ by side (Fisher's exact p = 0.93). The per-tooth prevalence of an extra root was 3.2% on the right (32/1007, 95% CI 2.3-4.5%) and 4.3% on the left (43/1003, 95% CI 3.2-5.7%). Because the two sides are paired within the patient this was tested with McNemar's exact test on the patient-level table (12 both sides, 20 right only, 31 left only), p = 0.16.

Extra root	Right	Left	Total
RE	8 (25)	10 (23.3)	18 (24)
RE/RP	3 (9.4)	3 (7)	6 (8)
RP	21 (65.6)	30 (69.8)	51 (68)
Total	32 (100)	43 (100)	75 (100)

Fisher's exact test
Abbreviations: RE, radix entomolaris; RP, radix paramolaris; RE/RP, co-occurrence of RE and RP

Table 5. Unilateral and bilateral distribution of extra roots in first and second molars on a patient basis [n (%)]. Percentages are column percentages of the 51 unilateral, 12 bilateral and 63 affected patients. The distribution did not differ between the molar types (Fisher's exact p = 1.00). Bilateral involvement affected 19.0% of the 63 affected patients (95% CI 11.2-30.4%) and 1.81% of all 662 patients (95% CI 1.04-3.14%).

Tooth type	Unilateral	Bilateral	Total
First molar	26 (51)	6 (50)	32 (50.8)
Second molar	25 (49)	6 (50)	31 (49.2)
Total	51 (100)	12 (100)	63 (100)

Fisher's exact test (p = 1.00)

Table 6. Unilateral and bilateral distribution of extra roots by sex [n (%)]. Percentages are column percentages of the 51 unilateral, 12 bilateral and 63 affected patients. The distribution did not differ between the sexes (Fisher's exact p = 1.00). At patient level the prevalence of an extra root was 8.9% in males (29/325, 95% CI 6.3-12.5%) and 10.1% in females (34/337, 95% CI 7.3-13.8%) (p = 0.61).

Sex	Unilateral	Bilateral	Total
Male	23 (45.1)	6 (50)	29 (46)
Female	28 (54.9)	6 (50)	34 (54)
Total	51 (100)	12 (100)	63 (100)

Fisher's exact test (p = 1.00)

Discussion

This retrospective study provides a detailed analysis of supernumerary roots in mandibular molars in a patient cohort from the southeastern Anatolia region of Turkey, utilizing CBCT to evaluate their prevalence and distribution. An in-depth understanding of population-specific anatomical variations is paramount in contemporary endodontics, as this knowledge directly informs diagnosis, treatment strategies, and ultimately, procedural success rates. Therefore, preoperative awareness of root canal morphology is a critical determinant of favorable clinical outcomes (1).

The overall per-tooth prevalence of extra roots in the mandibular first and second molars in our cohort was 3.7% (75/2010, 95% CI 3.0-4.7%), and 9.5% of the patients were affected (63/662, 95% CI 7.5-12.0%). This finding is comparable to the 2.9% prevalence reported in a Slovenian population (19) but lower than the 5% (20) and 9% (21) rates observed in other Turkish studies that used similar methodologies. It is noteworthy that our study was based on a substantial sample size of 2010 teeth from 662 patients, providing robust data for this specific population.

The prevalence of RE is strongly linked to genetic and ethnic factors, as well documented in the endodontic literature (22). It is a rare finding in European, Caucasian, and African populations but is significantly more common in populations of Mongoloid ancestry, where it is often considered a normal morphological trait rather than a developmental anomaly (22). In their review of three-rooted mandibular first molars, De Moor et al. (23) reported a prevalence of less than 3% in African populations, less than 5% in Eurasian and Asian populations, and above 5% and up to

40% in populations with Mongolian traits, while in Caucasians the rate did not exceed 4.2%. Previous studies in Turkey have reported RE prevalence rates of 1% (24), 1.2% (25), and 4.2% (21), respectively. Our study identified a per-tooth RE prevalence of 0.90% (18/2010, 95% CI 0.57-1.41%), or 1.19% (24/2010, 95% CI 0.80-1.77%) when the six teeth with both RE and RP are included. The variability among these findings can likely be attributed to differences in research methodologies and inclusion criteria. For example, the low prevalence reported by Çolak et al. (24) may be due to their use of two-dimensional periapical radiography, which can fail to detect buccolingually oriented anatomical features.

In alignment with our first null hypothesis (H_{01}), which predicted no significant difference in the distribution of extra roots between the sexes, our findings established no association between sex and the frequency of these variations. This confirms the results of numerous previous studies (21, 26, 27). When RE and RP were analyzed separately, no significant relationship was found with sex, which is also consistent with much of the literature (14, 21, 28). However, some conflicting reports exist, such as Bhatia et al. (29), who found RP to be more common in females, and Duman et al. (25), who reported that RE was more frequent in males. These discrepancies are likely attributable to the racial and ethnic diversities of the populations studied. A notable limitation of the existing literature, which this study sought to address, is that many investigations evaluate the overall frequency of a third root without providing a detailed, separate analysis of RE and RP (14, 28).

Consistent with established findings, RE was observed more frequently in mandibular first molars (1.44%, 14/974, 95% CI 0.86-2.40%) than in second molars (0.39%, 4/1036, 95% CI 0.15-0.99%) in our study (3, 17, 18, 30), although this difference did not survive correction for multiple comparisons (unadjusted p = 0.016, Holm-adjusted p = 0.26). While primarily associated with the first molar, its occurrence in the second molars has also been documented (9, 17, 18, 25). Our observed prevalence of 0.4% in second molars is slightly lower than rates reported by Zhang (1.2%) (18), Song (0.7%) (17), and Duman et al. (0.6%) (25). The clinical significance of this finding is heightened by the fact that mandibular first molars are the first permanent teeth to erupt and are thus highly susceptible to caries, making them frequent candidates for endodontic therapy (31).

The prevalence of RP has been investigated less extensively than RE, likely due to its lower frequency (29). In our study, RP was more prevalent in second molars (3.09%, 32/1036, 95% CI 2.20-4.33%) than in first molars (1.95%, 19/974, 95% CI 1.25-3.03%), although the difference was not significant on these at-risk denominators (p = 0.12); this aligns with some reports (32, 33) but contrasts with others that found it more common in the first molars (6, 16). Our second null hypothesis (H_{02}), which concerned the prevalence of extra roots by tooth and molar type, was not rejected because the prevalence did not differ between the four tooth positions (4.7%, 3.9%, 3.1%, and 3.2% for #36, #37, #46, and #47; p = 0.56). However, the distribution of root type among the affected teeth differed significantly by tooth number. It was driven by the distribution within tooth #37, where RP was observed in 19 cases versus only one case of RE; the contrast between the proportion of RP at #37 and at #36 was the only tooth-position comparison that survived Holm correction (adjusted p = 0.020). Furthermore, we observed six teeth in which RE and RP co-existed in the same tooth; these four-rooted molars occurred bilaterally in our cohort.

Regarding anatomical location, no significant difference was found in the prevalence of extra roots between the right and left sides of the mandible, so our third null hypothesis (H_{03}) was not rejected. Because the two sides are paired within the patient, this hypothesis was tested with McNemar's exact test on the patient-level table (12 patients affected on both sides, 20 on the right only and 31 on the left only), which gave p = 0.16 overall, p = 0.17 for the first molars and p = 0.69 for the second molars. This result is in agreement with studies reporting no significant side-related difference (19, 21, 28), whereas right-side predominance has been reported in Taiwanese and Turkish cohorts (14, 25, 34), possibly because of differences in sample size, imaging technique, and ethnicity.

Różyło et al. (35), who analyzed periapical and panoramic radiography data, did not detect a statistically significant difference in the prevalence of third root variations between the right and left mandible. Conversely, Taiwanese studies (14, 34) have indicated a higher frequency of these variations on the right side of the mandible. The current study aligns with the former finding, as a comparison of the right and left sides revealed no significant difference regarding the prevalence of RP.

Our fourth null hypothesis (H_{04}), stating that unilateral or bilateral occurrence would not be related to molar type or sex, was also not rejected. Dental anatomical variations are often expressed bilaterally (22, 36), and while some studies report a high rate of bilateral RE (23, 37–39), others, including a recent Turkish study, found a majority of cases to be unilateral (64%) (25), supporting our findings. Reported bilateral distolingual-root/RE rates vary substantially, including 9.1% in a Hong Kong Chinese population (40) and 5% in an Indian population (41). In our patient cohort, 19.0% (12 of 63, 95% CI 11.2-30.4%) of individuals with an extra root exhibited bilaterality, corresponding to 1.81% of all 662 patients (95% CI 1.04-3.14%).

Limitations

This study had some limitations. Its retrospective nature precluded the correlation of radiographic findings with clinical data. Furthermore, as the data were sourced exclusively from the ethnically distinct Southeastern Anatolia region, the results may not be generalizable to the entire Turkish population. Finally, CBCT is not yet a routine diagnostic tool in endodontics and may not be universally accessible. Despite these limitations, this study provides a valuable contribution as one of the few investigations in a Turkish population to examine the association of bilateral extra roots with sex and tooth type.

Conclusion

The use of CBCT enabled detailed three-dimensional morphological evaluation, overcoming the inherent limitations of two-dimensional radiography and providing clinically relevant data for practitioners. In this sample, an extra root was present in 3.7% of the 2010 mandibular molars examined (95% CI 3.0-4.7%) and in 9.5% of the 662 patients (95% CI 7.5-12.0%). The prevalence of an extra root did not differ between the sexes, between the right and left sides, between first and second molars or between the four tooth positions. Accordingly, none of the four null hypotheses was rejected for its stated outcome. The distribution of extra-root type did differ: among the affected teeth radix paramolaris was relatively more common in the second molars and radix entomolaris in the first molars, although after correction for multiple testing only the radix paramolaris contrast remained significant.

Disclosures

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