ARTICLE IN PRESS

Revista Portuguesa de Estomatologia, Medicina Dentária e Cirurgia Maxilofacial
Portuguese Journal of Stomatology, Dental Medicine and Maxillofacial Surgery

REV PORT ESTOMATOL MED DENT CIR MAXILOFAC. 2026;67(x):1-8

Original Research

Prevalence of *radix molaris* in mandibular molars of a Portuguese subpopulation

Ana Ferreira[1], *Ana Cristina Braga*[2], *Irene Pina-Vaz*[3], *Pedro Mesquita*[1], *Inês Ferreira*[3,*]

[1] *Faculty of Dental Medicine, University of Porto, Porto, Portugal*
[2] *ALGORITMI Research Centre, LASI, University of Minho, Braga, Portugal*
[3] *RISE-Health, Faculty of Dental Medicine, University of Porto, Porto, Portugal*

ARTICLE INFO

Article history:
Received 20 May 2026
Accepted 5 August 2026
Available online 16 September 2026

Keywords:
Anatomy
Cone-beam computed tomography
Endodontics
Prevalence
Root canal therapy
Tooth

ABSTRACT

Objectives: To evaluate the prevalence of *radix molaris* in mandibular first and second molars in a Portuguese subpopulation using cone-beam computed tomography and to characterize its anatomical features.

Methods: This retrospective cross-sectional study included 505 cone-beam computed tomography scans comprising 1641 mandibular molars (776 first and 865 second molars). Based on tooth morphology assessment, the presence of *radix molaris*, its subtype (*entomolaris* or *paramolaris*), associated tooth, location, and patient sex were recorded. Main analyses used generalized estimating equations with an exchangeable correlation matrix to control for patient-level clustering. For the affected subsample ($n = 18$), data were aggregated per patient and evaluated using exact tests. Statistical significance was set at $p < 0.05$.

Results: The overall tooth-level prevalence of *radix molaris* was 1.34% (95% confidence interval: 0.87–1.99). *Radix entomolaris* was the predominant subtype (1.16%), whereas *radix paramolaris* was rare (0.18%). *Radix molaris* was descriptively more frequent in mandibular first molars than in second molars. Type AC morphology and Type I curvature were the most frequent patterns among *radix entomolaris* cases. No significant associations were found between the presence of *radix molaris* and sex or molar type in the adjusted analysis ($p > 0.05$).

Conclusions: *Radix molaris* was an uncommon anatomical variation in this Portuguese clinical subpopulation, with *radix entomolaris* as the predominant subtype. Although more frequently observed in mandibular first molars, no significant association with molar type was found. Recognition of this variation is clinically important to reduce the risk of missed canals and endodontic treatment failure. (Rev Port Estomatol Med Dent Cir Maxilofac. 2026;67(x):1-8)

* Corresponding author.
E-mail address: iferreira@fmd.up.pt (Inês Ferreira).

http://doi.org/10.24873/j.rpemd.2026.09.1583
1646-2890/

Introduction

Mandibular permanent molars are among the teeth most frequently requiring endodontic treatment, and a thorough knowledge of their root canal morphology is fundamental to achieving successful clinical outcomes.[1-3] The root canal system of mandibular molars typically comprises two roots—one mesial and one distal—with a total of two to four canals.[3,4] However, numerical and morphological variations are not uncommon, and their prevalence varies considerably across populations.[5,6] Among these variations, the presence of a supernumerary root represents one of the most clinically significant anatomical anomalies, as failure to identify it during treatment can result in missed canals, persistent periapical pathology, and endodontic failure.[7-9] Missed root canal systems remain one of the leading causes of endodontic treatment failure. Therefore, a comprehensive understanding of possible anatomical deviations is indispensable for the practicing clinician.[10]

The term *radix molaris* (RM) refers collectively to supernumerary roots occurring in mandibular molars.[11,12] When located on the distolingual aspect of the tooth, the additional root is designated *radix entomolaris* (RE); when located on the mesiobuccal aspect, it is termed *radix paramolaris* (RP).[11,12] Both variants can present as separate or non-separate from the main roots, and their external morphology has been systematically classified according to the widely adopted classification system proposed by Carlsen and Alexandersen (1990).[13] RE curvature assessment is particularly relevant for endodontic treatment planning given the direct relationship between root curvature and the risk of procedural complications. Thus, RE curvature has also been categorized under another classification system.[3,14] RE is substantially more prevalent than RP and has been identified across a broad range of populations, whereas RP is considered an exceptional finding in most ethnic groups.[8]

The global prevalence of RE in mandibular first molars varies widely, ranging from less than 1% in certain Middle Eastern and African populations to up to approximately 30% in East Asian cohorts, particularly in Chinese and Korean samples.[15-17] This marked ethnic variability has been well documented and is thought to reflect genetic and population-related factors.[16,17] In European Caucasian populations, RE prevalence in mandibular first molars is generally low, typically ranging between 0.7% and 3%.[18,19] In contrast, Asian populations exhibit substantially higher frequencies, and three-rootedness in mandibular first molars is considered a normal morphological variant rather than an anatomical anomaly in these groups.[17,20]

Accurate preoperative identification of RM is important for successful endodontic management. Conventional periapical radiography, although routinely used, has inherent limitations: buccolingual superimposition may obscure the presence of a supernumerary root, and the two-dimensional nature of the image precludes reliable assessment of three-dimensional root morphology.[3] Cone-beam computed tomography (CBCT) addresses these limitations by allowing multiplanar evaluation in the axial, sagittal, and coronal planes, thereby facilitating precise assessment of root number, morphology, and canal configuration. Its diagnostic superiority over conventional radiography for detecting supernumerary roots and complex root anatomy has been well documented, and CBCT has increasingly been adopted as the reference imaging modality in epidemiological studies of root canal morphology.[8,21]

The aim of this study was to evaluate the prevalence of RM in mandibular first and second molars in a Portuguese subpopulation using CBCT, as well as to analyze its anatomical characteristics.

Material and Methods

This cross-sectional, retrospective study analyzed CBCT images of mandibular first and second molars from patients attending the Dental Clinic of the Faculty of Dental Medicine, University of Porto, Porto, Portugal, representing a northern Portuguese clinical subpopulation. The previously published methodology followed preferred reporting items for epidemiologic cross-sectional studies on root and root canal anatomy using CBCT technology.[21]

Sample size was calculated at the patient level using the Raosoft® Sample Size Calculator (Raosoft Inc., Seattle, WA, USA). Based on an expected RM prevalence of 3% reported in previous CBCT studies, a 2% margin of error, a 95% confidence level, and an estimated population of 20,000 individuals, the estimated minimum required sample size was 276 patients.[15,22] To strengthen the analysis and account for potential exclusions, a larger sample was included.

All CBCT examinations were acquired for diagnostic or treatment-planning purposes and were not obtained specifically for this study. Patient identification data were anonymized and not accessed at any stage of the analysis. Patients aged 18 years or older with at least one mandibular first or second molar and available full-arch CBCT scans (mandibular or bimaxillary) were included in the study. CBCT scans were excluded if patients were completely edentulous, if the mandibular molars had immature apices or evidence of root resorption, or if image quality was compromised by artifacts that prevented reliable evaluation. Mandibular third molars were not included in the analysis. The CBCT acquisition parameters were 90 kV, 10 mA, a voxel size of 200 µm, an exposure time of 15 s, and fields of view of 100 × 60 mm for mandibular scans and 100 × 100 mm for bimaxillary scans.

Figure 1 summarizes the CBCT selection process. A non-probabilistic convenience sample of 542 CBCT examinations performed between 2017 and 2024 was initially screened from the institutional imaging database. After applying the inclusion and exclusion criteria, 37 examinations were excluded, resulting in a final sample of 505 CBCT scans: 240 from males and 265 from females. A total of 1641 mandibular molars were included, comprising 776 first molars and 865 second molars. The mean patient age was 33.0 years (SD = 12.5).

All CBCT scans were obtained using a Planmeca ProMax® unit (Planmeca, Helsinki, Finland). Image analysis was performed using Romexis® imaging software (Planmeca, Helsinki, Finland). Assessments were conducted in the axial, sagittal, and coronal planes. The following variables were recorded: tooth type (first or second mandibular molar), presence or absence of RM, RM subtype (*entomolaris* or *paramolaris*), arch side (right/left), and localization (unilateral/bilateral).

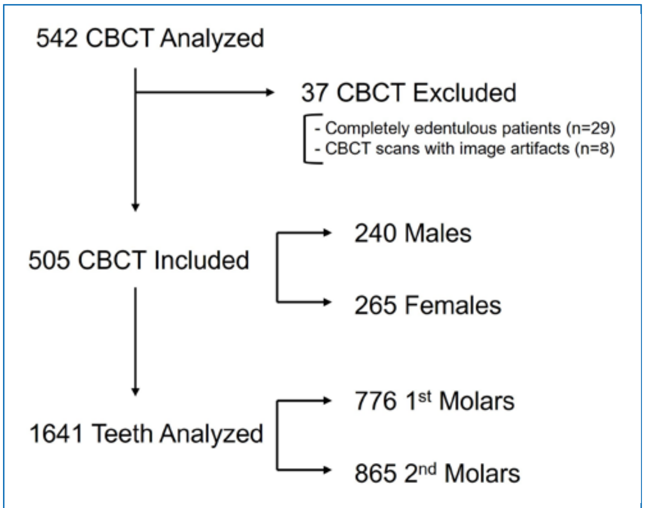

Figure 1. Flowchart of the cone-beam computed tomography dataset selection process.

Prior to the main analysis, a calibration session was conducted using a subset of CBCT scans not included in the final sample. The morphological position of RM was classified according to the widely used classification system proposed by Carlsen and Alexandersen (1990): Type A, a supernumerary root originating at the level of the root bifurcation and positioned lingually between the main roots; Type B, distolingually positioned RE associated with a markedly reduced distal root; Type C, mesial location of RE; and Type AC, RE with the cervical part located distolingually and adjacent to the distal root.[13] Root curvature was assessed exclusively for RE cases using a previously established classification approach, due to its specific applicability and clinical relevance to this anatomic variant: Type I, straight; Type II, single curvature; and Type III, double curvature.[14] In cases where RM was identified, CBCT images were independently evaluated by two calibrated observers for RM morphology and root-curvature classification. Interobserver agreement was assessed using the weighted kappa coefficient, and 95% confidence intervals were calculated.

Data were analyzed using IBM SPSS Statistics software (version 30.0; IBM Corp., Armonk, NY, USA). Descriptive statistics were used to characterize the sample, including absolute (n) and relative (%) frequencies, with 95% confidence intervals (95% CI) when appropriate. To account for the clustering effect resulting from multiple observations (up to four molars) within the same patient (n = 505 subjects; n = 1641 molars), generalized estimating equations (GEE) with a binary logistic link function and an exchangeable working correlation matrix were employed. The presence of RM was defined as the dependent variable, while sex (female vs. male) and molar type (first vs. second molar) were included as independent predictors. Quasi-likelihood under the Independence Model Criterion (QIC) was used to assess model fit. However, for clinical and anatomical characterization within the subsample of affected patients (n = 18), several contingency tables contained very small cell counts ($n < 5$). In these instances, data were analyzed at the patient level using Fisher's exact test for 2 × 2 tables, and the Fisher–Freeman–Halton exact test was specifically applied for 3 × 2 tables (e.g., molar type and arch side distribution). Two-sided exact p-values were reported for Fisher's exact and Fisher–Freeman–Halton tests, whereas p-values for the GEE parameter estimates were based on Wald chi-square statistics. Statistical significance was set at $p < 0.05$.

Results

A total of 1641 mandibular molars (first and second molars) were analyzed using CBCT. The overall tooth-level prevalence of RM was 1.34% (n = 22; 95% CI: 0.87–1.99). RE accounted for most cases, with a prevalence of 1.16% (19/1641; 95% CI: 0.70–1.80), whereas RP was considerably less frequent, occurring in only 0.18% (3/1641; 95% CI: 0.04–0.53) of the examined molars. RM was identified in 1.9% of first molars (15/776) and 0.8% of second molars (7/865) (Table 1). RE prevalence was 1.80% in first molars (14/776; 95% CI: 0.99–3.01) and 0.58% in second molars (5/865; 95% CI: 0.19–1.34). RP was identified in 0.13% of first molars (1/776; 95% CI: 0.00–0.72) and 0.23% of second molars (2/865; 95% CI: 0.03–0.83). RE was more frequently observed than RP in both first and second molars (Table 2).

Table 1. **Distribution of *radix molaris* according to molar type at the tooth level (n = 1641).**

Molar type	*Radix molaris*		Total
	Absent, n (%)	Present, n (%)	
1st Molar	761 (98.1%)	15 (1.9%)	776 (100%)
2nd Molar	858 (99.2%)	7 (0.8%)	865 (100%)
Total	1619 (98.7%)	22 (1.3%)	1641 (100%)

n – absolute frequency; % – relative frequency

Table 2. **Distribution of *radix molaris* subtypes according to molar type at the tooth level (n = 1641).**

Molar type	Absent n (%)	*Radix molaris*		Total n (%)
		Radix entomolaris n (%)	*Radix paramolaris* n (%)	
1st Molar	761 (98.1%)	14 (1.8%)	1 (0.1%)	776 (100%)
2nd Molar	858 (99.2%)	5 (0.6%)	2 (0.2%)	865 (100%)
Total	1619 (98.7%)	19 (1.2%)	3 (0.2%)	1641 (100%)

n – absolute frequency; % – relative frequency

Morphological characterization was performed on the 22 teeth presenting RM (Table 3). Interobserver agreement for the classification of RE morphology showed a linearly weighted Cohen's kappa of 0.604 (95% Bootstrap CI: –0.075–1.000), indicating moderate point-estimate agreement, albeit with a wide confidence interval secondary to the limited sample size. Moderate interobserver agreement was observed for root-curvature assessment (κ = 0.651; 95% CI: 0.365–0.938).

RE was the predominant variant, with 86.4% of cases (n = 19; 95% CI: 67.9–96.0), whereas RP accounted for 13.6% of cases (n = 3; 95% CI: 4.0–32.1). Regarding RE morphology, Type AC was the most frequent configuration (n = 13; 68.4%; 95% CI: 46.1–85.6), while RE curvature was classified as Type I in most cases (n = 13; 68.4%; 95% CI: 46.1–85.6). Among the three RP cases, Type A morphology was the most prevalent (n = 2; 66.7%; 95% CI: 17.7–96.1).

Associations between sex, molar type, and the presence of RM were evaluated using a GEE logistic regression model (Table 4). Males had higher odds of presenting RM than females (OR = 2.30; 95% CI: 0.82–6.51), although this difference did not reach statistical significance (p = 0.116). Likewise, no significant association was observed between molar type and the presence of RM (OR = 2.41; 95% CI: 0.88–6.63; p = 0.088) (Table 4).

At the patient level, RM was identified in 18 individuals, of whom six (33.3%) were female and twelve (66.7%) were male. Table 5 details the clinical and anatomical features per patient. RE was the predominant variant, identified in 83.3% (n = 15) of the patients, whereas RP occurred exclusively in males, affecting 3 of 12 male patients (25.0%). Regarding tooth type, the condition was isolated to first molars in 10 patients (55.6%), second molars in seven patients (38.9%), and both first and second molars in one female patient (5.6%). Unilateral occurrence on the left side was more frequent among female patients (4/6, 66.7%), whereas unilateral right-side occurrence predominated among male patients (7/12, 58.3%). Bilateral presentation was observed in 22.2% (n = 4) of the patients. No statistically significant differences between sexes were found for any of the anatomical characteristics evaluated (all p > 0.05) (Table 5).

Discussion

The present cross-sectional CBCT-based study evaluated the prevalence and morphological characteristics of RM in mandibular first and second molars in a Portuguese subpopulation. The overall tooth-level prevalence of RM was 1.34%, which is consistent with data reported for European popula-

Table 3. **Morphological classification of *radix entomolaris* and *radix paramolaris* and root-curvature patterns of *radix entomolaris*.**

			n	%	95% CI
***Radix entomolaris* (n = 19)**	Morphology	Type A	2	10.5%	2.3–29.7
		Type B	0	0%	–
		Type C	4	21.1%	7.6–42.6
		Type AC	13	68.4%	46.1–85.6
	Curvature	Type I	13	68.4%	46.1–85.6
		Type II	4	21.1%	7.6–42.6
		Type III	2	10.5%	2.3–29.7
***Radix paramolaris* (n = 3)**	Morphology	Type A	2	66.7%	17.7–96.1
		Type B	1	33.3%	3.9–82.3
		Type C	0	0%	–

n – absolute frequency; % – relative frequency; 95% CI – 95% confidence interval
Morphological classification: Type A – distal location with two distal root components; Type B – distal location with one distal root component; Type C – mesial location; Type AC – central location between the mesial and distal root components. Root-curvature classification: Type I – straight; Type II – single curvature; Type III – double curvature.

Table 4. **Generalized estimating equation (GEE) logistic regression analysis of factors associated with the presence of *radix molaris*.**

Variable	Total teeth analyzed n (%)	Presence of RM n (%)	Adjusted OR	95% Wald CI for OR	p-value
Sex					
Female	831 (50.6%)	7 (0.8%)	1.00	(Reference)	—
Male	810 (49.4%)	15 (1.9%)	2.30	0.82–6.51	0.116
Molar type					
2nd Molar	865 (52.7%)	7 (0.8%)	1.00	(Reference)	—
1st Molar	776 (47.3%)	15 (1.9%)	2.41	0.88–6.63	0.088

Note: Percentages for the presence of RM represent the prevalence within that specific category (e.g., 1.9% of all male molars presented the condition). GEE Model Specifications: binomial distribution, logit link function, and exchangeable working correlation matrix to account for patient-level clustering (n = 505 subjects). Fit indices: QIC (Quasi-likelihood under the Independence Model Criterion) = 234.00; QICC (Corrected Quasi-likelihood under the Independence Model Criterion) = 232.31. Adjusted ORs are presented with Wald 95% confidence intervals, and p-values are based on Wald tests. OR: Odds Ratio; 95% CI: 95% confidence interval; RM: *radix molaris*

Table 5. Patient-level clinical and anatomical characteristics of *radix molaris* according to sex (n = 18).

	Female (n = 6)	Male (n = 12)	Total (n = 18)	p-value
Radix type	n (%)	n (%)	n (%)	
Entomolaris	6 (100%)	9 (75.0%)	15 (83.3%)	0.515*
Paramolaris	0 (0%)	3 (25.0%)	3 (16.7%)	
Molar type				
1st Molar	2 (33.3%)	8 (66.7%)	10 (55.6%)	0.305**
2nd Molar	3 (50.0%)	4 (33.3%)	7 (38.9%)	
1st and 2nd Molar	1 (16.7%)	0 (0%)	1 (5.6%)	
Arch side				
Unilateral right	1 (16.7%)	7 (58.3%)	8 (44.4%)	0.159**
Unilateral left	4 (66.7%)	2 (16.7%)	6 (33.3%)	
Bilateral	1 (16.7%)	3 (25.0%)	4 (22.2%)	
Localization				
Unilateral	5 (83.3%)	9 (75.0%)	14 (77.8%)	1.000*
Bilateral	1 (16.7%)	3 (25.0%)	4 (22.2%)	

* Fisher's exact test; ** Fisher–Freeman–Halton exact test; n – absolute frequency; % – relative frequency. Percentages represent column percentages. Female (n = 6), Male (n = 12), and Total (n = 18) were used as denominators for the corresponding percentage calculations.

tions, including previous studies conducted in Portugal.[15,18,23] These findings reinforce the notion that RM is a relatively uncommon anatomical variation in European populations, in contrast to the markedly higher prevalences reported in Asian populations, particularly in Chinese and Korean cohorts where prevalence rates ranging from 23% to 33% have been documented.[20,24] However, considering the frequent population mobility across regions, it is essential to recognize anatomical variations and associated individual factors during diagnosis and treatment planning.

In the present study, RE accounted for most RM cases (1.16%), whereas RP remained a rare finding (0.18%). The results align closely with previously published CBCT-based data from different regions of Portugal and suggest a relatively homogeneous distribution of RE within the country.[18] In a southern Portuguese population (Lisbon), an RE prevalence of 2.2% in mandibular first molars and 0.6% in second molars has been reported, while RP was found to be uncommon.[18] Similarly, a multinational cross-sectional study including a Portuguese subpopulation from Coimbra (central Portugal) identified an RE prevalence of approximately 3.0% in mandibular first molars.[15] Taken together with the present findings from a northern Portuguese population (Porto), these data indicate that the prevalence of RE in Portugal remains consistently low, with no clear evidence of marked regional variation within the country.

A higher prevalence of RM was observed in mandibular first molars than in second molars. This gradient has been reported in the literature and was also confirmed by a large CBCT study from Slovenia, which reported tooth-level RE prevalences of 1.2% and 0.9% in first and second permanent mandibular molars, respectively.[22] A recent Brazilian CBCT study conducted in the Northeast region and encompassing 3315 mandibular molars reported a similar pattern, with prevalences of 2.92% in first molars and 1.47% in second molars.[12] Regarding RP, its prevalence was very low in both mandibular first molars (0.13%) and second molars (0.23%) in the present study, which is consistent with findings from other studies reporting RP as a rare anatomical variant.[8] Although a higher prevalence of RM was observed in mandibular first molars, this difference was not statistically significant in the adjusted analysis, and the relatively small number of positive cases warrants cautious interpretation of this finding.

Similar to previous studies, RM's morphology and positional relationship were assessed according to the widely used classification system proposed by Carlsen and Alexandersen (1990).[13,16,22] In the present sample, RE most frequently exhibited a Type AC configuration. In a large CBCT study from Slovenia, first permanent mandibular molars exclusively exhibited Type A RE, whereas Types B and AC predominated in second and third molars.[22] Likewise, Type A has been reported as the most prevalent configuration in mandibular first molars.[16] The predominance of a Type AC configuration in the present sample, particularly in first mandibular molars, appears to be uncommon within the European context and may reflect specific population-related characteristics not assessed in this study.

RE curvature was assessed using a previously described classification system that categorizes the distolingual root trajectory as Type I (straight), Type II (single curvature), or Type III (double curvature).[14] In the present study, a Type I configuration predominated, accounting for 68.4% of cases, whereas Type II and Type III curvatures were observed in

21.1% and 10.5% of cases, respectively. This distribution differs from that reported in a Saudi Arabian study, in which Type III was the most prevalent curvature pattern (57.5%), followed by Type I (25%).[15] Differences were also reported in a Turkish CBCT-based study, where Type III was frequently observed, particularly in second mandibular molars.[16] From a clinical perspective, the identification of the root trajectory type (Type II and especially Type III curvatures) is relevant, as these configurations are associated with an increased risk of procedural complications during root canal instrumentation, including canal transportation, ledge formation, and instrument separation.

The present study found no statistically significant association between RM and sex, despite a numerically higher prevalence in males. This finding is consistent with the most recent systematic review and meta-analysis, which included 26 CBCT-based studies comprising 21,383 mandibular second molars and demonstrated that sex does not significantly influence the occurrence of either RE or RP.[8] Although isolated studies have reported sex-related differences in prevalence, these findings were not consistent across studies and were characterized by wide confidence intervals, likely reflecting sampling variability and the low overall prevalence of RM.[16,26] Taken together, the available evidence suggests that RM cannot be considered a sex-dependent anatomical trait, and that apparent differences observed in isolated populations are more plausibly attributable to methodological factors and population-specific characteristics rather than true biological dimorphism.

The use of CBCT represents a clear methodological strength of the present study, allowing reliable three-dimensional visualization of both external and internal root morphology. To minimize potential selection bias, only scans showing the entire mandibular arch or both dental arches were included. Although small field-of-view scans provide higher spatial resolution and are frequently employed in endodontic practice, including them could artificially inflate prevalence estimates. The methodological approach adopted favors epidemiological representativeness over maximal spatial resolution.

Despite these strengths, certain limitations must be acknowledged. As with most retrospective CBCT studies, the sample consisted of patients who underwent imaging for diagnostic reasons and not as part of a screening protocol, and many patients did not present a full complement of teeth. Nevertheless, the use of a large pre-existing imaging database enabled the analysis of a substantial number of teeth without exposing patients to unnecessary radiation, in accordance with ethical guidelines. As CBCT scans are generally prescribed for specific diagnostic and treatment-planning purposes, the included individuals may not represent the overall Portuguese population. In addition, information regarding the original referral indication for each CBCT examination was not consistently available. Therefore, the present findings should be interpreted as representative of a Portuguese clinical subpopulation rather than the general population. In addition, only three cases of RP were identified. Consequently, conclusions regarding its morphological characteristics, distribution by arch side, and potential associations with sex should be interpreted with caution. Larger studies are required to provide more robust evidence regarding this uncommon anatomical variant.

The findings of the present study carry important clinical implications. The orifice of a supernumerary root canal is often difficult to locate without appropriate modification of the access cavity, and when left untreated, it may act as a persistent source of microbial contamination, potentially resulting in post-treatment disease.[10,25] From a technical standpoint, RM roots are frequently shorter, more curved, and of smaller diameter than the main roots, which significantly increases the complexity of instrumentation and the risk of procedural errors, including ledge formation, canal transportation, and instrument fracture.[3,7] Adequate access cavity preparation is therefore essential and typically requires extension of the conventional outline form in a distolingual direction, resulting in a trapezoidal rather than rectangular access design to ensure straight-line access to the distolingual canal orifice.[3,7] In this context, CBCT should be considered a valuable complementary diagnostic tool, particularly in cases of ambiguous anatomy, suspected anatomical variations, or previous treatment failure, as it allows improved detection and spatial understanding of additional roots and canals that may not be evident on conventional radiographs.

Conclusions

RM was identified as an uncommon anatomical variation in this Portuguese clinical subpopulation, being more frequently observed in mandibular first molars, with RE as the predominant subtype. Despite its low prevalence, recognition of this anatomical variation is clinically important, as failure to identify an additional root and canal may result in missed canals, procedural errors, and compromised endodontic treatment outcomes.

Conflict of interest

The authors have no conflicts of interest to declare.

Ethical disclosures

Protection of human and animal subjects. The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Confidentiality of data. The authors declare that no patient data appear in this article.

Right to privacy and informed consent. Due to the retrospective nature of the study, written informed consent was not required, in accordance with institutional requirements and ethics committee approval (approval no. 16/2025).

CRediT authorship contribution statement

Ana Ferreira: Investigation; Methodology; Writing – original draft; **Ana Cristina Braga:** Formal analysis; Writing – review & editing; **Irene Pina-Vaz:** Conceptualization; Writing – review & editing; **Pedro Mesquita:** Visualization; Writing – review & editing; **Inês Ferreira:** Conceptualization; Resources; Supervision; Writing – original draft; Writing – review & editing.

ORCID

Ana Ferreira 0009-0007-6420-6365
Ana Cristina Braga 0000-0002-1991-9418
Irene Pina-Vaz 0000-0002-5885-0724
Pedro Mesquita 0000-0003-0735-2482
Inês Ferreira 0000-0001-9587-3557

REFERENCES

1. Gu Y, Lu Q, Wang H, Ding Y, Wang P, Ni L. Root canal morphology of permanent three-rooted mandibular first molars—part I: pulp floor and root canal system. J Endod. 2010;36:990-4.
2. de Pablo OV, Estevez R, Péix Sánchez M, Heilborn C, Cohenca N. Root anatomy and canal configuration of the permanent mandibular first molar: a systematic review. J Endod. 2010;36:1919-31.
3. Peters OA, editor. The guidebook to molar endodontics. 1st ed. Berlin, Heidelberg: Springer; 2017.
4. Pham KV, Le AHL. Evaluation of roots and canal systems of mandibular first molars in a Vietnamese subpopulation using cone-beam computed tomography. J Int Soc Prev Community Dent. 2019;9:356-62.
5. Yousefi F, Mohammadi Y, Shokri E. Prevalence of c-shaped canal morphology in premolar and molar teeth assessed by cone-beam computed tomography: systematic review and meta-analysis. BMC Oral Health. 2025;25:1657.
6. Martins JNR, Nole C, Ounsi HF, Parashos P, Plotino G, Ragnarsson MF, et al. Worldwide assessment of the mandibular first molar second distal root and root canal: a cross-sectional study with meta-analysis. J Endod. 2022;48:223-33.
7. Calberson FL, De Moor RJ, Deroose CA. The radix entomolaris and paramolaris: clinical approach in endodontics. J Endod. 2007;33:58-63.
8. Al-Haddad A, Alarami N, Alshammari AF, Hatipoğlu Ö, Hatipoğlu FP, Madfa AA. The worldwide prevalence of radix molaris in mandibular second molars assessed by cone beam computed tomography: systematic review and meta-analysis. J Endod. 2026;52:24-36.
9. Souza-Flamini LE, Leoni GB, Chaves JF, Versiani MA, Cruz-Filho AM, Pécora JD, et al. The radix entomolaris and paramolaris: a micro-computed tomographic study of 3-rooted mandibular first molars. J Endod. 2014;40:1616-21.
10. Costa F, Pacheco-Yanes J, Siqueira JF Jr, Oliveira ACS, Gazzaneo I, Amorim CA, et al. Association between missed canals and apical periodontitis. Int Endod J. 2019;52:400-6.
11. Al-Alawi H, Al-Nazhan S, Al-Maflehi N, Aldosimani MA, Zahid MN, Shihabi GN. The prevalence of radix molaris in the mandibular first molars of a Saudi subpopulation based on cone-beam computed tomography. Restor Dent Endod. 2020;45:e1.
12. Martins Araújo de Oliveira Y, Mendes Gomes MC, Nascimento M, Machado R, Mota Moreira D, Paiva HC, et al. Prevalence of radix molaris in mandibular molars of a subpopulation of Brazil's Northeast region: a cross-sectional CBCT study. Sci Rep. 2025;15:22651.
13. Carlsen O, Alexandersen V. Radix entomolaris: identification and morphology. Scand J Dent Res. 1990;98:363-73.
14. Song JS, Choi HJ, Jung IY, Jung HS, Kim SO. The prevalence and morphologic classification of distolingual roots in the mandibular molars in a Korean population. J Endod. 2010;36:653-7.
15. Hatipoğlu FP, Mağat G, Hatipoğlu Ö, Al-Khatib H, Elatrash AS, Abidin IZ, et al. Assessment of the prevalence of radix entomolaris and distolingual canal in mandibular first molars in 15 countries: a multinational cross-sectional study with meta-analysis. J Endod. 2023;49:1308-18.
16. Duman SB, Duman S, Bayrakdar IS, Yasa Y, Gumussoy I. Evaluation of radix entomolaris in mandibular first and second molars using cone-beam computed tomography and review of the literature. Oral Radiol. 2020;36:320-6.
17. Qiao X, Zhu H, Yan Y, Li J, Ren J, Gao Y, et al. Prevalence of middle mesial canal and radix entomolaris of mandibular first permanent molars in a western Chinese population: an in vivo cone-beam computed tomographic study. BMC Oral Health. 2020;20:224.
18. Martins JNR, Marques D, Mata A, Caramês J. Root and root canal morphology of the permanent dentition in a Caucasian population: a cone-beam computed tomography study. Int Endod J. 2017;50:1013-26.
19. Schäfer E, Breuer D, Janzen S. The prevalence of three-rooted mandibular permanent first molars in a German population. J Endod. 2009;35:202-5.
20. Zhang R, Wang H, Tian YY, Yu X, Hu T, Dummer PM. Use of cone-beam computed tomography to evaluate root and canal morphology of mandibular molars in Chinese individuals. Int Endod J. 2011;44:990-9.
21. Martins JNR, Kishen A, Marques D, Nogueira Leal Silva EJ, Caramês J, Mata A, et al. Preferred reporting items for epidemiologic cross-sectional studies on root and root canal anatomy using cone-beam computed tomographic technology: a systematized assessment. J Endod. 2020;46:915-35.
22. Štamfelj I, Hitij T, Strmšek L. Radix entomolaris and radix paramolaris: a cone-beam computed tomography study of permanent mandibular molars in a large sample from Slovenia. Arch Oral Biol. 2024;157:105842.
23. Martins JNR, Gu Y, Marques D, Francisco H, Caramês J. Differences on the root and root canal morphologies between Asian and white ethnic groups analyzed by cone beam computed tomography. J Endod. 2018;44:1096-104.
24. Park JB, Kim N, Park S, Kim Y, Ko Y. Evaluation of root anatomy of permanent mandibular premolars and molars in a Korean population with cone-beam computed tomography. Eur J Dent. 2013;7:94-101.
25. Javed MQ, Srivastava S, Alotaibi BBR, Bhatti UA, Abulhamael AM, Habib SR. A cone beam computed tomography-based investigation of the frequency and pattern of radix entomolaris in the Saudi Arabian population. Medicina (Kaunas). 2023;59:2025.
26. Mantovani VO, Gabriel AES, Silva RG, Savioli RN, Sousa-Neto MD, Cruz-Filho AM. Analysis of the mandibular molars root canals morphology. Study by computed tomography. Braz Dent J. 2022;33:1-8.

Prevalência de *radix molaris* em molares mandibulares numa subpopulação portuguesa

RESUMO

Objetivos: Avaliar a prevalência de *radix molaris* nos primeiros e segundos molares mandibulares de uma subpopulação portuguesa por tomografia computorizada de feixe cónico e caracterizar a sua morfologia.

Métodos: Este estudo retrospetivo transversal englobou 505 exames de tomografia computorizada de feixe cónico, correspondendo a 1641 molares mandibulares (776 primeiros e 865 segundos molares). Registaram-se a presença de *radix molaris*, o respetivo subtipo (*entomolaris* ou *paramolaris*), o dente afetado, a localização e o sexo do paciente. Realizaram-se equações de estimação generalizadas para controlar a correlação entre dentes do mesmo paciente. A subamostra de pacientes afetados (n=18) foi analisada com testes exatos. O nível de significância foi de p<0,05.

Resultados: A prevalência global de *radix molaris* ao nível do dente foi de 1,34% (intervalo de confiança de 95%: 0,87–1,99). *Radix entomolaris* foi o subtipo predominante (1,16%), enquanto *radix paramolaris* foi raro (0,18%). *Radix molaris* foi, descritivamente, mais frequente nos primeiros molares mandibulares. A morfologia Tipo AC e a curvatura Tipo I foram as mais frequentes nos casos de *radix entomolaris*. Não se observaram associações significativas entre a presença de *radix molaris* e o sexo ou o tipo de molar (p>0.05).

Conclusões: *Radix molaris* foi uma variação anatómica pouco frequente nesta subpopulação clínica portuguesa, sendo *radix entomolaris* o subtipo predominante. Apesar de mais frequente nos primeiros molares mandibulares, não foi encontrada associação significativa com o tipo de molar. O reconhecimento desta variação é importante para reduzir o risco de canais não identificados e de insucesso do tratamento endodôntico. (Rev Port Estomatol Med Dent Cir Maxilofac. 2026;67(x):xxx-xxx)

Palavras-chave:
Anatomia
Tomografia Computadorizada de Feixe Cónico
Endodontia
Prevalência
Tratamento do Canal Radicular
Dente