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Frequency and anatomical configuration of *Radix entomolaris* and *Radix paramolaris* in mandibular molars assessed by cone-beam computed tomography

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Abstract
Objective: To determine the frequency and anatomical configuration of *Radix entomolaris* and *Radix paramolaris* in mandibular molars using cone-beam computed tomography (CBCT).
Methods: A quantitative, observational, descriptive, cross-sectional, retrospective study was conducted. A total of 750 anonymized tomographic records from adult patients treated at a radiology center in Quito, Ecuador, were analyzed. Multiplanar assessment included permanent mandibular molars and recorded sex, age group, laterality, number of roots and canals, internal configuration according to Vertucci, and three-dimensional root morphology. Frequencies, percentages, and 95% confidence intervals were calculated; associations with sex and age were explored using the chi-square test, with $\alpha = 0.05$.
Results: *Radix entomolaris* was identified in 44 of 750 cases (5.9%; 95% CI: 4.4-7.8), whereas no cases of *Radix paramolaris* were observed. The frequency was 5.9% in both men and women and was not associated with sex ($\chi^2 = 0.00006$; $p = 0.994$) or age group ($\chi^2 = 1.654$; $p = 0.647$). Among positive cases, 29 were unilateral (65.9%) and 14 bilateral (31.8%); 44 had three roots and four canals, all coded records corresponded to Vertucci Type I, and 43 accessory roots were separate (97.7%).
Conclusions: *Radix entomolaris* was a relatively infrequent but clinically relevant anatomical variant, predominantly characterized by a separate distolingual root with an independent canal. The absence of *Radix paramolaris* is limited to the sample studied. In selected cases, CBCT supports three-dimensional characterization and may reduce the risk of missing accessory roots or canals.

Keywords: *Radix entomolaris*, *Radix paramolaris*, mandibular molars, cone-beam computed tomography, root anatomy

Introduction

The success of endodontic treatment depends, among other factors, on complete recognition of the external and internal anatomy of the root canal system. Mandibular molars usually have two roots, one mesial and one distal, and three or four canals; however, this pattern is a clinical reference rather than an invariable configuration. Additional roots may alter access design, orifice location, instrumentation, irrigation, and obturation. When one of these structures remains unidentified, spaces capable of harboring pulp tissue or microorganisms may persist and compromise the treatment prognosis.

Among the variations of greatest interest are *Radix entomolaris* (RE), usually located distolingually, and *Radix paramolaris* (RP), located mesiobuccally. In addition to altering the external morphology of the molar, these roots may contain independent, narrow, and curved canals. Calberson *et al*. (2007) [5] emphasized that preoperative recognition, access modification, and careful management of curvatures are essential for treatment. Although Vertucci's classification (1984) [25] predates the widespread adoption of three-dimensional imaging, it remains a useful reference for describing the course of the root canal system.

The frequency of RE varies considerably among populations. The multinational study and meta-analysis by Hatipoğlu *et al*. (2023) [11], based on images of mandibular first molars from 15 countries, estimated a global prevalence of 3%, with substantial geographic heterogeneity. In a Chilean population, Betancourt *et al*. (2022) [4] reported 5.7%, whereas Duman *et al*. (2020) [8] described differences between first and second molars in a Turkish population. This variability precludes uncritical extrapolation of values from one population to another and supports the generation of local evidence using homogeneous diagnostic criteria.

Periapical radiography is indispensable for initial endodontic assessment, but its two-dimensional nature may obscure accessory roots because of structural superimposition. CBCT provides axial, coronal, and sagittal reconstructions that make it possible to trace root continuity, establish its position, and identify an independent canal. Nevertheless, clinical use should be selective and based on whether three-dimensional information could change the diagnosis or treatment plan, in accordance with optimization and radiation-protection principles (European Society of Endodontology, 2019) [22]. In retrospective research, analysis of previously acquired images allows these variants to be studied without additional exposure.

In Ecuador, tomographic information on RE and RP remains scarce. This gap limits the availability of population-specific anatomical references for specialist education and clinical practice. Therefore, this study aimed to determine the frequency and anatomical configuration of RE and RP in mandibular molars using CBCT and to describe their distribution according to sex, age, laterality, number of roots and canals, Vertucci configuration, and three-dimensional morphology.

Materials and Methods

A quantitative, observational, descriptive, cross-sectional, retrospective study was conducted. The primary unit of analysis was each patient's tomographic record. Images were obtained from Xplora: Diagnóstico e Imagen Maxilofacial in Quito, Ecuador, and had previously been acquired for diagnostic purposes. The study population comprised CBCT scans of individuals older than 18 years with evaluable permanent mandibular first or second molars. The final sample included 750 cases and 2,654 available molars (teeth 36, 46, 37, and 47). The planned sample size was calculated for a finite population, with 95% confidence, an expected proportion of 0.50, and a maximum error of 3%.

Images of sufficient quality to assess anatomy in all three planes and without distortion preventing recognition of roots and canals were included. Molars with previous endodontic treatment, intraradicular metallic artifacts, severe calcifications, root resorption, morphological alterations precluding interpretation, or inadequate diagnostic resolution were excluded. Selection depended on the availability of studies meeting these conditions.

Structured tomographic assessment was performed on DICOM files using OnDemand3D™ Communicator. Each volume was oriented along the long axis of the tooth; standardized settings of brightness 50, contrast 70, and sharpness 3 were used. The axial plane served as the primary reference and was reviewed from the cementoenamel junction to the apex using sequential slices of approximately 0.2-0.3 mm. Coronal and sagittal planes were used to confirm continuity, separation or fusion, divergence, curvature, and the presence of an independent canal.

An additional root was classified as RE when it occupied the distolingual region and as RP when it was located in the mesiobuccal region. Diagnosis required three conditions: a clearly defined additional root, a consistent finding in at least two planes, and an independent root canal. Sex, age group, available teeth, laterality, number of roots, number of canals, Vertucci configuration, and three-dimensional configuration (separate, partially fused, or fused) were recorded. The database recorded RE and RP at the patient level rather than for a specific tooth; therefore, frequency is expressed by case and does not allow direct comparison between first and second molars.

Data were cleaned in Microsoft Excel and processed in SPSS version 21.0. Absolute frequencies, percentages, and a 95% confidence interval for RE frequency were calculated. Associations between RE and sex or age group were explored using the chi-square test, with a significance level of 0.05. No inferential analyses were applied to RP because no positive cases were observed. The study was not designed to establish causality.

The analysis used anonymized records and involved neither intervention nor additional radiation exposure. Personal identifiers were omitted, access was restricted to the authorized team, and results were reported in aggregate. Institutional authorization was obtained to use the images for academic and scientific purposes, and the study was conducted in accordance with the principles of confidentiality, risk minimization, and protection of clinical data.

Results

The sample included 426 women (56.8%), 323 men (43.1%), and one record without valid sex data. The 18-29-year age group was the largest (29.7%), followed by 30-39 years (27.3%), 50 years or older (22.1%), and 40-49 years (20.7%); one case could not be classified. Of the 2,654 available molars, 1,244 were first molars (46.9%) and 1,410 were second molars (53.1%).

Table 1: Frequency of *Radix entomolaris* and *Radix paramolaris* (n = 750)

Finding	Present, n (%)	Absent, n (%)
Radix entomolaris	44 (5.9)	706 (94.1)
Radix paramolaris	0 (0.0)	750 (100.0)

Source: Prepared by the authors from the analyzed tomographic database.

RE was identified in 44 cases, corresponding to 5.9% (approximate 95% CI: 4.4-7.8). No RP was identified. The database structure showed that 43 positive cases had at least one first molar available and 41 had at least one second molar; however, the finding could not be assigned to a specific tooth. Consequently, these data describe tooth availability rather than prevalence by molar type.

Table 2: Distribution of *Radix entomolaris* according to sex and age group

Variable	RE present	RE absent	Total	% within group
Male sex	19	304	323	5.9
Female sex	25	401	426	5.9
18-29 years	16	207	223	7.2
30-39 years	9	196	205	4.4
40-49 years	10	145	155	6.5
≥ 50 years	9	157	166	5.4

Source: Prepared by the authors from the analyzed tomographic database.

* Vertucci classification was recorded only in positive cases and does not constitute a comparison with molars without an accessory root.

The finding was predominantly unilateral. After excluding the case without valid laterality data, 67.4% of findings were unilateral and 32.6% bilateral. All positive cases were coded as having three roots and four canals, and the accessory-root canal corresponded to Vertucci Type I. Separate morphology was overwhelmingly predominant (97.7%); only one case showed fusion, and no partial fusion was recorded.

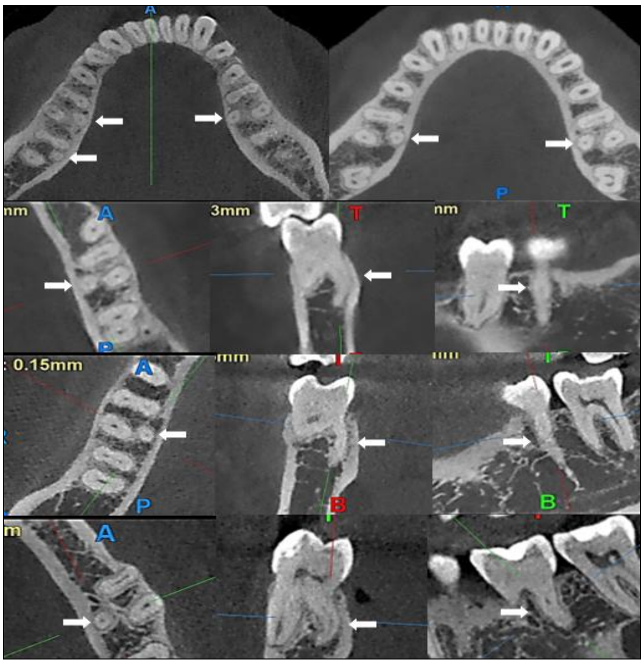

Fig 1: *Radix entomolaris* and *Radix paramolaris* in mandibular molars

Discussion

The main finding was a patient-level RE frequency of 5.9%, with predominance of separate roots, an independent canal, and unilateral presentation. This value exceeds the global prevalence of 3% reported by Hatipoğlu *et al*. (2023) [11] for mandibular first molars from 15 countries, but is close to the 5.7% described by Betancourt *et al*. (2022) [4] in a subpopulation from southern Chile. This comparison should be interpreted cautiously: the multinational study evaluated mandibular first molars bilaterally, whereas the present database included first and second molars and recorded the finding by case rather than by tooth. Differences in unit of analysis, population composition, and selection criteria may affect the observed estimate.

International variability in RE is well documented. Duman *et al*. (2020) [8] found differences between first and second molars in a Turkish population and emphasized the value of CBCT for identifying the variant. The present Ecuadorian sample could not reproduce that comparison because the field identifying RE was not linked to tooth 36, 46, 37, or 47. This limitation prevents a conclusion that the variant was more frequent in first or second molars and requires the estimate to remain at the patient level. Even so, the 4.4-7.8% confidence interval indicates that the finding was not exceptional in the database studied.

No association between RE and sex was observed, consistent with the identical frequency of 5.9% in both groups. There was also no association with age. Because root morphology is established during tooth development, the absence of an age gradient is biologically plausible; percentage differences among groups may reflect sampling variation. However, age was grouped, reducing analytical sensitivity and precluding evaluation as a continuous variable.

Unilateral predominance was consistent with the trend reported in some populations, although bilateral occurrence reached 32.6% among cases with valid data. This proportion is clinically relevant: identifying RE in one side of the arch increases the need to carefully examine the contralateral molar, without assuming that bilateral occurrence is mandatory. Hatipoğlu *et al*. (2023) [11] also highlighted substantial bilateral occurrence, supporting symmetrical assessment of the anatomy when images are available.

All RE cases in the database were associated with three roots, four canals, and a Type I configuration, and 97.7% appeared as separate roots. Clinically, this pattern describes a distinct distolingual structure with a canal that remains independent to the apex. It may facilitate tomographic identification, but may also increase the risk of omission when access and exploration are limited to the conventional pattern. The curved morphology commonly associated with RE additionally requires cautious instrumentation to reduce iatrogenic errors (Calberson *et al*., 2007) [5].

The absence of RP does not demonstrate that this variant is absent from the Ecuadorian population. It only indicates that it was not observed among the 750 records. Given its reported low frequency, a sample from a single center may fail to capture positive cases. Consequently, its laterality, internal configuration, and relationship with demographic variables could not be analyzed. Multicenter studies and tooth-level coding would provide greater capacity to estimate this uncommon variant.

The results support the value of CBCT as a method for anatomical characterization, but do not justify its routine use in every treatment. The European Society of Endodontology (2019) [22] recommends considering three-dimensional information when conventional assessment does not resolve a clinically relevant question. Thus, in the presence of atypical root contours, persistent superimposition, difficulty interpreting the pulp-chamber map, or suspicion of an additional root, limited-field CBCT may provide decisive information, always under the principle of dose optimization.

The main limitations were patient-level rather than tooth-level recording of the finding, grouped age data, Vertucci coding only in positive cases, the retrospective design, and the single-center setting. No intra- or interobserver agreement assessment was documented in the final database, an aspect that should be incorporated into future morphological studies. These conditions limit comparisons by molar type and nationwide generalizability, but do not negate the initial descriptive contribution of a large Ecuadorian sample.

Conclusions

In the sample analyzed, *Radix entomolaris* was present in 5.9% of cases, whereas *Radix paramolaris* was not identified. RE frequency was not statistically associated with sex or age group. Unilateral presentation, three roots, four canals, Vertucci Type I configuration, and separate root morphology predominated; although less frequent, bilateral occurrence was observed in nearly one-third of cases with valid information.

These findings confirm that RE is a relatively uncommon variant that can nevertheless increase the diagnostic and therapeutic complexity of mandibular molars. Recognition requires acknowledging that the pattern of two roots and three canals is not universal. When clinical and conventional radiographic assessment suggests atypical anatomy, selective use of CBCT may help locate the accessory root and its canal, guide access, and reduce omissions.

The estimate should be interpreted at the patient level rather than the tooth level. Ecuadorian multicenter studies are needed that record the affected tooth, age as a continuous variable, the internal configuration of all molars, and diagnostic agreement among observers. These improvements will enable comparisons between first and second molars, more precise estimation of rare variants such as RP, and stronger external validity.

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