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Review article

Presence of a distolingual root in mandibular first molars as an indicator of association with other tooth canal anatomies: A systematic review

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Abstract Understanding anatomical variations in root canal morphology is crucial for achieving successful endodontic outcomes. The presence of a distolingual root (DLR) in mandibular first molars (MFMs) has been proposed as an indicator of complex root canal anatomy in other teeth. This systematic review aimed to evaluate the association between DLRs in MFMs and root canal configurations in other teeth across different ethnic populations. Following PRISMA guidelines, a comprehensive search of PubMed, MEDLINE Complete, Scopus, ClinicalKey, and relevant registries was performed up to October 10, 2025, using the keywords "distolingual root" and "radix entomolaris." Inclusion criteria comprised *in vivo* CBCT-based clinical studies that reported both DLR prevalence and its association with root canal morphology of other teeth. Study quality was assessed using the Newcastle–Ottawa Scale. Twelve studies involving 8,024 participants and

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51,762 teeth were included. Reported DLR prevalence ranged from 3.6 % to 41.2 %. Studies from East Asia (Taiwan, South Korea, China) consistently demonstrated positive correlations between DLRs in MFMs and complex canal anatomies in mandibular lateral and central incisors and first premolars. In contrast, data from India and Turkey showed variable or negative associations. The presence of a DLR in MFMs may serve as a reliable anatomical marker for anticipating complex canal configurations in adjacent or contralateral teeth. Ethnic differences were evident, highlighting the need for standardized CBCT-based multicenter studies to confirm these findings and improve predictive endodontic diagnosis.

Introduction

Successful root canal therapy relies primarily on achieving thorough chemomechanical cleaning and precise obturation of the canal system.[1] These key procedures depend heavily on a clinician's comprehensive knowledge of root and canal morphology, which often exhibits considerable variation. Recognizing potential anatomical differences, such as additional canals, accessory branches, apical ramifications, or atypical root configurations, greatly improves the practitioner's ability to identify, access, and debride the entire canal network. In contrast, limited awareness of these variations can result in missed canals, incomplete disinfection, or suboptimal obturation, all of which contribute to persistent periapical disease and treatment failure.[2]

Research on root canal anatomy has been conducted for more than fifty years. In the past, particularly between the 1970s and 1990s, the primary method for studying canal morphology involved decalcifying extracted teeth and injecting dye or ink,[3] as exemplified by the highly cited work of Vertucci.[4] With the advent of advanced imaging technologies, especially cone-beam computed tomography (CBCT), first introduced in dentistry by Mozzo et al., in 1998, researchers gained a powerful non-invasive tool for three-dimensional visualization.[5] Since then, CBCT has become the most widely used technique for investigating root canal morphology because of its non-invasive, time-efficient, and three-dimensional imaging capabilities.[3] Beyond research applications, clinicians can now directly observe the complex internal anatomy of teeth, improving both diagnostic accuracy and treatment planning. However, some patients remain reluctant to undergo CBCT imaging due to concerns about radiation exposure, even though studies have demonstrated that small field-of-view (FOV) CBCT scans deliver low and safe radiation doses.

Wu et al. were the first to report the relationship between root and root canal variations among different tooth types and demonstrated that the presence of a distolingual root (DLR) in mandibular first molars (MFMs) was significantly associated with an approximately 20 % higher frequency of complex root canal configurations in mandibular first premolars.[6] Based on this study, clinicians can gain the additional information by taking a mesial-shift periapical film of MFMs. Although the prevalence of DLRs has been widely documented,[7] their potential associations with other root canal complexities across various teeth have also been explored in numerous studies.[8–11] Understanding these anatomical correlations may assist clinicians in anticipating canal morphology in adjacent or contralateral teeth, thereby improving diagnostic accuracy and treatment outcomes. This review aims to systematically analyze current evidence regarding the relationship between the presence of DLRs in MFMs and root canal variations in other teeth across different ethnic populations, contributing to a more predictive and anatomy-based approach to endodontic diagnosis and therapy.

Materials and methods

This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Table S1) and was prospectively registered in PROSPERO (registration number: CRD420251165342).

Database search and identification of eligible studies

A systematic literature search was conducted in PubMed, MEDLINE Complete, Scopus, ClinicalKey, and relevant trial registries from inception to October 10, 2025, using the following search terms: ("Distolingual root" OR "Radix entomolaris"). The electronic search strategy combined MeSH terms and free-text words using Boolean operators (AND, OR). The searches were limited to studies published in English, with no restriction on publication year. In addition, a manual search was performed to identify potentially eligible studies published in the *Journal of Endodontics*, *International Endodontic Journal*, and *Australian Endodontic Journal*. The search was conducted to identify additional relevant studies published between January 2000 and August 2024 in the reference lists of included articles and related reviews. Studies screened independently by two authors with a process to resolve differences.

Inclusion and exclusion

The aim of this systematic review was to analyze clinical studies investigating the association between the presence of a distolingual root (DLR) in permanent MFMs and root canal anatomy in other teeth.

Inclusion criteria were as follows:

1. Studies including a sufficient number of participants to allow for statistical analysis.
2. Articles reporting the number of participants as well as the number and type of teeth evaluated.
3. *In vivo* studies utilizing cone-beam computed tomography (CBCT) for the evaluation of root and root canal morphology.
4. Abstracts and full-text articles available in English and published in peer-reviewed scientific journals.

Exclusion criteria were as follows:

1. *Ex vivo* or *in vitro* studies, case reports, review articles, short communications, or letters to the editor.
2. Studies that did not disclose, or from which it was not possible to extract, data regarding the number of participants and the prevalence of DLR in MFMs.

Data extraction and quality evaluation

Two independent reviewers screened the articles that met the predefined inclusion and exclusion criteria and extracted the relevant data. Any discrepancies between reviewers were resolved through discussion with the corresponding author. Extracted information included the number of participants, number of teeth analyzed, and the prevalence of distolingual roots (DLR) in MFMs. When essential data were missing or incomplete, the corresponding authors were contacted by email to obtain additional information. The methodological quality of the included studies was evaluated by two reviewers using the Newcastle—Ottawa Scale (NOS), and any differences in assessment were resolved by consensus with the corresponding author (Table S2).

Results

Study identification and collection

The PRISMA flowchart illustrating the literature selection process is shown in Fig. S1. After removing duplicate records and excluding irrelevant studies based on titles and abstracts, 12 studies met the inclusion criteria and were included in the final analysis. These comprised five articles from Taiwan,[6,8—11] two from Turkey,[12,13] and one each from South Korea,[14] China,[15] India,[16] Malaysia,[17] and Saudi Arabia.[18] Together, the eligible publications encompassed 8,024 participants and 51,762 teeth. A detailed summary of the extracted data is presented in Table 1.

Evaluation of quality of the selected studies

Regarding methodological quality, all included studies were rated as high quality. No studies were deemed to have a high risk of bias. A detailed evaluation of the quality assessments by NOS was provided in Table S2.

Prevalence of DLR in MFMs

Among the 12 included studies, all reported the prevalence of a DLR in MFMs, with rates ranging from 3.6 % to 41.2 %. The origins of country across East Asia, Southeast Asia, South Asia and Middle East. Number of participants in these studies varied from 150 to 2,000, and the number of examined teeth ranged from 900 to 16,000. Each study used the presence of a DLR in MFMs as an indicator to explore associations with other tooth types, including mandibular anterior teeth, mandibular first premolars, and mandibular second molars (Table 1).

Association of other tooth canal anatomy and presence of a DLR in MFMs

Regarding the association between the presence of a DLR in MFMs and other tooth canal anatomies, data from East Asian countries, including Taiwan, South Korea, and China, consistently reported a positive correlation between DLRs in MFMs and complex canal configurations in mandibular lateral incisors. Additionally, studies from South Korea demonstrated an association with mandibular central incisors, whereas the Taiwanese cohort revealed a relationship with mandibular first premolars (Table 1).

Interestingly, two studies from Turkey reported markedly different prevalence rates of distolingual roots (DLRs) in mandibular first molars (MFMs), 3.6 % in one study and 41.2 % in the other. Both investigations included a considerable number of participants and examined teeth. Kurt et al. identified a positive association between the presence of DLRs in MFMs and complex canal anatomy in mandibular anterior teeth, whereas Aydin et al. found no significant correlation between DLRs in MFMs and canal configurations in the maxillary first premolars, maxillary second molars, or mandibular first premolars. Furthermore, a study from India by Sheth et al. reported a negative correlation, indicating that the presence of DLRs in MFMs was associated with a lower frequency of complex root canal configurations in mandibular incisors within the Indian population (Table 1).

Regarding research from Southeast Asia, Khazin et al. reported an increased prevalence of C-shaped canals in mandibular second molars when a DLR was present in MFMs. Similarly, a study from Saudi Arabia demonstrated a positive correlation between the presence of DLRs in MFMs and complex canal morphology in mandibular central and lateral incisors (Table 1).

Discussion

The present systematic review synthesized evidence on the association between the presence of a DLR in MFMs and

Table 1 The collected studies' essential information.

First author	Year of pub.	Journal	Origin	Number of participants (N)	Number of teeth (n)	Prevalence of DLR in MFMs	Targeting tooth type	Significant association
Wu et al.[6]	2017	J Endod	Taiwan	233	932	24.7 %	Mandibular first premolars	Yes
Wu et al.[8]	2018	J Endod	Taiwan	300	1200	24.3 %	Mandibular lateral incisors	Yes
Wu et al.[9]	2018	J Endod	Taiwan	400	1600	23.0 %	Mandibular central incisors	Yes
Wu et al.[10]	2018	J Endod	Taiwan	400	1600	23.0 %	Mandibular first premolars	Yes
Wu et al.[11]	2020	Quintessence Int	Taiwan	380	1520	23.3 %	Mandibular second molars	Yes
Lee and Seo[14]	2022	BMC Oral Health	Korea	150	900	27.0 %	Mandibular central, lateral incisors	Yes
Yang et al.[15]	2022	BMC Oral Health	China	1896	15168	23.4 %	Mandibular anterior teeth	Yes[a]
Aydin[12]	2022	Odontology	Turkey	630	5040	3.6 %	Maxillary second molars Maxillary first premolars Mandibular first premolars	No
Sheth et al.[16]	2024	Sci Rep	India	400	2400	6.6 %	Mandibular central incisors Mandibular lateral incisors	Yes[b]
Khazin et al.[17]	2025	Aust Endod J	Malaysia	1015	2030	21.2 %	Mandibular second molars	Yes[c]
Kurt and Solakoğlu[13]	2025	BMC Oral Health	Turkey	2000	16000	41.2 %	Mandibular anterior teeth	Yes[d]
Mirza[18]	2025	Diagnostics	Saudi Arabia	562	3372	5.2 %	Mandibular central incisors Mandibular lateral incisors	Yes

Year of pub., year of publication; DLR, distolingual root; MFMs, mandibular first molars.

[a] The possibility of complicated root canal configuration in mandibular lateral incisors was higher when DLR appeared in MFMs.

[b] The possibility of complicated root canal configuration in mandibular incisors was lesser in the presence of DLRs in MFMs among theIndian population.

[c] The increased appearance of C-shaped canal in mandibular second molars when DLR was present in MFMs.

[d] DLR in MFMs were significantly associated with complex mandibular anterior tooth canal configurations.

variations in root canal morphology of other teeth across different populations. The included studies consistently demonstrated that additional roots or complex configurations in one tooth may reflect developmental patterns shared by neighboring or contralateral teeth. In particular, East Asian studies from Taiwan, South Korea, and China revealed a strong correlation between the presence of DLRs in MFMs and complex canal systems in mandibular lateral incisors and, to a lesser extent, mandibular central incisors and first premolars.[6,8–11,14,15] These findings suggest that the presence of a DLR may serve as a clinically useful anatomical predictor for detecting additional canals in adjacent teeth. This concept aligns with the broader understanding that root morphology follows genetic and developmental determinants, where concurrent variations can appear along the same dental arch or quadrant.

The variation in DLR prevalence among different ethnic groups further underscores the role of population-specific factors in root canal morphology. The prevalence in the reviewed studies ranged widely, from 3.6 % in a Turkish cohort to 41.2 % in another Turkish sample, reflecting both biological diversity and methodological differences in imaging field of view or diagnostic criteria.[12,13] Generally, East Asian populations reported higher DLR prevalence, consistent with earlier morphologic and CBCT studies, whereas lower rates were observed in Middle Eastern and South Asian cohorts (Table 1). The substantial difference between the two Turkish studies may be related to sample size, geographic region, or imaging resolution, highlighting the need for standardized CBCT protocols in morphologic epidemiology. Interestingly, Indian data suggested a negative correlation, with DLRs associated with a reduced frequency of complex canal configurations in mandibular incisors, which may indicate distinct developmental trajectories across populations.[16] The observed differences in root and canal morphology among populations may also be influenced by variations in CBCT image quality, such as voxel size, field of view, and resolution, rather than solely reflecting true biological variation. Differences in scanning protocols and equipment parameters should therefore be considered when interpreting inter-population comparisons in future studies.

Beyond prevalence differences, the collective findings emphasize the diagnostic implications of DLR identification. The anatomical interplay between MFMs and other teeth may reflect a shared morphogenetic origin, and recognizing such patterns can assist clinicians in anticipating atypical canal anatomy before endodontic procedures. For example, identifying a DLR on a preoperative periapical radiograph or CBCT scan may alert clinicians to examine mandibular anterior or premolar teeth more carefully for additional canals. This predictive concept could enhance the efficiency of treatment planning while minimizing missed anatomy, one of the major causes of endodontic failure. The reviewed studies also reinforce the clinical relevance of small field-of-view CBCT imaging, which offers three-dimensional visualization with acceptable radiation exposure. However, given cost and dose considerations, periapical radiographs combined with anatomical predictors such as DLR presence may provide a reasonable compromise for routine clinical use.

Despite its strengths, this systematic review has several limitations that must be acknowledged. First, the included studies exhibited heterogeneity in imaging parameters, sample sizes, and classification criteria for canal morphology, precluding meta-analytic pooling of data. Second, all eligible studies were cross-sectional and observational, limiting the ability to infer causality between the presence of a DLR and variations in other teeth. Third, although the Newcastle—Ottawa Scale ratings indicated high methodological quality, potential selection bias and population imbalance remain possible, as most available data originated from East and Southeast Asia. Additionally, some reports lacked detailed demographic stratification, such as age and sex, which could influence developmental variations in root morphology. Finally, publication bias may exist because only English-language, peer-reviewed articles were included. Future research employing standardized CBCT acquisition protocols, consistent classification systems, and broader multinational sampling is warranted to validate these anatomical associations and enhance their clinical applicability.

This systematic review comprehensively analyzed the relationship between the presence of a DLR in MFMs and variations in root canal anatomy of other teeth across diverse populations. The findings consistently indicate that the presence of a DLR may serve as a reliable anatomical marker for predicting complex canal configurations in adjacent or contralateral teeth, particularly in the mandibular anterior and premolar regions. Ethnic differences were notable, with East Asian cohorts demonstrating higher DLR prevalence and stronger correlations than Middle Eastern and South Asian populations, suggesting both genetic and developmental influences. Clinically, recognizing DLRs through radiographic or CBCT examination could help clinicians anticipate anatomical challenges, thereby improving diagnosis, cleaning, shaping, and obturation outcomes.

Despite these insights, further multicenter, standardized CBCT-based investigations are necessary to confirm these associations and clarify population-specific trends. Future studies integrating morphogenetic, genetic, and radiographic analyses will deepen our understanding of root canal anatomy and enhance predictive approaches in precision endodontics.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jds.2025.11.011.

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