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ORIGINAL RESEARCH

MANDIBULAR THIRD MOLAR ROOTS AND THE LINGUAL CORTEX: A CROSS-SECTIONAL CBCT ASSESSMENT OF TOPOGRAPHIC RELATIONSHIP AND MORPHOLOGIC VARIANTS

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ABSTRACT

Background: This study aimed to assess the topographic relationship between mandibular third molar roots and the lingual cortical plate, as well as variations in lingual cortex morphology, using cone-beam computed tomography (CBCT). A root-specific approach was employed to evaluate each root individually in multi-rooted mandibular third molars.

Materials and Methods: A total of 304 CBCT scans (168 females, 136 males; mean age = 35.10 ± 8.34 years) were retrospectively analyzed. The sample included 74.0% two-rooted, 19.7% single-rooted, and 6.3% three-rooted mandibular third molars. Each root was assessed for its topographic relationship to the lingual cortex and categorized as type A (non-contact), B (contact), or C (perforation). Lingual cortex morphology was classified into undercut (U), parallel (P), slanted (S), or round (R) types. Chi-square and Fisher's exact tests were used ($p \leq 0.05$).

Results: Type A was most frequent in single-rooted molars (40.0%, p=0.04) and mesial roots of two-rooted molars (40.9%, p=0.0007), while type B was predominant in distal roots (49.8%, p<0.0001). Three-rooted molars showed no significant differences, though distolingual roots tended toward type B (64.7%, p=0.07). Undercut morphology was most prevalent (77.6%, p<0.0001), with significant differences across all cortex types.

Conclusions: This study presents a root-specific, CBCT-based assessment that provides a more detailed and accurate understanding of the anatomical relationship between mandibular third molar roots and the lingual cortex, as well as variations in lingual cortex morphology. These insights contribute to more precise surgical risk evaluation and support improved decision-making in treatment planning for surgical procedures.

Keywords**:** Cone Beam Computed Tomography (CBCT), Mandibular third molar, Oral Surgery, Digital Imaging/Radiology.

INTRODUCTION

Mandibular third molar extraction is one of the most frequently performed procedures in oral and maxillofacial surgery. Despite its routine nature, it is often associated with complications such as lingual nerve injury, hemorrhage, infection, and displacement of root fragments into adjacent anatomical spaces, including the submandibular, sublingual, and pterygomandibular regions[1,2,3]. These adverse outcomes are often influenced by the anatomical relationship between the third molar roots and surrounding bone structures, particularly the lingual cortical plate[4]. Understanding this spatial relationship between the mandibular third molar roots is essential in preoperative planning to minimize surgical complications and improve clinical outcomes. The lingual cortex in the mandibular third molar region is typically thinner than its buccal counterpart and may exhibit varying morphologies or configurations[5]. These anatomical variations may present zones of structural weakness that may predispose the lingual plate to fracture or dehiscence during surgical procedures [6]. Fracture or perforation of the lingual cortex not only complicates the extraction process but also elevates the risk of root tip displacement and potential neurovascular complications, such as lingual nerve injury [7]. The lingual nerve is in direct contact with the lingual plate in almost 25% of cases and its position is influenced by the mandibular third molar position [8]. Consequently, accurate assessment of lingual plate morphology and its spatial relationship with mandibular third molar roots are of critical importance in high-risk cases.

Traditionally, intraoral periapical and panoramic radiographs have been employed for preoperative imaging due to their accessibility and low radiation dose. While these modalities provide acceptable two-dimensional visualization of dental structures, they are limited in their ability to depict the bucco-lingual dimension and may suffer from distortion and superimposition of anatomical structures [9,10]. Advanced imaging techniques, particularly cone-beam computed tomography (CBCT), have emerged as essential tools in oral and maxillofacial diagnostics, offering high-resolution three-dimensional visualization of osseous structures with reduced radiation exposure compared to conventional CT. CBCT allows for precise assessment of the proximity of the third molar roots to the lingual plate and lingual cortical thickness morphology, thereby facilitating more accurate risk stratification and surgical planning [11,12,13].

Despite the growing use of CBCT in preoperative evaluations, much of the literature to date has focused on the relationship between mandibular third molar roots and the inferior alveolar canal, with comparatively limited attention given to their relationship with the lingual cortex. Given the clinical significance of this anatomical interface, further investigation is warranted. Therefore, the objective of this study is to evaluate the topographic relationship between mandibular third molar roots and the lingual cortical plate and lingual cortex morphology using CBCT imaging. The findings aim to enhance preoperative assessment protocols and support evidence-based clinical decision-making to reduce surgical complications.

MATERIALS AND METHODS

Ethics and Informed Consent Statement

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Faculty of Dentistry, Cairo University, Egypt, known as Research Ethics Committee (REC) with approval number 43 2 90. Informed consent was obtained from all individual participants included in the study.

Eligibility

The CBCT data for this study were retrospectively collected from the database maintained by the Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Cairo University, Cairo, Egypt. All scans had been previously acquired as part of routine dental diagnosis and/or treatment planning. Eligible CBCT scans were selected based on predefined criteria, including patients aged 18–65 years with fully developed mandibular third molar roots and intact lingual cortices. Both erupted and impacted third molars were included, provided the region of interest was clearly visible and the scan quality was adequate (voxel size ≤ 0.4 mm). Scans presenting developmental anomalies, root resorption, canal calcification, previous endodontic treatment, root-associated pathology, restorations, caries, or significant image artifacts were excluded.

Sample Size

Based on a 95% confidence level and a ±5% margin of error, the estimated sample size required to assess prevalence was 304 subjects. Sample size calculation was performed using EPI Info 7.2.2.2 and a total of 304 mandibular third molars that met the inclusion criteria were retrieved from the archive, which was deemed adequate to fulfill the study objectives while ensuring both statistical power and practical feasibility.

CBCT Assessment

Radiographic examination of all patients was done using Planmeca ProMax® 3D Mid (Planmeca OY, Helsinki, Finland) with exposure parameters varying according to patient size, age, and diagnostic purpose. Only scans with a maximum voxel size of 0.4 mm were included in the analysis to ensure optimal image resolution. CBCT scans were collected in a digital DICOM format from the computer workstation for retrospective data analysis. The images were then imported to Planmeca Romexis® Viewer application (Romexis version 4.6.2.R; Planmeca OY,Helsinki, Finland) for assessment. Two oral and maxillofacial radiologists, one with six years of experience and the other with at least twelve years of experience, independently analyzed the CBCT scans retrospectively. Prior to data collection, both examiners participated in calibration sessions to standardize the assessment protocol. To ensure consistency between observers, inter-reader agreement was assessed using intraclass correlation coefficients (ICC) with a 95% confidence interval.

CBCT images were evaluated in the three primary orthogonal planes: axial, coronal, and sagittal. Initially, sagittal and coronal reformatted sections were generated, with the vertical reference lines aligned parallel to the long axis of the root under examination. Subsequently, the horizontal reference lines were adjusted in the axial view to ensure proper alignment with the same root (Figure 1).

Figura1. Adjusting the intersection lines and scan orientation to ensure proper viewing of the root to be examined

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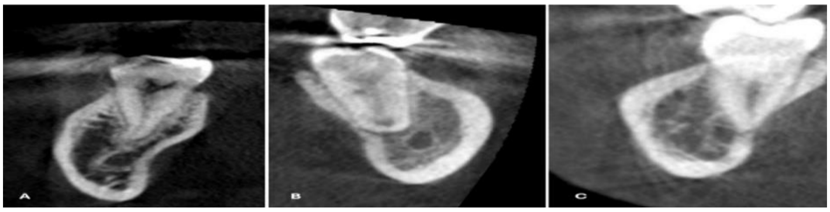

Figura 2. Example of relationship between mandibular third molar root and lingual cortex. (A) represents type A (Non-Contact), (B) represents type B (Contact), while (C) represents type C (Perforation)

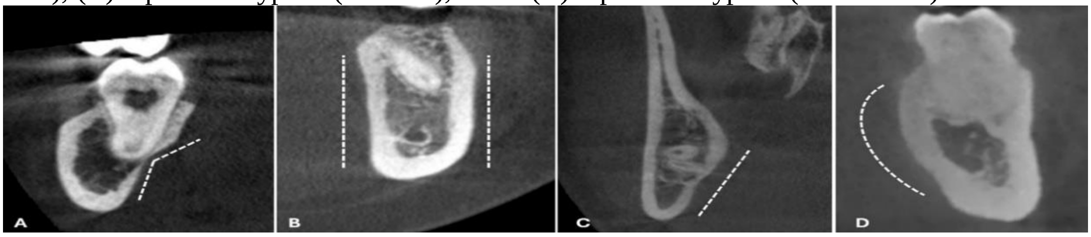

Figure 3. Example of different lingual cortex morphology. (A) Undercut 'U', (B) Parallel 'P', (C) Slanted 'S', and (D) Round 'R'

Statistical Analysis

Statistical analysis was performed with SPSS 27®, Graph Pad Prism® and Microsoft Excel 2016. All data presented as count (N) and frequency (%). All comparisons were performed by using Chi square test and Fishers Exact test. The significance level was set at p≤0.05 within all tests.

RESULTS

The study sample comprised 304 cases, with a mean age of 35.10 years (SD = 8.34), and a gender distribution of 55.3% females ($n = 168$) and 44.7% males ($n = 136$) as presented in Table 1. The majority of third molars had two roots (74.0%, $n = 225$), while single-rooted and three-rooted teeth were less common, accounting for 19.7% ($n = 60$) and 6.3% ($n = 19$), respectively as shown in Table 2. Examination of eruption status in Table 3 demonstrated a highly significant difference in distribution among eruption patterns ($p < 0.0001$). Fully erupted third molars were predominant (78.0%, $n = 237$). Among impacted molars, mesio-angular impaction was the most frequent (13.5%, $n = 41$), followed by horizontal impaction (6.3%, $n = 19$), while straight impaction was notably rare. The inter-reader agreement was good, with an ICC of 0.83 (95% CI), indicating a high level of consistency across observers.

Table 1. Baseline data for all cases

		Mean	Standard Deviation
Age		35.0978	8.34091
		N	%
Gender	Male	136	44.7%
	Female	168	55.3%

Table2.Distribution of number of roots among cases

	N	%	P value
Single root	**60 [a]**	**19.7%**	**<0.0001***
Two roots	**225 [b]**	**74.0%**	
Three roots	**19 [c]**	**6.3%**	

**Significant difference as P≤ 0.05.*

Counts with different superscript letters were significantly different as P ≤0.05.

Table 3. Distribution of different third molar eruption patterns among all cases

		N	%	P value
Eruption	Erupted	237 [a]	78.0%	<0.0001*
	Horizontal Imp	19 [b]	6.3%	
	Straight Impacted	7 [c]	2.3%	
	Mesio-Angular Imp	41 [d]	13.5%	

Counts with different superscript letters were significantly different as P ≤0.05.

**Significant difference as P≤ 0.05.*

Topographic relationship between mandibular third molar roots and the lingual cortex

The assessment of the topographic relationship between mandibular third molar roots and the lingual cortex is summarized in Table 4. For single-rooted third molars, the distribution of topographic relationships differed significantly (p = 0.04). Type A was the most prevalent (40.0%, *n* = 24), followed by type B (36.7%, *n* = 22) and type C (23.3%, *n* = 14). Statistical comparison showed a significant difference between types A and C, while type B did not significantly differ from either. In two-rooted teeth, the mesial root showed a significant difference in distribution (p = 0.0007), with type A predominating (40.9%, *n* = 92), followed by type B (33.3%, *n* = 75) and type C (25.8%, *n* = 58). In contrast, the distal root showed a highly significant variation (p < 0.0001), with type B markedly predominant (49.8%, *n* = 112), and types A and C occurring at comparable frequencies (24.9%, *n* = 56 and 25.3%, *n* = 57, respectively). For three-rooted teeth, neither the mesial nor distal roots showed significant differences in distribution (p = 0.76 for both), with type A and B occurring at similar frequencies (approximately 52.6% vs. 47.4%), and type C not observed. The distolingual third root exhibited a non-significant trend toward type B predominance (64.7%, *n* = 11) over type A (35.3%, *n* = 6) (p = 0.07). The rare mesiobuccal third root (*n* = 2) exclusively demonstrated type A relationships.

Table 4. Assessment of the topographic relationship between mandibular third molar roots and lingual cortex

		Type		N	%	P value
Single root		A		24^{a}	40.0%	0.04*
		B		22^{b}	36.7%	
		C		14^{b}	23.3%	
Two roots	Mesial root	A		92^{a}	40.9%	0.0007*
		B		75^{ab}	33.3%	
		C		58^{b}	25.8%	
	Distal root	A		56^{a}	24.9%	<0.0001*
		B		112^{b}	49.8%	
		C		57^{a}	25.3%	
Three roots	Mesial root	A		10	52.6%	0.76
		B		9	47.4%	
		C		0	0.0%	
	Distal root	A		10	52.6%	0.76
		B		9	47.4%	
		C		0	0.0%	
	Accessory 3rd root	Distolingual (Radix Entomolaris	A	6	35.3%	0.07
			B	11	64.7%	
		Mesiobuccal (Radix Paramolaris)	A	2	100.0%	-----
			B	0	0.0%	

Association Between Topographic Relationship and Other Factors

The association between third molar root topographic relationship and eruption status is detailed as follows; for single-rooted third molars, a significant difference was noted ($p = 0.001$). Type A was most prevalent in erupted teeth (50.0%) and horizontally impacted cases (40.0%), while absent in straight-impacted teeth. In contrast, type C was predominantly associated with mesio-angular impactions (62.5%) and was rare in other groups.

Among two-rooted molars, both mesial and distal roots showed highly significant associations with eruption status ($p = 0.0001$). In mesial roots, type A was found in 48.4% of erupted teeth but was nearly absent in impacted molars, except for 8.0% in mesio-angular cases. Type C was most frequent in straight-impacted (100.0%) and mesio-angularly impacted teeth (68.0%). A similar pattern was observed in distal roots, where type B predominated in erupted molars (56.5%) but declined markedly in impacted cases. Type C appeared in all straight-impacted and 84.0% of mesio-angularly impacted molars. For three-rooted molars, no significant association was found in mesial or distal roots ($p = 0.11$), though type A was more frequent in erupted teeth (58.8%) and absent in impacted ones. Similarly, no significant difference was observed in the distolingual root ($p = 0.26$), although type A occurred in 40.0% of erupted molars and was absent in impacted teeth.

No significant gender differences were observed in topographic relationships for **single-rooted** ($p = 0.46$) or two-rooted third molars, including both mesial ($p = 0.86$) and distal roots ($p = 0.17$).

In three-rooted molars, a significant association was noted: type A configuration was present in 66.7% of males and absent in females for both mesial and distal roots ($p = 0.01$). No significant gender differences were found in the distolingual ($p = 0.26$) or mesiobuccal root positions.

Lingual Cortex Morphology

The distribution of lingual cortex morphology among the 304 cases exhibited highly significant differences between categories ($p<0.0001$). The "U" morphology type was overwhelmingly predominant, constituting 77.6% (n=236) of all cases, making it more than six times more common than any other morphological variant. The "P" morphology represented the second most frequent type at 12.5% (n=38), followed by "S" morphology at 6.6% (n=20), while the "R" morphology was notably rare, observed in only 3.3% (n=10) of cases. Statistical analysis confirmed significant differences between all four morphological types presented in Table 5.

Table 5. Distribution of lingual cortex morphology among all cases

		N	%	P value
Lingual Cortex Morphology	U	236 [a]	77.6%	<0.0001*
	P	38 [b]	12.5%	
	R	10 [c]	3.3%	
	S	20 [d]	6.6%	

Counts with different superscript letters were significantly different as P ≤0.05.

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Association Between Lingual Cortex Morphology and Other Factors

The association between lingual cortex morphology and patient age was evaluated, and one-way ANOVA revealed no statistically significant differences. revealed a statistically significant difference in age among the different morphological types (p = 0.04). Patients with **"U"** and **"P"** morphologies showed comparable mean ages (35.53 ± 8.61 years and 35.7 ± 7.63 years, respectively), with no significant difference between these groups. The **"R"** morphology group presented an intermediate mean age (32.75 ± 7.46 years), which did not differ significantly from either the "U"/ "P" groups or the **"S"** morphology group. Notably, the **"S"** morphology was associated with a significantly younger mean age (28.83 ± 2.21 years) compared to both "U" and "P" morphologies. No statistically significant association was found between gender and lingual cortex morphology (p=0.136), although the "r" morphology showed a notable male predominance.

DISCUSSION

This study evaluated the topographic relationship between mandibular third molar roots and the lingual cortical plate, along with variations in lingual cortex morphology in that area, using cone-beam computed tomography (CBCT). With a sample size of 304 cases and a voxel size cutoff of 0.4 mm offering a comprehensive evaluation with high-resolution imaging standards for anatomical assessments.

Our study introduced a novel approach to evaluating the relationship between mandibular third molar roots and the lingual cortical plate by assessing each root individually in multi-rooted teeth. In contrast, previous studies typically focused only on the root closest to the lingual cortex. While informative, that approach may have overlooked the variability among roots in the same tooth. This difference in methodology may partly explain the higher frequency of type A (non-contact) relationships observed in our findings compared to other studies that reported a higher prevalence of types B and C[14]. By providing an individualized root analysis, our method offers clinically relevant insights, especially valuable when planning surgical procedures involving root separation or sectioning.

For single-rooted molars, type A relationship was the most prevalent, followed by type B and a significantly lower frequency of type C, possibly since a smaller number of roots can lead to a relative greater thickness of the lingual plate in these cases. This comes in agreement with Wihokrut et al (2022), who reported a significant difference in the thickness of the lingual cortex between single rooted and multiple rooted teeth, with the latter having less lingual cortex thickness [6].

Also, our analysis demonstrated root-specific differences in topographic relationships; for example, in two-rooted molars, the mesial root predominantly exhibited a type A (non-contact) configuration, while the distal root more frequently displayed type B (contact), suggesting that root proximity to the lingual cortex increases posteriorly. To the best of knowledge, our study is the first to individually assess the relationship between each mandibular third molar root and the lingual cortex, exact direct comparisons with previous research on this specific aspect were not feasible. Furthermore, in three-rooted molars, our analysis showed a predominance of type B in distolingual roots (Radix Entomolaris), aligning with anatomical expectations as these accessory roots tend to curve toward the lingual and distal surfaces. Conversely, when the additional root was located mesially, commonly as a mesiobuccal root (Radix Paramolaris), the relationship was most often type A [16,17,18].

Another methodological strength of our study is the inclusion of both erupted and impacted mandibular third molars, unlike most previous studies that focused exclusively on impacted teeth. Although not intentional, the predominance of fully erupted third molars allowed for a broader and more representative assessment of this less commonly studied category. In our study, we noted that the frequency of type A relationship markedly decreased in multi-rooted vertical, mesio-angular, and horizontal impacted mandibular third molars respectively compared to the erupted ones. These findings are consistent with Menziletoglu et al (2019), they reported that vertically impacted teeth posed a greater risk with thinner lingual cortex than mesio-angular impactions [19]. However, Tolstunov et al. (2016), reported that the lingual covering cortex was found to be approximately 3.6 times thinner particularly in horizontal and mesio-angular impactions [20].

A key methodological decision in our study was the adoption of Emes et al. (2015) categorical classification system for topographic relationships over numerical measurements. While numerical data allow for precise quantification, they may lack immediate clinical relevance. For instance, both type A and type B relationships could share similar distance values in millimeters, despite one representing non-contact and the other representing contact configuration. By contrast, the categorical classification offers clearer clinical implications: type A implies relative surgical safety, type B suggests caution due to cortical contact, and type C indicates a high risk of perforation.

Our study did not find a statistically significant association between gender and the relationship between the roots and the lingual cortex. This aligns with the findings reported by Momin et al.[21], but contrast with the results reported by Wang et al. [15] and Sathapana et al. [22], where the latter observed that cortical bone thickness tends to increase with age in women more than in men. This discrepancy may be attributed to differences in sample size and sampling criteria across studies.

Moreover, our choice of imaging parameters further reinforces the reliability of our observations. We set a voxel size threshold of ≤0.4 mm, which ensured sufficient spatial resolution for evaluating cortical morphology in fine detail. This contrasts with studies like that of Leung et al. (2023), which, although CBCT-based, varied in voxel size and focused primarily on risk assessment without detailed morphological classification [23].

Our study adopted the modified Chan and Momin classification [21,24] first adopted by wang et al (2016) [15]. This modified classification expands these models by including additional morphologies like the slanted type, offering a more comprehensive framework for clinical application, especially in the context of mandibular third molar extraction where anatomic variation can influence risk of complications such as lingual plate fracture or nerve injury. In our study, undercut (U) morphology emerged as the most prevalent type of lingual cortical morphology. These findings are consistent with previous studies by Chan et al. [24], Wang et al [15] and Huang et al. [25], all of which reported a similarly high prevalence of undercut morphology in the posterior mandible. Clinically, the undercut configuration, especially when accompanied by a thin lingual cortical plate, may create anatomical weak points during surgical procedures such as mandibular third molar extraction [26]. This condition increases the risk of lingual plate perforation and potential displacement of the root into the sublingual space, emphasizing the importance of accurate preoperative CBCT evaluation.

We also explored possible associations between lingual cortical morphology and demographic factors such as age and gender. Although the "R" morphology appeared more frequently in males, no statistically significant association was observed between gender and lingual cortex morphology. These results come in line with the findings of Momin et al.[21], where they reported no statistically significant differences in cortical morphology between males and females. Furthermore, we did observe a significant association between slanted (S-type) morphology and younger age groups. This pattern may reflect age-related changes in mandibular structure, where the alveolar bone in younger individuals tends to be more tapered and angular before complete skeletal maturation and cortical thickening occurs.

The limitations of our study included an unequal distribution of erupted and non-erupted third molars, which was inherent to its retrospective cross-sectional design. Additionally, a right–left side comparison was not feasible, as some scans lacked bilateral third molars meeting the inclusion criteria, and others were restricted to a single quadrant due to limited field of view. Moreover, as with most retrospective studies, the sample size could be further expanded in future research to enhance the generalizability of the findings.

CONCLUSION

This study demonstrated that in single-rooted molars, type A was the most prevalent, with type C (perforation) being rare. In two-rooted mandibular third molars, mesial roots most exhibited a type A (non-contact) relationship with the lingual cortex, while distal roots more frequently showed type B (contact) configurations. Finally, in three-rooted molars, distolingual roots predominantly showed type B relationships, whereas accessory mesiobuccal roots were more often classified as type A. Statistically significant associations were observed between topographic root-cortex relationships and eruption status, with type C configurations linked to mesio-angular impactions. Regarding cortical morphology, the undercut (U) form was the most frequently observed, followed by the parallel (P), slanted (S), and round (R) types. These findings not only reinforce previously reported anatomical patterns but also contribute new insights by evaluating each root individually, applying a clinically focused classification system, and integrating both erupted and impacted third molars. These methodological enhancements provide a more detailed understanding of root-cortex relationships, with direct implications for surgical planning and patient safety.

DECLARATION

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Conflict of interests

There are no conflicts of interests

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