International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 21s, 2025
https://www.theaspd.com/ijes.php

Assessment Of The Relationship Of The Distance Between Mandibular First And Second Molars With The Inferior Alveolar Canal And Cortical Bone Plate: A Cbct Study

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Abstract

The aim of the present cone beam computed tomography (CBCT) study was to evaluate the proximity of mandibular first and second molar roots to the inferior alveolar canal (IAC) and mandibular cortex in an Indian population. Scans of 55 adult patients were retrieved from the departmental archive at Shree Bankey Bihari Dental College and Research Centre, Ghaziabad. Measurements were obtained for the buccal and lingual bone plates and root thickness at a site 3 mm from the radiographic apex, as well as the proximity of the root apices to the IAC. Right and left mandibular first and second molars were recorded for each root. Four specific measurements were assessed: distance from the buccal root surface to the outer edge of the buccal cortical plate (M1), distance from the lingual root surface to the outer edge of the lingual cortical plate (M2), minimum distance from the IAC to the root apex (M3), and total bone width including the root (M4). Statistical analysis was performed using ANOVA and post hoc tests, with significance set at $p \leq 0.05$. The results revealed that mandibular second molar apices demonstrated closer proximity to the IAC compared to the first molars, with mesial roots positioned at a shorter distance than distal roots. The second molars also exhibited the greatest total bone width. These findings underline the importance for dental practitioners to be aware of the anatomical relationship of mandibular molar roots to the surrounding cortical plates and the IAC when planning surgical or endodontic procedures in the Indian population.

Keywords: *CBCT, Mandibular molars, Inferior alveolar canal (IAC), Cortical plates, Proximity, Distance measurements (M1-M4), Indian population, Clinical significance.*

INTRODUCTION

The mandible plays a pivotal role in oral function, bearing responsibilities for chewing, speech articulation, and facial aesthetics. Of paramount importance is the inferior alveolar nerve (IAN), which courses through the inferior alveolar nerve canal (IANC) from the mandibular foramen to the mental foramen[1]. Due to the nerve's primary function in sensory innervation, even minor trauma in this region can precipitate significant neurosensory disturbances, reinforcing the need for precise anatomical information when planning invasive dental procedures[3]. Central to this planning is an accurate understanding of the spatial relationship between the mandibular molars and the IANC, which significantly influences endodontic treatment, surgical extractions, implant placement, and other mandibular interventions that might endanger the nerve[3].

Historically, conventional radiography—panoramic or periapical—has been the mainstay for visualizing the mandible. However, these two-dimensional techniques inherently suffer from geometric distortion, superimposition of anatomical structures, and limited viewing angles[5]. In contrast, Cone Beam Computed Tomography (CBCT) offers comprehensive three-dimensional assessment, enabling highly accurate reconstructions in the axial, coronal, and sagittal planes[2]. This enhanced spatial resolution facilitates more precise evaluation of the IANC's trajectory and its proximity to the tooth apices, minimizing the risk of iatrogenic

nerve injury[2]. Moreover, CBCT allows for the identification of anatomical anomalies such as bifid canals or accessory mental foramina, which, if overlooked, can adversely affect surgical outcomes.

Cortical bone thickness also exerts a vital role in treatment decisions. The buccal and lingual cortical plates provide structural support and influence implant stability, extraction protocols, and flap designs. Various factors—age, genetics, functional loading—can alter cortical thickness, and population-specific trends have been identified[4]. Indeed, research in different ethnic groups reveals measurable differences in distances between molar apices and the IANC, and in cortical plate measurements[4]. Such findings emphasize the clinical relevance of adopting region-specific data rather than relying solely on generalized global averages[6].

Third molar extractions exemplify how critical precise anatomical knowledge is, given the high potential for neurosensory disturbance if the IANC is impinged[7]. Similarly, in endodontics, an accurate working length ensures effective cleaning and obturation while sparing the nerve. For implant placement, detailed mapping of the canal and cortical structures is indispensable to avoid mechanical compression of the nerve and subsequent neuropathy[8]. Even subtle variations in cortical density can significantly affect surgical planning, as they may increase the complexity of osteotomy or necessitate modifications in implant size.

Building upon existing literature, the present investigation aims to correlate the distances between the first and second mandibular molars and the IANC with cortical bone thickness using CBCT. By integrating prior evidence on population-specific jaw morphology with advanced imaging insights, the study aspires to refine clinical guidelines by establishing quantifiable parameters for "safe" nerve distances and bone thickness thresholds. Ultimately, such data-driven approaches can enhance patient safety and foster more predictable outcomes across a wide range of dental and maxillofacial treatments.

MATERIALS AND METHODS

This retrospective, cross-sectional observational study was conducted in the Department of
Oral Medicine and Radiology, Shree Bankey Bihari Dental College and Research Centre, Ghaziabad, in collaboration with Atal Bihari Vajpayee Medical University, Uttar Pradesh. The study was approved by the Institutional Ethics Committee, and all CBCT records used were retrieved from the departmental patient database.

SAMPLE SELECTION

A total of 55 adult patients (29 males and 26 females) aged between 18 and 47 years were included in the study. Inclusion criteria required that both mandibular first and second molars were present and intact bilaterally, and that high-resolution CBCT scans with acceptable diagnostic quality were available. Exclusion criteria were: the presence of more than one missing mandibular posterior or anterior tooth on each side (excluding third molars), severe periodontitis, signs of external or internal root resorption in the relevant mandibular teeth, pathological lesions in the area of interest, history of orthodontic treatment, skeletal or dental malocclusions, or previous root canal treatment in the examined region.

CBCT Imaging Protocol

All CBCT scans were obtained using a high-resolution cone beam CT scanner with the field of view encompassing the full mandible, ensuring visibility of both the molar roots and the inferior alveolar canal. Slices were reconstructed at 0.5 mm intervals to allow for clear visualization of root apices. Patient positioning during scanning was standardized, with individuals seated upright, chin rest and head supports used to minimize movement, and a bite block applied if necessary to align the occlusal plane.

MEASUREMENT PROTOCOL

For each mandibular first and second molar root (both right and left sides), measurements were performed at a plane 3 mm coronal to the radiographic apex. Four specific measurements were recorded for each root:

- **M1:** Distance from the buccal root surface to the outer edge of the buccal cortical plate. • **M2:** Distance from the lingual root surface to the outer edge of the lingual cortical plate.
- **M3:** Minimum distance between the IAC and the apex of the root.
- **M4:** Total bone width encompassing the root.

All measurements were performed by a single, calibrated examiner to minimize inter-examiner variability[9]. Calibration was achieved by repeating measurements on 15 randomly selected scans two weeks apart, and intra-examiner reliability was assessed using the intraclass correlation coefficient (ICC).

STATISTICAL ANALYSIS

Data were compiled and analyzed using SPSS software, version [XX] (IBM Corp., Armonk, NY, USA). All measurements were expressed as mean ± standard deviation (SD). Intergroup comparisons were made using one-way analysis of variance (ANOVA), and the Tukey post hoc test was applied for pairwise group differences. Statistical significance was defined as $p \leq 0.05$.

RESULTS

1. Demographic Data of the Study Sample

Gender Distribution

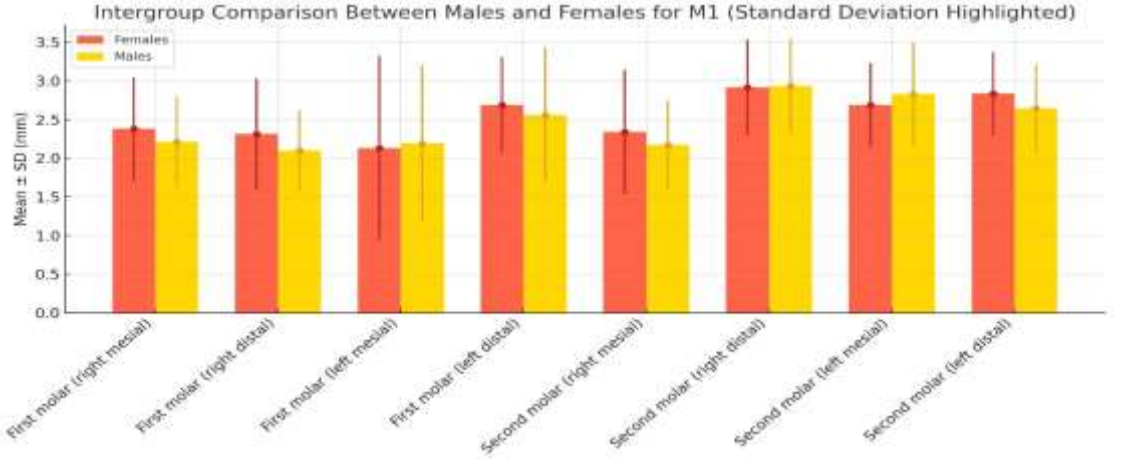
The study sample included 55 adult patients, comprising 29 males (52.72%) and 26 females (47.27%).

Gender	Frequency	Percent
Female	26	47.27%
Male	29	52.72%

2. Quantitative Measurements of Mandibular Molar Sites

Table no 1 : INTERGROUP COMPARISON BETWEEN MALES AND FEMALES FOR M1

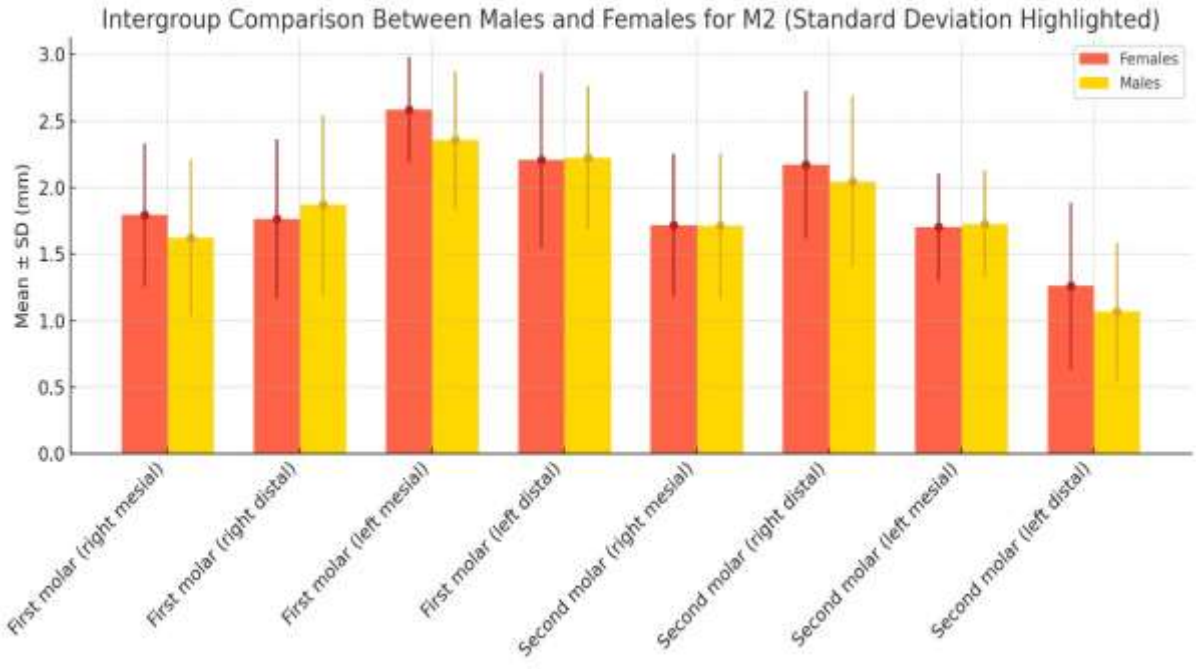
Tooth & Root	Females: Mean ± SD (mm)	Males: Mean ± SD (mm)	P value	Significance
First molar (right mesial)	2.378 ± 0.669	2.210 ± 0.588	0.24*	Not significant
First molar (right distal)	2.312 ± 0.720	2.098 ± 0.521	0.18*	Not significant
First molar (left mesial)	2.129 ± 1.191	2.192 ± 1.005	0.82*	Not significant
First molar (left distal)	2.690 ± 0.618	2.559 ± 0.872	0.61*	Not significant
Second molar (right mesial)	2.338 ± 0.803	2.169 ± 0.579	0.41*	Not significant
Second molar (right distal)	2.916 ± 0.621	2.932 ± 0.614	0.94*	Not significant
Second molar (left mesial)	2.687 ± 0.543	2.831 ± 0.666	0.39*	Not significant
Second molar (left distal)	2.834 ± 0.541	2.645 ± 0.564	0.27*	Not significant



In the present study, the distance between the outer border of the buccal cortical plate and the buccal root surface (M1) was measured at multiple root positions of the first and second molars in both males and females. The results demonstrated that, across all measured sites, there were no statistically significant differences between the sexes. Among females, the mean M1 values ranged from 2.129 ± 1.191 mm at the left mesial root of the first molar to 2.916 ± 0.621 mm at the right distal root of the second molar. Similarly, in males, the mean values ranged from 2.098 ± 0.521 mm at the right distal root of the first molar to 2.932 ± 0.614 mm at the right distal root of the second molar. Statistical analysis revealed p-values greater than 0.05 for all root positions, indicating that these differences were not significant.

TABLE NO 2 : INTERGROUP COMPARISON BETWEEN MALES AND FEMALES FOR M2

Tooth & Root	Females: Mean ± SD (mm)	Males: Mean ± SD (mm)	P value*	Significance
First molar (right mesial)	1.793 ± 0.537	1.620 0.587 ±	0.32	Not significant
First molar (right distal)	1.765 ± 0.598	1.870 0.678 ±	0.61	Not significant
First molar (left mesial)	2.583 ± 0.396	2.355 0.516 ±	0.15	Not significant
First molar (left distal)	2.206 ± 0.660	2.222 0.539 ±	0.94	Not significant
Second molar (right mesial)	1.716 ± 0.539	1.712 0.544 ±	0.98	Not significant
Second molar (right distal)	2.172 ± 0.554	2.044 0.643 ±	0.56	Not significant
Second molar (left mesial)	1.702 ± 0.402	1.723 0.400 ±	0.89	Not significant
Second molar (left distal)	1.259 ± 0.626	1.065 0.516 ±	0.30	Not significant

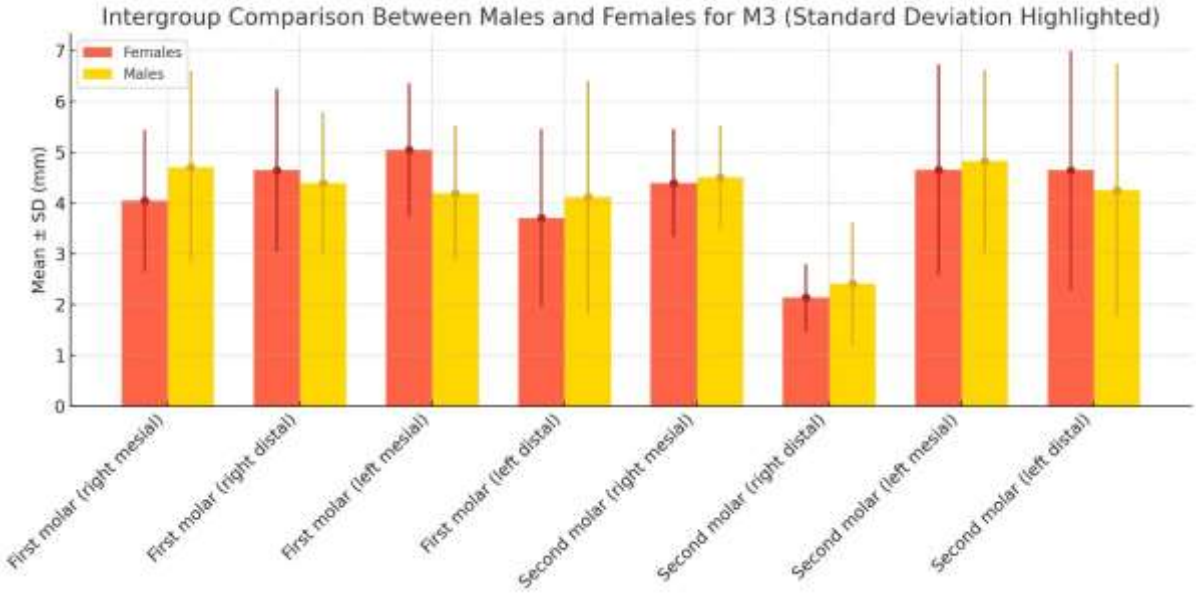


In the present study, the distance between the outer border of the lingual cortical plate and the lingual root surface (M2) was assessed at various root positions of the first and second molars in both males and females. The results showed that, at all measured sites, there were no statistically significant differences between the sexes. Among females, the mean M2 values ranged from 1.259 ± 0.626 mm at the left distal root of the second molar to 2.583 ± 0.396 mm at the left mesial root of the first molar. In males, the corresponding values ranged from 1.065 ± 0.516 mm at the left distal root of the second molar to 2.355 ± 0.516 mm at the left mesial root of the first molar. Statistical analysis revealed p-values greater than 0.05 for all root positions, confirming the absence of significant sex-based differences. These findings indicate that the lingual bone thickness adjacent to the molar

roots is similar in both males and females, suggesting that gender does not significantly influence this anatomical parameter in the studied population

TABLE NO 3 : INTERGROUP COMPARISON BETWEEN MALES AND FEMALES FOR M3

Tooth & Root	Females: Mean ± SD (mm)	Males: Mean ± SD (mm)	P value*	Significance
First molar (right mesial)	4.044 ± 1.397	4.703 ± 1.889	0.28	Not significant
First molar (right distal)	4.645 ± 1.607	4.396 ± 1.388	0.71	Not significant
First molar (left mesial)	5.049 ± 1.313	4.193 ± 1.328	0.10	Not significant
First molar (left distal)	3.705 ± 1.747	4.121 ± 2.292	0.59	Not significant
Second molar (right mesial)	4.394 ± 1.060	4.502 ± 1.018	0.81	Not significant
Second molar (right distal)	2.140 ± 0.656	2.416 ± 1.223	0.49	Not significant
Second molar (left mesial)	4.652 ± 2.070	4.821 ± 1.795	0.80	Not significant
Second molar (left distal)	4.639 ± 2.353	4.251 ± 2.488	0.73	Not significant

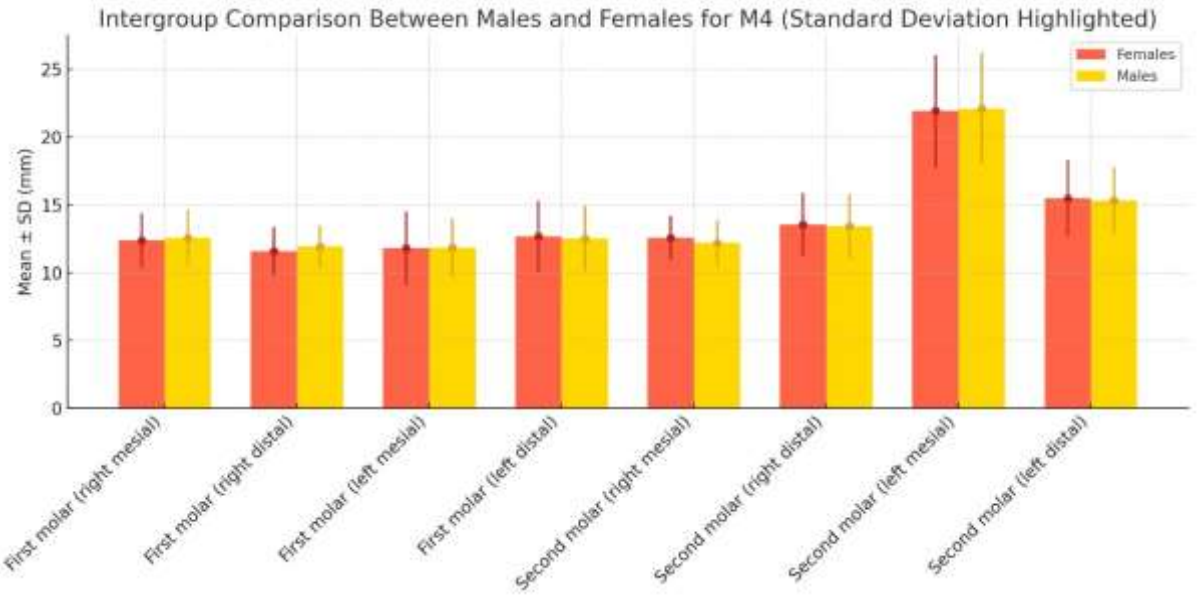


In this study, the closest distance between the inferior alveolar canal (IAC) and the root apex (M3) was measured at various root positions of the first and second molars in both males and females. The results showed that, across all sites, there were no statistically significant differences between the sexes. Among females, mean M3 values ranged from 2.140 ± 0.656 mm at the right distal root of the second molar to 5.049 ± 1.313 mm at the left mesial root of the first molar. In males, mean values ranged from 2.416 ± 1.223 mm at the right distal root of the second molar to 4.821 ± 1.795 mm at the left mesial root of the second molar. Statistical analysis revealed p-values greater than 0.05 for all comparisons, confirming that these differences were not significant. These findings indicate that the anatomical relationship between the molar root apices and the IAC is similar in both males and females, suggesting that gender does not significantly influence this parameter in the studied population.

TABLE NO 4 : INTERGROUP COMPARISON BETWEEN MALES AND FEMALES FOR M4

Tooth & Root	Females: Mean ± SD (mm)	Males: Mean ±SD (mm)	P value*	Significance
First molar (right mesial)	12.364 ± 2.001	12.578 ± 2.083	0.80	Not significant
First molar (right distal)	11.588 ± 1.756	11.923 ± 1.546	0.61	Not significant

First molar (left mesial)	11.806 ± 2.740	11.843 ± 2.158	0.97	Not significant
First molar (left distal)	12.673 ± 2.606	12.512 ± 2.388	0.89	Not significant
Second molar (right mesial)	12.571 ± 1.613	12.191 ± 1.703	0.59	Not significant
Second molar (right distal)	13.564 ± 2.346	13.420 ± 2.356	0.89	Not significant
Second molar (left mesial)	21.930 ± 4.159	22.101 ± 4.109	0.91	Not significant
Second molar (left distal)	15.495 ± 2.812	15.313 ± 2.463	0.85	Not significant



In the present analysis, the total bone width, including the root (M4), was measured at various root positions of the first and second molars in both males and females. The results indicated that there were no statistically significant differences in M4 values between the sexes at any of the evaluated sites. Among females, mean M4 values ranged from 11.588 ± 1.756 mm at the right distal root of the first molar to 21.930 ± 4.159 mm at the left mesial root of the second molar. In males, the corresponding values ranged from 11.843 ± 2.158 mm at the left mesial root of the first molar to 22.101 ± 4.109 mm at the left mesial root of the second molar. Statistical analysis revealed that all p-values were greater than 0.05, confirming the absence of significant differences between males and females. These findings suggest that the total bone width surrounding the molar roots is comparable in both sexes, and gender does not appear to significantly influence this anatomical parameter in the studied population.

DISCUSSION

The present CBCT study elucidates critical anatomical relationships between mandibular first/second molars, the inferior alveolar canal (IAC), and cortical bone plates in an Indian population. A pivotal finding is the absence of statistically significant sex-based differences across all measured parameters: buccal cortical plate distance (M1), lingual cortical plate distance (M2), root apex-to-IAC proximity (M3), and total bone width (M4) (all *p* > 0.05). This contrasts with studies in other populations, such as the Egyptian cohort[6], where males exhibited significantly thicker total bone width (M4) at second molars (*p* < 0.05), and Saudi research[10] (Aljarbou et al., 2019), where females demonstrated shorter root-IAC distances (M3) at second molar distal roots. This divergence underscores population-specific craniofacial morphology in Indians, potentially attributable to genetic factors, dietary habits (e.g., harder food textures increasing uniform biomechanical loading), or epigenetic influences that minimize sexual dimorphism in mandibular anatomy[1].

Notably, mandibular second molars consistently posed the highest risk of IAC proximity in our cohort (M3: 2.14–4.65 mm), with mesial roots exhibiting shorter distances than distal roots. This aligns with global trends:

- Egyptian data[6] revealed 17% of second molars directly contacting the IAC.

- Saudi findings[10] reported even higher contact rates (25–38%).
- German CBCT studies[3] documented mean M3 distances of 1.42–2.64 mm for second molars.

The IAC's anterior ascension toward the mental foramen likely explains this universal vulnerability, as its path inherently approximates second molar apices during skeletal maturation[4].

The lack of sex differences in cortical bone metrics (M1, M2) in our Indian cohort contradicts reports from other regions. For instance, Egyptian females[6] showed significant lingual asymmetry (*p* = 0.004), while Saudi females[10] had thinner buccal plates. Methodological factors may contribute:

- Our 0.5 mm CBCT slices[9], though diagnostically robust, might overlook subtler variations detectable with higher-resolution protocols (e.g., 0.2–0.3 mm voxels in Egyptian studies[6]).
- The broader age range (18–47 years) in our sample could dilute age-related trends observed in younger cohorts[4], where craniofacial maturation amplifies sexual dimorphism.

Clinical implications emphasize three key considerations:

1. **Population-specific protocols**: Indian clinicians can prioritize tooth position over sex for IAC risk assessment, whereas Egyptian/Saudi practitioners must integrate sexspecific data[6,10].
2. **CBCT indispensability**: Second molars universally require 3D mapping to identify high-risk zones (e.g., distal roots in Saudis[10], mesial roots in Indians) before surgical interventions.
3. **Age-dependent caution**: Younger patients (<30 years) warrant heightened vigilance across populations due to shorter root-IAC distances[4].

Limitations include a moderate sample size (*n* = 55) compared to Egyptian (*n* = 120)[6] and Saudi (*n* = 60)[10] studies, potentially limiting statistical power for subtle anatomical disparities. Future multi-center collaborations should:

- Standardize CBCT voxel sizes (≤0.3 mm) for cross-population comparisons[9].
- Investigate biomechanical influences (e.g., masticatory forces) on cortical bone dimorphism[4].
- Correlate CBCT metrics with clinical outcomes (e.g., postoperative neurosensory deficits)[3].

CONCLUSION

This anatomical survey of mandibular molars in an Indian cohort delivers two critical points of relevance for clinical practice. First, there was a uniform absence of sexual dimorphism across measured cortical bone thickness (M1, M2), root apex-to-IAC distances (M3), and overall bone width (M4). These results diverge from findings in Saudi and Egyptian populations, where sexual dimorphism was a significant determinant, implying that specific genetic or biomechanical determinants of the Indian population may attenuate sex-related morphological differences. Second, mandibular second molars exhibited a narrow and clinically critical interface with the inferior alveolar canal (IAC), with M3 distances falling between 2.14 and 4.65 mm, thus reinforcing a worldwide pattern of increased potential for iatrogenic injury. Taken together, these observations warrant tailored CBCT imaging guidelines: Indian clinicians should emphasize the positional context of the tooth rather than the patient's sex when evaluating surgical and endodontic risks, especially for second molars, whereas practitioners in other regions should incorporate sex-specific benchmarks. To improve the clinical relevance of these findings and enable robust comparisons across populations, we advocate for the standardized use of high-resolution CBCT with voxel sizes of 0.3 mm or smaller. Additionally, we encourage collaborative, multicenter studies to investigate the biomechanical factors influencing cortical bone adaptation.

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