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Assessment of the distance between root apices of mandibular posterior teeth and the mandibular canal: A cone beam computed tomographic study in an Indian subpopulation

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Abstract

INTRODUCTION. The mandibular canal (MC) is a critical anatomical structure that houses the inferior alveolar nerve (IAN). Its juxtaposition to the apices of the mandibular posterior teeth has significant clinical consequences for dental implant placement and endodontic procedures. Despite its importance, limited data exist on its anatomical variations in the Eastern Indian population.

AIM. This study aimed to evaluate the distances between the MC and root apices of mandibular premolars and molars, considering age and sex differences.

MATERIALS AND METHODS. This retrospective Cone Beam Computed Tomography (CBCT)-based observational study included 111 participants aged 18–50 years. Distances from the MC to the root apices of mandibular premolars and molars were measured using CBCT scans. Spearman's correlation test was employed to assess the relationship between age and the measured distances. Distances between genders were compared using the Mann-Whitney test, and Friedman's ANOVA analyzed intragroup variations. An alpha level of five percent was considered as a level of statistical significance.

RESULTS. A positive correlation was observed between age and the distance from the MC to root tips. Males exhibited greater distances compared to females. Significant pairwise comparisons showed differences between the second premolar and both roots of the first and second molars. No discernible differences were found between sides (right versus left). Notably, molar root tips, especially second molars were closest to the MC, with distal roots showing the greatest variability.

CONCLUSIONS. The study emphasizes the necessity of precise preoperative evaluations in endodontics and implantology to reduce the incidence of IAN injuries by highlighting age-related increases in the MC to tooth root apices distances, especially in males.

Keywords: aging, cone-beam computed tomography, inferior alveolar nerve, mandibular canal, tooth apex

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Оценка расстояния между верхушками корней задних зубов нижней челюсти и нижнечелюстным каналом: исследование с использованием конусно-лучевой компьютерной томографии в индийской субпопуляции

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Резюме

ВВЕДЕНИЕ. Нижнечелюстной канал (НЧК) является важной анатомической структурой, содержащей нижнечелюстной нерв (НЧН). Его близость к верхушкам корней задних зубов нижней челюсти имеет существенные клинические последствия при проведении дентальной имплантации и эндодонтиче-

ского лечения. Несмотря на значимость данной структуры, существует ограниченное количество данных о ее анатомических вариациях среди населения восточной Индии.
ЦЕЛЬ. Оценить расстояние между НЧК и верхушками корней премоляров и моляров нижней челюсти с учетом возрастных и половых различий.
МАТЕРИАЛЫ И МЕТОДЫ. В ретроспективное обсервационное исследование на основе конусно-лучевой компьютерной томографии (КЛКТ) были включены 111 участников в возрасте от 18 до 50 лет. Расстояния от НЧК до верхушек корней премоляров и моляров нижней челюсти измерялись по данным КЛКТ. Для оценки корреляции между возрастом и измеренными расстояниями применялся корреляционный тест Спирмена. Сравнение расстояний между мужчинами и женщинами проводилось с использованием критерия Манна-Уитни, а внутригрупповые различия анализировались с помощью дисперсионного анализа Фридмана. Статистическая значимость устанавливалась на уровне 5% ($\alpha = 0,05$).
РЕЗУЛЬТАТЫ. Выявлена положительная корреляция между возрастом и расстоянием от НЧК до верхушек корней зубов. У мужчин данные расстояния были больше, чем у женщин. Значимые парные различия наблюдались между вторым премоляром и обоими корнями первого и второго моляров. Существенных различий между правой и левой сторонами не обнаружено. Наиболее близкое расположение к НЧК отмечалось у корней моляров, особенно вторых моляров, при этом дистальные корни демонстрировали наибольшую изменчивость.
ВЫВОДЫ. Настоящее исследование подчеркивает важность точной предоперационной оценки в эндодонтии и имплантологии для минимизации риска повреждения нижнечелюстного нерва. Установлено, что расстояние от НЧК до верхушек корней увеличивается с возрастом, особенно у мужчин, что необходимо учитывать при планировании хирургических вмешательств.

Ключевые слова: старение, конусно-лучевая компьютерная томография, нижнечелюстной нерв, нижнечелюстной канал, верхушка зуба

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INTRODUCTION

The mandibular canal (MC), a bony passageway within the mandible, houses the mandibular nerve. This canal, which begins near the mandibular foramen, concludes at the mental foramen, roughly aligning with the second premolar teeth [1].

The intricate architecture of the MC, including its course and the positioning of its openings, is dictated by the branching pattern of blood vessels and the canal's proximity to the mandibular arch. This arrangement facilitates the innervation of the lower molars, premolars, lower lip, and chin, thereby ensuring optimal function of the stomatognathic system [2].

The MC's location and anatomical traits might differ depending on the individual and ethnic group.

Given that certain dental procedures have the potential to harm the inferior alveolar nerve (IAN), the distance between the MC and the root apices of the mandibular molars and premolars is clinically significant. These operations consist of dental implants, periradicular surgery, endodontic therapy, and third molar extraction [3; 4]. Furthermore, the majority of mandibular nerve lesions have been seen in conjunction with second molar therapy. Nevertheless, premolars and permanent mandibular first molars may also experience this. Cone-beam computed tomography (CBCT), widely used across dental specialties, provides precise, sensitive, and noninvasive three-dimensional reconstructions of maxillofacial structures, overcoming the limitations of conventional imaging, such as overlapping, geometric distortion, and localization errors.

Before beginning any endodontic intervention, doctors must have a comprehensive awareness of the anatomical variety and relative placement of the MC in order to plan therapy properly.

This study was conducted to evaluate MC's relationship to the root apices of the mandibular posterior teeth using CBCT images of an Indian subpopulation, taking into account the landmark's importance and the paucity of research in this area within the Indian population.

MATERIALS AND METHODS

Sample size estimation and Image selection

This retrospective observational study was conducted in the Dental College, following approval from the Institutional Ethics Committee (RADCH/EC/52/2024), ensuring adherence to ethical standards.

Sample size calculation was done considering the results of the previous study [5] with the distance between the second premolar's root apices and the MC as the main outcome variable. A minimal sample size of 111 was determined using the G*Power Software version 3.1.9.7 (Heinrich Heine University, Düsseldorf, Germany). The computation was predicated on a *t*-test model, which assumed a two-tailed significance level ($\alpha = 0.05$), an effect size of 0.7, and a ninety-five percent power.

Bilaterally present, completely erupted mandibular permanent canines, premolars, and molars with fully developed, pathology-free apices were necessary for inclusion. Patients under the age of 18, bone loss,

disease or congenital mandibular abnormalities, low-quality CBCT scans, and prior endodontic treatment were all excluded.

Thereby a total of 111 CBCT scans from the departmental archives, acquired between 2018 and 2023 for reasons unrelated to this study, were included in the final analysis.

CBCT acquisition

CBCT images were captured using the SkyView CBCT Scanner, a device manufactured by My-Ray Dental Imaging in Imola, Italy. Gray levels of 4096 (12-bit) at 90 kV and 10 mA were used to operate the scanner. The digital pictures were imported into the iRYS viewer application after being exported from Skyview CBCT Scanner.

The distance measurements were performed using the IRYS SkyView CBCT software. The CBCT scans were first loaded into the software, and the distance measurement tool, accessible via the toolbar, was selected. The sagittal, coronal, and axial views were aligned to ensure a clear visualization of the inferior border of the mandible, the root apex of the second premolars, the mandibular molars, and the MC (Fig. 1). The cursor was then placed on the apex of the respective teeth to mark the first point and subsequently dragged to the nearest point on the MC to mark the second point. The software displayed the measured distance, which was verified for accuracy and recorded for analysis (Fig. 2).

CBCT assessment

Two trained and calibrated observers (MP and NR), analyzed all CBCT images using specialized viewing software to ensure consistent interpretation. The observers reviewed the images to reach a consensus, and any disagreements were resolved through a definitive evaluation by an endodontist (DS). The intra-class correlation coefficient was utilized to assess inter-observer agreement, which yielded a value of 0.98, indicating excellent agreement.

Statistical Analysis

IBM Statistical Package for the Social Sciences for Windows, Version 27.0, was used to perform statistical analysis after the gathered data was tabulated in a spreadsheet using Microsoft Excel 2021. (IBM Corp., Armonk, NY). The gathered data was skewed, as demonstrated by a Shapiro-Wilk test and a visual examination of the box plots, normal Q-Q plots, and histograms.

The chi-square test was used to assess the categorical variables. Non-parametric testing was used to assess the quantitative variables. The association between age and the outcome variables was determined using Spearman's rank correlation test. For intragroup analysis, Friedman's analysis of variance (ANOVA) was employed, and for intergroup comparisons, the Mann-Whitney test. The level of significance was defined as a *P* value of less than 5 percent.

RESULTS

In this study, 111 participants were included, consisting of 57 females (51.35%) and 54 males (48.65%) with no significant difference in sex distribution ($P = 0.12$).

Overall, the mean age was 25.5 ± 7.1 years, with a median (Interquartile range [IQR]) of 24(21–31) years. Among females, the mean age was 24.3 ± 6.16 years, with a median (IQR) of 23 (20.5–27), and among males, the mean age was 26.6 ± 7.86 years, with a median (IQR) of 25 (21–32). There was no statistically significant difference in age distribution between the two groups ($P = 0.84$) (Table 1).

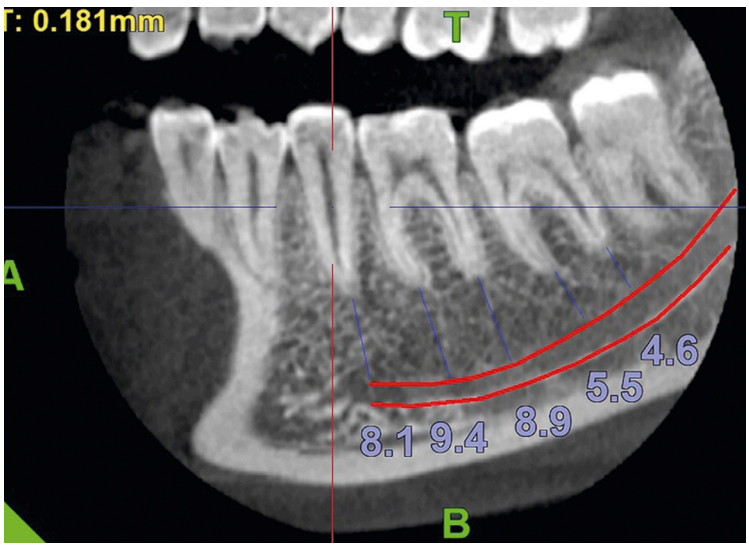

Fig. 1. Oblique sagittal section tracing the mandibular canal and its relationship to the apex of the second premolar as well as the mesial and the distal roots of the first and second molars

Рис. 1. Косой сагиттальный разрез, прослеживающий нижнечелюстной канал и его отношение к верхушке второго премоляра, а также к мезиальному и дистальному корням первого и второго моляров

Fig. 2. Cross-sectional view illustrating linear measurements between the root apex and the Mandibular canal

Рис. 2. Поперечное сечение, иллюстрирующее линейные измерения между верхушкой корня и нижнечелюстным каналом

Table 2 summarizes the descriptive characteristics of the distance from the root apex to the MC for the second premolars, first molars, and second molars, categorized by sides and genders.

On the right side, the distance of the root tip from the MC for the second premolar was 4.16±2.07 mm, with a median (IQR) of 4.0 (2.5–5.4) mm across all participants. For females, the mean (±SD) was 3.95±2 mm (median (IQR): 3.3 [2.5–5.1] mm), while for males, it was 4.39±2.13 mm (median (IQR): 4.5 [2.63–5.85] mm). For the first molar (mesial root), the mean (±SD) across all participants was 4.98±2.54 mm, with a median (IQR): (IQR) of 4.9 (2.8–6.3) mm. In females, the mean ((±SD)) was 4.36±1.88 mm (median (IQR): 4.4 [2.75–5.85] mm), while males exhibited a mean of 5.64±2.96 mm (median (IQR): 5.35 [2.88–7.73] mm). The distal root of the first molar tooth had an overall mean (±SD) of 4.99±2.5 mm and a median (IQR) of 4.5 (3.1–6.7) mm. For females, the mean (±SD) was 4.42±2.17 mm (median (IQR): 4.3 [2.65–5.95] mm), and for males, it was 5.59±2.71 mm (median (IQR): 5.75 [3.3–7.98] mm). For the second molar (mesial root), the overall mean (±SD) was 3.75±2.45 mm,

Table 1. Demographic characteristics of study subjects

Таблица 1. Демографические характеристики участников исследования

Characteristics	Female	Male	Total	*P* value
Frequency (%)[a]	57 (51.35)	54 (48.65)	111	0.12^{NS}
Age[b]				
Mean±SD	24.3±6.16	26.6±7.86	25.5±7.1	0.84^{NS}
Median (Q1–Q3)	23 (20.5–27)	25 (21–32)	24 (21–31)	
Min–Max	14–46	15–53	14–53	

Note: [a] analysed by the Chi-square Test; [b] analysed by the Mann-Whitney Test; SD – standard deviation; Q1 – first quartile; Q3 – third quartile; Q1–Q3 – inter-quartile range; Min – minimum value; Max – maximum value; ^{NS} **м**not significant ($P > 0.05$), * statistically significant ($P \leqslant 0.05$)

Примечания: [a] анализировано с использованием критерия хи-квадрат; [b] анализировано с использованием критерия Манна-Уитни; SD – стандартное отклонение; Q1 – первый квартиль; Q3 – третий квартиль; Q1–Q3 – межквартильный размах; Min – минимальное значение; Max – максимальное значение; ^{NS}: незначимо ($P > 0,05$), * статистически значимо ($P \leqslant 0,05$)

Table 2. Descriptive statistics of the Distance of root tip from Mandibular Canal for different teeth according to sides and gender

Таблица 2. Описательная статистика расстояния от верхушки корня до нижнечелюстного канала для различных зубов в зависимости от стороны и пола

Teeth	Descriptive characteristics	Left			Right		
		Female (*n* = 57)	Male (*n* = 54)	Total (*N* = 111)	Female (*n* = 57)	Male (*n* = 54)	Total (*N* = 111)
2nd Premolar	Mean±SD	3.73±2	4.46±2.36	4.09±2.2	3.95±2	4.39±2.13	4.16±2.07
	Median (Q1–Q3)	3.6 (2.1–5.05)	4.2 (2.65–5.45)	3.9 (2.3–5.2)	3.3 (2.5–5.1)	4.5 (2.63–5.85)	4 (2.5–5.4)
	Min–Max	0.7–9.3	0.9–11.8	0.7–11.8	0.9–9.6	0.7–9.6	0.7–9.6
1st molar (Mesial Root)	Mean±SD	4.19±1.86	5.24±2.63	4.7±2.32	4.36±1.88	5.64±2.96	4.98±2.54
	Median (Q1–Q3)	4.3 (2.7–5.15)	4.95 (3.3–6.2)	4.5 (2.9–5.5)	4.4 (2.75–5.85)	5.35 (2.88–7.73)	4.9 (2.8–6.3)
	Min–Max	0.7–9.4	1.3–11.7	0.7–11.7	0.9–9.2	1.1–13.4	0.9–13.4
1st molar (Distal Root)	Mean±SD	4.02±1.96	5.29±2.68	4.64±2.42	4.42±2.17	5.59±2.71	4.99±2.5
	Median (Q1–Q3)	3.8 (2.7–5.4)	4.7 (3–6.88)	4.3 (2.9–5.9)	4.3 (2.65–5.95)	5.75 (3.3–7.98)	4.5 (3.1–6.7)
	Min–Max	1–8.9	1.3–11.1	1–11.1	1.1–10.9	1.1–11.6	1.1–11.6
2nd molar (Mesial Root)	Mean±SD	3.06±1.94	4.59±2.84	3.8±2.53	3.01±1.87	4.52±2.75	3.75±2.45
	Median (Q1–Q3)	2.3 (1.7–4)	3.8 (2.15–6.73)	2.9 (1.7–5.2)	2.2 (1.6–4.6)	3.8 (2.28–6.93)	3.2 (1.7–5.5)
	Min–Max	0.7–9.3	0.1–11	0.7–11	0.6–7.1	0.4–10.3	0.4–10.3
2nd molar (Distal Root)	Mean±SD	2.73±1.71	4.37±2.75	3.53±2.41	2.68±1.66	4.19±2.78	3.41±2.39
	Median (Q1–Q3)	2.3 (1.5–3.45)	3.15 (2–6.43)	2.8 (1.8–5)	2.1 (1.3–4)	3 (1.98–6.55)	2.8 (1.6–4.7)
	Min–Max	0.7–8.1	0.7–10.3	0.7–10.3	0.4-6.6	0.6-10.3	0.4–10.3

Note: *n* – sample size per gender; *N* – total sample size; SD – standard deviation; Q1 – first quartile; Q3 – third quartile; Q1–Q3 – inter-quartile range; Min – minimum value; Max – maximum value

Примечания: *n* – размер выборки для каждого пола, *N* – общий размер выборки; SD – стандартное отклонение; Q1 – первый квартиль; Q3 – третий квартиль; Q1-Q3 – межквартильный размах; Min – минимальное значение; Max – максимальное значение

and the median (IQR): (IQR) was 3.2 (1.7–5.5) mm. Females showed a mean (±SD) of 3.01±1.87 mm (median (IQR): 2.2 [1.6–4.6] mm), while males showed a mean of 4.52±2.75 mm (median (IQR): 3.8 [2.28–6.93] mm). For the distal root of the second molar, the mean (±SD) across all participants was 3.41±2.39 mm, with a median (IQR): (IQR) of 2.8 (1.6–4.7) mm. For females, the mean (±SD) was 2.68±1.66 mm (median (IQR): 2.1 [1.3–4] mm), and for males, it was 4.19±2.78 mm (median (IQR): 3.0 [1.98–6.55] mm).

On the left side, similar trends were observed. The second premolar had an overall mean (±SD) of 4.09±2.2 mm (median (IQR): 3.9 [2.3–5.2] mm), while for the first molar (mesial root), the mean (±SD) was 4.7±2.32 mm (median (IQR): 4.5 [2.9–5.5] mm). The distal root of the first molar had a mean (±SD) of 4.64±2.42 mm (median (IQR): 4.3 [2.9–5.9] mm). The second molar (mesial root) and distal root exhibited overall means of 3.8±2.53 mm and 3.53±2.41 mm, respectively, with median (IQR): s (IQR) of 2.9 (1.7–5.2) mm and 2.8 (1.8–5.0) mm.

The analysis of the correlation between age and the distance from the IAN canal to root apices revealed a positive correlation (Table 3). On the left side, a significant positive correlation was noted with the distal root of the second molar (r_s = 0.223, P = 0.0189), while weak and non-significant correlations were noted for other roots, including the first molar's mesial and distal roots and the second molar's mesial root. On the right side, correlations were generally weak and not statistically significant for all roots examined. In the overall analysis, significant positive correlations were identified for the distal roots of the first molar (r_s = 0.133, P = 0.0481) and the second molar (r_s = 0.134, P = 0.0459), indicating an age-related increase in distance in these specific roots. Correlations for the second premolar and other roots were weak and not significant, suggesting minimal age-related influence in these areas.

Table 3. Correlation between Age and Mandibular Canal-Molar / Premolar Root tip Distance Using Spearman's Correlation Coefficient

Таблица 3. Корреляция между возрастом и расстоянием от нижнечелюстного канала до верхушки корня моляра / премоляра с использованием коэффициента корреляции Спирмена

Teeth	Left	Right	Total
2nd Premolar	0.05249	0.0602	0.06032
1st Molar (Mesial Root)	0.1236	0.05762	0.09027
1st Molar (Distal Root)	0.1691	0.1143	0.1328*
2nd Molar (Mesial Root)	0.1206	0.00049	0.05704
2nd Molar (Distal Root)	0.2225*	0.05096	0.1341*

Note: all correlation values were found to be positive; * statistically significant correlations ($P \leqslant 0.05$)

Примечания: все значения корреляции оказались положительными; * статистически значимые корреляции ($P \leqslant 0{,}05$)

The primary outcome variable, the distance of the root tip from the MC for each tooth, showed significant variations in pairwise comparisons across teeth, sides, and genders. On the right side, significant differences were observed between the second premolar and the first molar (distal root) in males (P = 0.0014) and the total population (P = 0.0006), as well as between the second premolar and the second molar (distal root) in females (P < 0.0001) and the total population (P = 0.001). The first molar (mesial root) differed significantly from the second molar (mesial root) in females (P < 0.0001), males (P = 0.0047), and the total population (P < 0.0001). Comparisons involving the first molar (mesial root) and second molar (distal root), as well as the first molar (distal root) and second molar (distal root), consistently showed significant differences across all groups (P < 0.0001) (Table 4).

Table 4. Pairwise comparisons between teeth

Таблица 4. Попарные сравнения между зубами

	Female (n = 57)		Male (n = 54)		Total (N = 111)	
	Right	Left	Right	Left	Right	Left
P value#	<0.0001*		<0.0001*		<0.0001*	
Pairwise comparisons						
2nd Premolar vs. 1st molar (Mesial Root)	0.8583NS	>0.9999NS	0.0001*	0.1913NS	0.0002*	0.0618NS
2nd Premolar vs. 1st molar (Distal Root)	0.5802NS	>0.9999NS	0.0014*	0.0065*	0.0006*	0.0043*
2nd Premolar vs. 2nd molar (Mesial Root)	0.0038*	0.284NS	>0.9999NS	>0.9999NS	0.5087NS	0.7123NS
2nd Premolar vs. 2nd molar (Distal Root)	<0.0001*	0.0053*	>0.9999NS	>0.9999NS	0.001*	0.0068*
1st molar (Mesial Root) vs. 1st molar (Distal Root)	>0.9999NS	>0.9999NS	>0.9999NS	>0.9999NS	>0.9999NS	>0.9999NS
1st molar (Mesial Root) vs. 2nd molar (Mesial Root)	<0.0001*	0.0019*	0.0047*	0.0741NS	<0.0001*	<0.0001*
1st molar (Mesial Root) vs. 2nd molar (Distal Root)	<0.0001*	<0.0001*	<0.0001*	0.0026*	<0.0001*	<0.0001*
1st molar (Distal Root) vs. 2nd molar (Mesial Root)	<0.0001*	0.0015*	0.0316*	0.0018*	<0.0001*	<0.0001*
1st molar (Distal Root) vs. 2nd molar (Distal Root)	<0.0001*	<0.0001*	<0.0001*	<0.0001*	<0.0001*	<0.0001*
2nd molar (Mesial Root) vs. 2nd molar (Distal Root)	>0.9999NS	>0.9999NS	>0.9999NS	>0.9999NS	0.5344NS	>0.9999NS

Note: NS – not significant (P > 0.05), * statistically significant ($P \leqslant 0.05$)

Примечания: NS – незначимо (P > 0,05), * статистически значимо ($P \leqslant 0{,}05$)

Table 5. Pairwise comparisons between sides

Таблица 5. Попарные сравнения между сторонами

Teeth	Females (*n* = 57)	Males (*n* = 54)	Total (*N* = 111)
2nd Premolar	0.27^{NS}	0.51^{NS}	0.74^{NS}
1st molar (Mesial Root)	0.47^{NS}	0.17^{NS}	0.13^{NS}
1st molar (Distal Root)	0.08^{NS}	0.34^{NS}	0.06^{NS}
2nd molar (Mesial Root)	0.94^{NS}	0.75^{NS}	0.72^{NS}
2nd molar (Distal Root)	0.8^{NS}	0.63^{NS}	0.66^{NS}

Note: NS – not significant ($P > 0.05$), * statistically significant ($P \leqslant 0.05$)

Примечания: NS – незначимо ($P > 0.05$), * статистически значимо ($P \leqslant 0.05$)

Table 6. Pairwise comparisons between Gender

Таблица 6. Попарные сравнения между полами

Teeth	Right	Left	Total
2nd Premolar	0.25^{NS}	0.1^{NS}	0.05*
1st molar (Mesial Root)	0.03*	0.06^{NS}	0.005*
1st molar (Distal Root)	0.03*	0.02*	0.001*
2nd molar (Mesial Root)	0.003*	0.004*	<0.0001*
2nd molar (Distal Root)	0.005*	0.001*	<0.0001*

Note: NS – not significant ($P > 0.05$), * statistically significant ($P \leqslant 0.05$)

Примечания: NS – незначимо ($P > 0,05$), * статистически значимо ($P \leqslant 0,05$)

On the left side, similar patterns were noted, with significant differences in the distance between the second premolar and the first molar (distal root) for males ($P = 0.0065$) and the total population ($P = 0.0043$). Substantial differences were also observed between the second premolar and the second molar (distal root) in females ($P = 0.0053$) and the total population ($P = 0.0068$). The first molar (mesial root) also showed significant differences from the second molar (mesial and distal roots), particularly in females ($P = 0.0019$) and the total population ($P < 0.0001$) (Table 4).

No notable differences were detected in the distance between the right and left sides for any tooth across genders or the total population ($P > 0.05$) (Table 5). However, gender-based comparisons revealed significant differences for the second premolar in the total population ($P = 0.05$), the first molar (mesial root) on the right side ($P = 0.03$) and overall ($P = 0.005$), and the first molar (distal root) across both sides and the total population ($P < 0.05$). Significant differences were also found for the second molar (mesial and distal roots) across all groups, with *P* values ranging from <0.005 to <0.0001 (Table 6).

DISCUSSION

Endodontic procedures bring on 35% of mandibular nerve neurosensory problems [6]. The dentist's experience, the patient's age and sex, and – most frequently – the structural relationship between the MC and the posterior tooth apices are among the risk factors that may result in harm to the mandibular nerve. Because the apices of the mandibular premolars and permanent mandibular molars are near when the MC is perforated, extrusion of endodontic material past the apex may harm the mandibular nerve [7]. When obturating material or irrigation products are overextended, the vacuoles assist the neuro-vascular bundle that travels through the low-density cancellous bone [5]. Several studies in the scientific literature have evaluated the nearness of the apex of molars and premolars to the MC. These findings indicate that the results may vary based on population type, age, and sex. Therefore, this study aimed to determine, by sex, the average distances between the root apices of the second premolars, first molars, and second molars to the MC using CBCT scans in a cohort of Eastern Indian individuals. In the present study, a positive correlation was observed between age and the distance of the inferior alveolar nerve (IAN) canal from the root apices. This correlation aligns with the findings of Hiremath et al. [8], who reported significant positive correlations between age and the root distances of the left first molar and the right second molar. However, the correlations for the second premolar and other molars were not significant in their study.

In the current analysis using Spearman's rank correlation, significant positive correlations were noted between age and the distal root of the second molar on the left side. Similarly, in the overall analysis, positive correlations were observed for the distal roots of both the first and second molars. These findings suggest that the distances between the IAN canal and the root apices increase with age, particularly in the distal roots of molars. While our study observed a trend of increasing distance with age, most changes were not statistically significant, aligning with the observations of Yu et al. [9] and Koivisto et al. [3] However, the mean distance between the IAC and root apices increased significantly across age groups, according to Srivastava et al. [10], particularly highlighting shorter distances in younger individuals aged 18–35 years compared to older age groups. This could be attributed to continued craniofacial adaptations over time.

Simonton et al. [11] proposed that this increase in distance may be the consequence of attrition and wear causing teeth to continue to emerge throughout life. These findings are further supported by a number of studies that demonstrate the craniofacial complex is still changing and adapting into the sixth decade of life [12; 13].

The study found that male participants exhibited significantly greater distances between the apices of their posterior teeth and the MC compared to female participants.

These findings align with the study by Hiremath et al. [8], Balaji et al. [14] and Oliveira A et al. [15] One possible explanation for this might be that women are more prone to MC injury since they often have smaller bodies. When placing dental implants, women are 3.29 times more likely than men to have MC injuries. Menopause and the alterations in bone metabolism that accompany it are risk factors. The risk is significantly increased by

osteoporosis, which is associated with decreased bone mass and residual ridge atrophy [16]. However, Manrique et al. [5] in their study found that although the distances of the root tips to the MC were greater in males, a significant difference existed only in the case of a second molar between the genders. A similar observation was noted by Koivisto et al. [3] These discrepancies can likely be attributed to differences in the populations studied, underscoring the importance of population-specific evaluations.

The apices of the second molar roots were found to be closest to the MC in both men and women, supporting the findings of Hiremath et al. [8], and Manrique et al. [5] Shokry et al. [17], Oliveira A et al. [15] and Srivastava et al. [10] Similarities with previous studies were found in terms of the physical aspects.

The MC begins its development within the mandibular process around the fifth-week post-conception, preceding any visible signs of tooth formation [18].

This research reveals distinct distance measurements between the bilateral posterior teeth, although not significant statistically. A plausible explanation for this variation lies in the dynamic nature of the MC's position throughout human development, shifting from a sucking to a chewing function. Masticatory muscle activity, particularly its influence on buccal cortical bone growth, contributes to the lingual displacement of the MC.

The clinical significance of these findings aligns with existing literature, which details numerous instances of IAN injury during endodontic treatment of lower second molars, as summarized in a systematic review [19]. Endodontic procedures on teeth adjacent to the MC demand meticulous attention, particularly regarding working length maintenance during instrumentation, medication placement, and obturation, to mitigate nerve damage. The bone density between the MC and oral apices, as well as their closeness, maybe prognostic variables for the damage of IAN and its branches [15]. This study was conducted on a small Eastern Indian subpopulation, which is a limitation due to the difficulty in accessing a comprehensive database that met the inclusion criteria. Most patient scans fell within the age range of 18–50 years, with fewer patients in the younger (<18 years) and older (>50 years) age groups. This imbalance may be ascribed to the fact that younger patients have less probability to undergo CBCT imaging unless for specific dental concerns, while older patients often present with partial edentulism, limiting their inclusion in the study.

Although the sample size was calculated and met the study's requirements, the authors suggest that future research should target more diverse populations, incorporating broader ethnicities to validate these findings. Additionally, the reliance on CBCT imaging posed limitations, such as challenges in obtaining precise measurements due to image resolution and potential artifacts. Overcoming these technical constraints and utilizing advanced imaging modalities would enhance the accuracy and reliability of future studies.

CONCLUSIONS

This study emphasizes the importance of understanding anatomical variations in the relationship of the MC to the root apices of mandibular posterior teeth. The findings reveal age-related increases in these distances, particularly for distal molar roots, and greater overall distances in males compared to females. These insights are crucial for clinical practice, emphasizing the need for accurate preoperative assessments in endodontics and implantology to minimize IAN injury risk.

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