INTERNATIONAL JOURNAL OF MEDICAL SCIENCE AND DENTAL HEALTH
(ISSN: 2454-4191)
www.ijmsdh.org (2026)

Check for updates

Received: 02 Oct 2026
Revised: 28 Oct 2026
Accepted: 02 Nov 2026
Published: 16 Nov 2026

Volume 12 Issue 11, 2026
Page No - 12-19
DOI - 10.55640/ijmsdh-12-11-02

Article Citation: Ali, M. B. . (2026). Radiographic Evaluation of the Proximity between Mandibular Molar Roots and the Inferior Alveolar Nerve Canal Using Cone-Beam Computed Tomography (CBCT) Among Different Age Groups in Najaf City: A Cross-Sectional Study. International Journal of Medical Science and Dental Health, 12(11), 12-19. https://doi.org/10.55640/ijmsdh-12-11-02.

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Radiographic Evaluation of the Proximity between Mandibular Molar Roots and the Inferior Alveolar Nerve Canal Using Cone-Beam Computed Tomography (CBCT) Among Different Age Groups in Najaf City: A Cross-Sectional Study

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Abstract

Aims: This study aimed to evaluate the proximity between mandibular molars roots and the inferior alveolar nerve (IAN) canal across different age and sex groups using Cone Beam Computed Tomography (CBCT) imaging modality in Najaf city.

Materials and Methods: A cross-sectional study was conducted on CBCT scans of 90 patients, aged 18-80 years. Patients were categorized into three age groups: 18-30, 31-45, 45-80 years. The shortest distance between the roots of the first, second, and third mandibular molars and the IAN canal was measured bilaterally using specialized CBCT software. Statistical analysis was performed to assess variations between age groups, sex groups, and sides of the mandible.

Results: The mean distance between the mandibular molar roots and the IAN canal was significantly smaller in the third molars compared to the first molars. Age-related differences were observed, with younger patients showing the smallest mean distances; this was statistically significant. No significant differences were found between the right and left sides. Gender differences were minimal.

Conclusion: CBCT imaging was effective in evaluating the relationship between mandibular molar roots and the inferior

alveolar nerve canal. The results showed that the distance between molar roots and the canal generally increased with age

and was slightly greater in males than in females. No significant difference was observed between the right and left sides of the mandible. In addition, the distance decreased from the first molar to the third molar, with the third molar showing the closest proximity to the inferior alveolar nerve canal. These findings highlight the importance of careful radiographic evaluation before performing surgical or endodontic procedures in the mandibular molar region.

Keywords: IAN Canal, CBCT, Dental Implant, Mandibular Molars, Radiography

Introduction

The anatomical relationship between mandibular molar roots and the inferior alveolar nerve (IAN) canal represents a critical consideration in modern dental practice, particularly in oral surgery, endodontics, and implant dentistry. The inferior alveolar nerve, a major branch of the mandibular division of the trigeminal nerve, travels within the mandibular canal and provides sensory innervation to the lower teeth, chin, and lower lip. The close proximity of mandibular molar roots—especially the second and third molars—to this nerve canal places the nerve at considerable risk during dental procedures such as surgical extraction, apical surgery, endodontic treatment, and implant placement [1,2].

Injury to the inferior alveolar nerve can result in neurosensory disturbances including paresthesia, hypoesthesia, dysesthesia, or even permanent anesthesia, which may significantly impair a patient's quality of life and carry potential medico-legal implications [3]. Accurate preoperative evaluation of the spatial relationship between mandibular molar roots and the inferior alveolar nerve canal is therefore essential to minimize the risk of complications and ensure safe and predictable clinical outcomes [4,5].

Radiographic assessment is the primary method for evaluating this relationship prior to any surgical or endodontic intervention. Conventional two-dimensional imaging modalities, such as periapical and panoramic radiographs, are widely used due to their accessibility and low radiation exposure [6]. However, these techniques have inherent limitations: image distortion, magnification errors, and superimposition of anatomical structures may compromise accurate visualization of the buccolingual position of the canal and the true distance between the root apices and the nerve canal [6,7]. Such inaccuracies may increase the likelihood of intraoperative complications, particularly in procedures involving the posterior mandible [2].

Three-dimensional imaging allows multiplanar visualization in axial, coronal, and sagittal views, enabling precise measurement of vertical and horizontal distances between the mandibular molar roots and the inferior alveolar nerve canal, as well as assessment of the canal's position relative to the roots and the presence or absence of cortical bone surrounding the canal [1,2,3].

Several anatomical and demographic factors influence the proximity between mandibular molar roots and the inferior alveolar nerve canal. Variations in root morphology, number of roots, degree of root curvature, and differences in canal trajectory contribute to individual variability [2,3]. Age is a significant factor because physiological changes such as root development, bone remodeling, and alveolar growth occur throughout life [5,7]. In younger individuals, incomplete root formation and ongoing skeletal growth may alter the relative position of the root apices in relation to the nerve canal [3,6]. In contrast, age-related bone remodeling, alveolar bone resorption, and changes in cortical bone thickness in older individuals may modify this spatial relationship, potentially affecting the level of surgical risk [2,5]. Gender, genetic background, and craniofacial morphology have also been suggested as contributors to variations in mandibular canal position and molar root proximity [2,3].

Understanding these variations is clinically important because the likelihood of inferior alveolar nerve injury may differ among patients depending on root morphology, canal position, and age. Direct contact between root apices and the nerve canal, penetration of the canal cortical wall, or the absence of cortical bone separation increases the probability of nerve trauma during extraction, apical surgery, or implant placement [1,4]. Similarly, the buccolingual position of the canal relative to the roots—whether lingual, buccal, inferior, or interradicular—can influence the surgical approach and difficulty, making precise preoperative assessment indispensable for patient safety [2,5].

While numerous international studies have examined the relationship between mandibular molars and the inferior alveolar nerve canal using advanced radiographic techniques, there is a lack of comprehensive data regarding the Iraqi population and specifically patients in Najaf City [3,7]. Regional anatomical characteristics may differ due to genetic, environmental, and lifestyle factors, highlighting the necessity of population-specific studies to inform clinical decision-making [6,7]. Understanding the local prevalence of different types of root-to-canal proximity and their variation across age groups can provide valuable evidence for planning surgical interventions and minimizing complications in the local population [2,5].

Therefore, this study aims to radiographically evaluate the proximity between mandibular molar roots and the inferior alveolar nerve canal among different age groups in Najaf City.

Using three-dimensional imaging, the study seeks to determine the distance between root apices and the nerve canal, classify positional relationships, and identify age-related differences that may affect the risk of nerve injury [1,4,7]. By providing detailed and region-specific anatomical data, this study aims to support safer clinical practice, improve treatment outcomes, and contribute to the body of knowledge regarding mandibular anatomy in the Iraqi population [3,5].

Materials and Methods

This cross-sectional study was conducted in Najaf City, Iraq. A total of 150 CBCT cases were collected for this study. However, 60 cases were excluded due to the absence of patient age information. Therefore, the final sample size included in the study consisted of 90 cases that met the study requirements. The total CBCT scans were collected from different dental radiology centers including SEEN Radiology Center, Spectrum Center, and other dental clinics.

The CBCT scans were collected during the period from late 2025 to early 2026. These radiographic images were used to evaluate the proximity between the roots of mandibular molars and the inferior alveolar nerve canal among different age groups.

Cone-beam computed tomography (CBCT) was used for radiographic evaluation. The images were examined in axial, coronal, and sagittal sections to determine the anatomical relationship between the mandibular molar roots and the inferior alveolar nerve canal. The axial view was first used to identify the mandibular molar region and to locate the inferior alveolar nerve canal. The image was adjusted to clearly visualize the canal pathway and surrounding anatomical structures (**Figure 1)**.

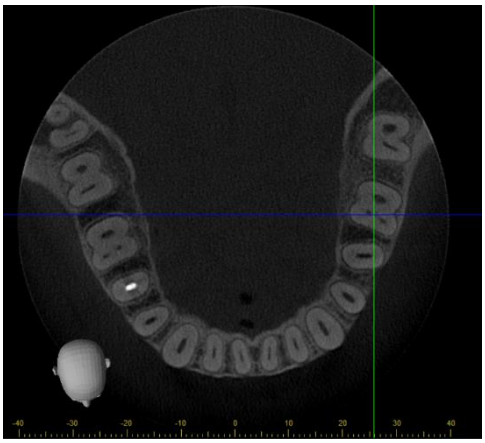


Figure (1): Axial view

After identifying the region of interest in the axial section, the image orientation was adjusted to obtain the sagittal view, which allows evaluation of the vertical relationship between the root apices of mandibular molars and the inferior alveolar nerve canal (**Figure 2)**.

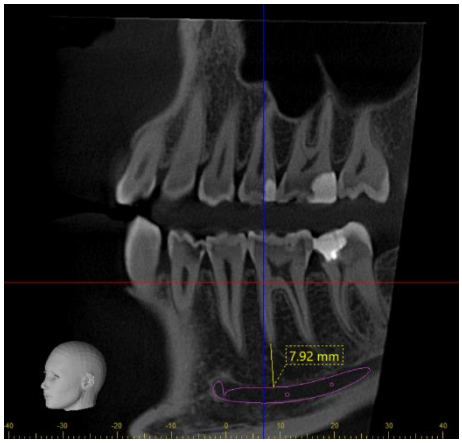


Figure (2): Sagittal view

Subsequently, the coronal view was used to evaluate the buccolingual relationship between the mandibular molar roots and the inferior alveolar nerve canal (**Figure 3)**.

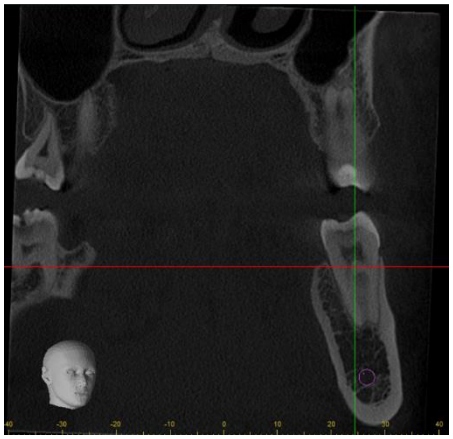


Figure (3): Coronal view

After visualizing the molars and the relation to IAN canal, measurement of the distance was done for each root at the proper and obvious angulation and the 3D CBCT views (**Figures 4,5)**.

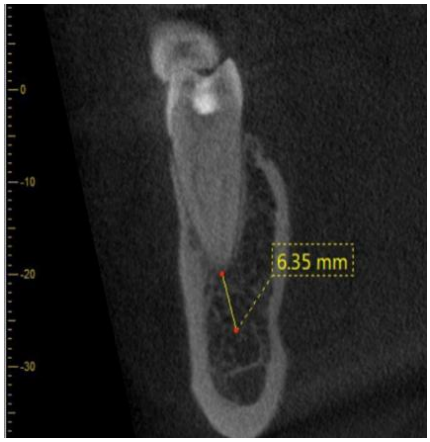


Figure (4): Male, Lower right first molar.



Figure (5): Male, 53 Lower right third molar

For each case, the patient's age and gender were recorded, and the distance between the root apices of the mandibular molars and the inferior alveolar nerve canal was evaluated.

2.2 Inclusion Criteria

- CBCT images that clearly show mandibular molars and the inferior alveolar nerve canal.
- Patients with fully developed mandibular molar roots.
- High-quality CBCT scans suitable for radiographic evaluation.
- Patients belonging to different age groups.

2.3 Exclusion Criteria

- CBCT scans with poor image quality or artifacts.
- Teeth with incomplete root formation.
- Presence of pathological lesions affecting the mandibular molar region.
- Presence of dental implants in the mandibular molar region.
- Teeth restored with fixed prosthesis that may interfere with accurate radiographic measurements.

2.4 Radiographic Evaluation

The CBCT images were carefully examined to evaluate the anatomical relationship between the mandibular molar roots and the inferior alveolar nerve canal. The images were analyzed in axial, coronal, and sagittal views using specialized CBCT software. The shortest distance between the root apex of the mandibular molars and the inferior alveolar nerve canal was measured and recorded.

Results

The Comparison According to Age

The analysis of the mean distance between mandibular molar roots and the inferior alveolar canal across different age groups showed a gradual increase in the mean values with increasing age. The 45–80 years group demonstrated the largest mean distances, particularly in the first molar (6.91 ± 2.41 mm) and third molar (4.69 ± 1.96 mm), whereas the 18–30 years group showed the smallest mean distances, especially in the third molar (3.01 ± 1.60 mm). This trend may be explained by age-related anatomical changes in the mandible, such as continuous bone remodeling and possible alveolar bone resorption over time, which can slightly increase the distance between tooth roots and the inferior alveolar canal, **Table (1)**.

Table (1): Distribution of mean distance between molar roots and the inferior alveolar canal according to age groups.

Age group	First molar (mean+_SD)	Second molar (mean +_SD)	Third molar (mean +_SD)
18-30 years	**5.12+_1.98**	**4.06+_1.82**	**3.01+_1.60**
31-45 years	**5.66+_2.14**	**4.54+_2.01**	**3.59+_1.73**
45-80 years	**6.91+_2.41**	**5.75+_2.23**	**4.69+_1.96**

The Comparison According to Gender

When comparing males and females, males demonstrated consistently greater mean distances between molar roots and the inferior alveolar canal in all molars. For example: First molar: males (6.21 ± 2.24 mm) showed larger values than females (5.33 ± 2.01 mm). Second molar: males (4.92 ± 2.05 mm) also exceeded females (4.18 ± 1.87 mm). Third molar: males (4.19 ± 1.91 mm) were higher than females (3.37 ± 1.73 mm) **Table (2)**.

Table (2): Comparison of mean distance between molar roots and the inferior alveolar canal according to gender.

Tooth	Male (mean+_SD)	Female (mean+_SD)

First molar	**6.21+_2.24**	**5.33 +_ 2.01**
Second molar	**4.92+_2.05**	**4.18 +_ 1.87**
Third molar	**4.19+_1.91**	**3.37 +_ 1.73**

Comparison of Molar Roots Between Right and Left Sides

The comparison between the right and left mandibular sides revealed very similar mean distances for all evaluated molar roots, including mesial and distal roots. For instance: First molar mesial root: right (5.84 ± 2.12 mm) and left (5.71 ± 2.09 mm) showed minimal difference. Second molar mesial root: right (4.63 ± 1.94 mm) and left (4.70 ± 1.98 mm). Third molar distal root: right (3.71 ± 1.76 mm) and left (3.66 ± 1.74 mm). All recorded P-values were greater than 0.05, indicating no statistically significant difference between the right and left sides of the mandible. This finding suggests that the anatomical relationship between mandibular molar roots and the inferior alveolar canal tends to be symmetrical, which is consistent with normal mandibular anatomical development, **Table (3)**.

Table (3): Comparison of mean distance between molar roots and the inferior alveolar canal between right and left sides.

Tooth root	Right (mean +_SD)	Left (mean+_SD)	p.value
First molar mesial	**5.84 +_ 2.12**	**5.71 +_ 2.09**	**0.71**
First molar distal	**6.02 +_ 2.18**	**5.88 +_ 2.16**	**0.66**
Second molar mesial	**4.63 +_ 1.94**	**4.70 +_ 1.98**	**0.79**
Second molar distal	**4.72+_ 2.02**	**4.61 +_ 1.97**	**0.68**
Third molar mesial	**3.91 +_ 1.82**	**3.84 +_ 1.80**	**0.74**
Third molar distal	**3.71+_ 1.76**	**3.66+_ 1.74**	**0.81**

The distribution mean distance by molar roots

The right side

The first molar demonstrated the greatest mean distance (5.84 mm) from the inferior alveolar nerve canal. This indicates that the first molar mesial root is relatively farther from the nerve canal compared with the other molars. The second molar showed a moderate mean distance (4.63 mm), suggesting a closer anatomical relationship with the inferior alveolar nerve canal compared with the first molar. The third molar exhibited the smallest mean distance (3.91 mm), indicating the closest proximity to the inferior alveolar nerve canal, (**Figure 6)**.

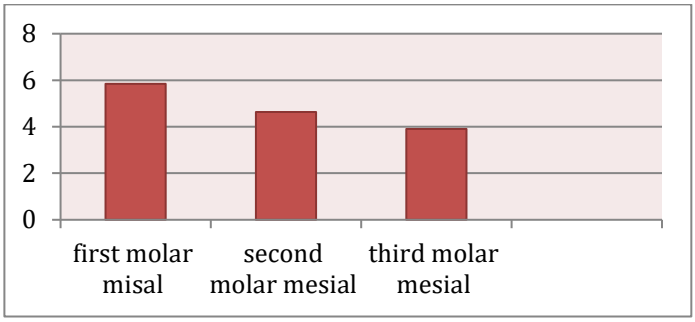


Figure (6): Mean distance between mesial roots of mandibular molars and the inferior alveolar canal on the right side.

The first molar distal root presented the largest mean distance (6.02 mm) from the inferior alveolar nerve canal, indicating a relatively safe anatomical separation. The second molar distal root demonstrated a moderate distance (4.72 mm), reflecting a closer relationship to the nerve canal. The third molar distal root showed the smallest mean distance (3.91 mm), suggesting a higher probability of proximity to the inferior alveolar nerve canal. Overall, the distal roots follow a gradual decrease in distance from first molar to third molar, (**Figure 7)**.

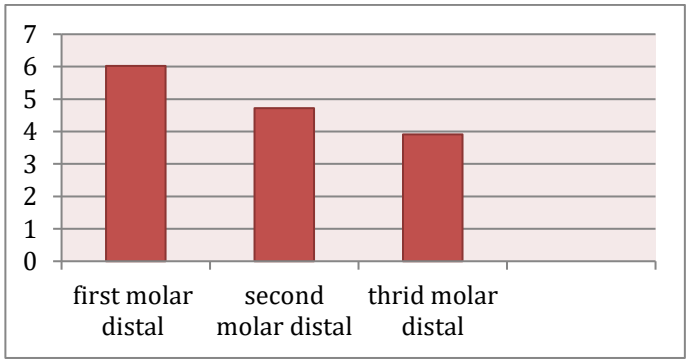


Figure (7): Mean distance between distal roots of mandibular molars and the inferior alveolar canal on the right side.

The left side

The first molar mesial root had the largest mean distance (5.71 mm), indicating a relatively safe anatomical separation. The

second molar mesial root showed a mean distance of (4.70 mm), reflecting a moderate proximity to the nerve canal. The third molar mesial root recorded the smallest mean distance (3.84 mm), indicating that this tooth is located closest to the inferior alveolar nerve canal, (**Figure 8)**.

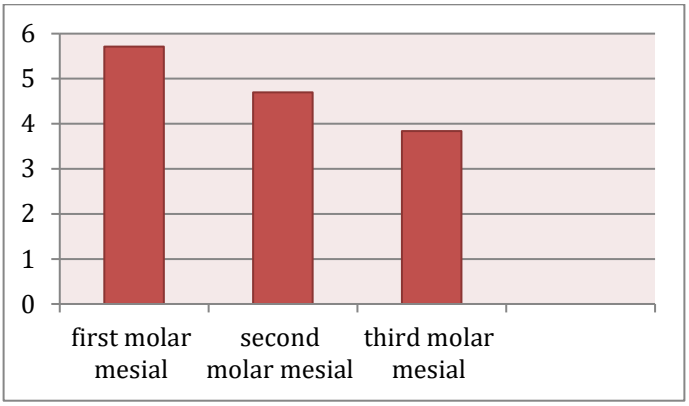


Figure (8): Mean distance between mesial roots of mandibular molars and the inferior

alveolar canal on the left side.

The first molar distal root showed the greatest mean distance (5.88 mm) from the IAN canal. The second molar distal root presented a mean distance of (4.61 mm), indicating moderate proximity. The third molar distal root had the smallest mean distance (3.66 mm), suggesting the closest anatomical relationship with the inferior alveolar nerve canal (**Figure 9)**.

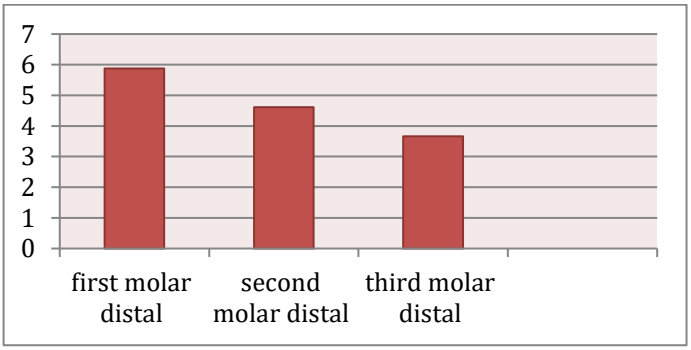


Figure (9): Mean distance between distal roots of mandibular molars and the inferior

alveolar canal on the left side.

Discussion

Cone Beam Computed Tomography (CBCT) is considered one of the most important imaging modalities used in modern dental diagnostics for evaluating the maxillofacial region in three dimensions [1]. The technology was first introduced in 1982 at the Mayo Clinic Biodynamics Research Laboratory for angiographic applications, and later adapted for dental imaging. In 1998, Piero Mozzo and colleagues developed the first CBCT system dedicated to dental use, known as the NewTom 9000 [6].

The anatomical relationship between the root apices of mandibular molars and the inferior alveolar nerve canal is of great clinical importance in dental practice. When the root apex is located very close to the inferior alveolar nerve canal, there is an increased risk of nerve injury during dental procedures such as tooth extraction, endodontic treatment, apical surgery, or implant placement [1,4]. Injury to the inferior alveolar nerve may result in complications including pain, paresthesia, numbness, or altered sensation [3].

Ghaeminia et al. (2011) and Kim et al. (2012) reported that mandibular third molars often show the closest anatomical relationship with the inferior alveolar canal compared with other molars, frequently lying in close proximity or direct contact, which increases the potential risk of injury. Our finding that the third molar exhibited the smallest mean distance (3.91 mm) is in full agreement with these studies [12, 13].

Park et al. (2015) and Brady et al. (2014) observed that the spatial relationship between molar roots and the mandibular canal changes with age due to bone remodeling and physiological changes. With increasing age, gradual bone deposition and structural changes may increase the distance between root apices and the canal. Our findings support this, showing that the 45–80 years group demonstrated the largest mean distances (first molar: 6.91 ± 2.41 mm, third molar: 4.69 ± 1.96 mm), whereas the 18–30 years group showed the smallest mean distances (third molar: 3.01 ± 1.60 mm) [14, 15].

Regarding gender differences, Al-Sudani et al. (2016) reported no statistically significant gender differences, which contrasts with our findings [16]. However, Baik et al. (2019) reported slightly greater distances in males than females, attributed to differences in mandibular size and bone density [17]. Our results demonstrated consistently greater mean distances in males across all molars, aligning with Baik et al.

Tantanapornkul et al. (2007) and Kang et al. (2018) reported symmetrical anatomical relationships between molar roots and the mandibular canal on both sides. Our results revealed no statistically significant differences between right and left sides ($P > 0.05$), confirming bilateral symmetry in normal mandibular development [18, 19].

Conclusion

CBCT assessment revealed that mandibular molar roots are closer to the inferior alveolar nerve canal in younger individuals, with the third molar presenting the highest anatomical risk. These findings emphasize the importance of careful radiographic evaluation prior to dental interventions.

Funding

The authors declare that no external funding was received for this study.

Conflicts of Interest

None declared.

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