



www.bioinformation.net
Volume 22(9)



Research Article

Received September 1, 2026; Revised September 30, 2026; Accepted September 30, 2026, Published September 30, 2026

DOI: 10.6026/973206300225616

SJIF 2026 (Scientific Journal Impact Factor for 2026) = 8.478

2022 Impact Factor (2023 Clarivate Inc. release) is 1.9

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Citation: Agrawal *et al.* Bioinformation 22(9): 5616-5620 (2026)

Cone beam computed tomographic evaluation of mandibular posterior root apices with mandibular canal

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Abstract:

Accurate assessment of the relationship between posterior mandibular root apices and the mandibular canal is essential to minimize inferior alveolar nerve injury during dental procedures. Therefore, it is of interest to evaluate root apex-mandibular canal distances in 400 patients from the Chhattisgarh population. Distances from the second premolars and first and second molars to the mandibular canal were measured using CBCT and analyzed by age and gender. The distal root of the first molar was farthest from the canal, whereas the distal root of the second molar was the closest; distances increased significantly with age but showed no gender differences. Thus, CBCT provides accurate three-dimensional assessment this should be considered before endodontic, surgical and implant procedures to reduce the risk of inferior alveolar nerve injury.

Keywords: Cone beam computed tomography, mandibular canal, inferior alveolar nerve, molar roots, premolar roots, CBCT, endodontics, posterior mandible

Background:

The inferior alveolar neurovascular bundle is an important anatomical structure which runs through the mandible in the mandibular canal. Its proximity to the roots of the posterior teeth is of great clinical significance in dentistry, especially in endodontic therapy, implant surgery, impacted tooth extraction, periapical surgery and other surgeries involving the posterior mandible. Damage to the inferior alveolar nerve can lead to paresthesia, anesthesia, dysesthesia and chronic neurosensory complications which can have a profound impact on patient quality of life. Thus, it is important to have a proper radiographic evaluation of the relationship of the root apices and the mandibular canal prior to any invasive procedure [1, 2]. Periapical radiographs and panoramic imaging have been the most common methods for assessing the mandibular anatomy using conventional 2D radiographic methods. These techniques, however, have their own inherent limitations such as magnification errors, geometric distortion and superimposition of structures and lack of precise three-dimensional anatomical localization. These restrictions can affect the ability to accurately evaluate the relationship of the mandibular canal to the root apices [3]. CBCT is a revolutionary technique in maxillofacial imaging due to its ability to produce high-resolution three-dimensional images at a relatively low radiation dose compared to conventional computed tomography. CBCT provides precise visualization of anatomical structures in the axial, sagittal, coronal and cross-sectional planes, leading to better diagnosis and treatment planning. Recent guidelines have highlighted the value of CBCT in endodontics and oral surgery to help determine root morphology, canal position and periapical pathology and neurovascular relationships [4, 5]. The position of the mandibular posterior teeth in relation to the mandibular canal is different between different populations due to ethnicity, age, sex, skeletal structure and the remodeling of the alveolar bone. Mandibular molar roots, particularly second molars, have been reported to be close to the inferior alveolar canal, which may lead to nerve injury during instrumentation or surgical

procedures. In addition, the position of the canal can change over time due to age-related bone changes and alveolar resorption [6]. Root apex-to-canal distances have been assessed by several investigators in various populations with the use of CBCT. But there is not much literature available on the population of Chhattisgarh. Anatomical variations are important to understand in order to optimize treatment planning and reduce procedural complications in the individual population [7]. The relationship between the mandibular canal and root apices may be affected by age due to the continuous remodelling of the bone, the deposition of secondary dentin and the compensatory eruption associated with occlusal wear. Likewise, there are differences in the size of the mandible and bone density between the sexes that could lead to anatomical variations. Assessment of these demographic factors may be useful for better prediction of surgical risks [8]. The anatomical evaluation using CBCT has gained more significance in recent years in the fields of conservative dentistry and endodontics. Irrigant extrusion, over instrumentation and overfilling beyond root apices in teeth that are close to the mandibular canal can lead to injury of the inferior alveolar nerve. Preoperative assessment can then improve the safety of the procedure and the clinical outcomes [9-11]. Therefore, it is of interest to assess the distance between the apices of the posterior roots of the mandible and the mandibular canal in the Chhattisgarh population on CBCT images and to evaluate the effect of age and gender on the position of the canal.

Materials and Methodology:

This is a retrospective cross sectional study done in the Department of Conservative Dentistry and Endodontics, Rungta College of Dental Sciences and Research. The study was approved by the institutional ethical committee prior to the start of data collection. This study used archived CBCT scans from the Department of Oral Medicine and Radiology. The study included 400 CBCT scans of patients aged 26 to 65 years. CBCT images were obtained with the New Tom Go 2D/3D Imaging

System, with fixed exposure parameters. Random images from institutional records were chosen, with patient confidentiality maintained. To reduce observer bias, only age and sex information were visible during image analysis.

The sample size was determined from a pilot study by the investigator. Using the formula for infinite population:

$$n = \frac{Z^2 \times P \times (1 - P)}{e^2}$$

Where $z = 1.96$ at 95% confidence interval, $p = 0.6$ and margin of error $e = 0.05$, the calculated sample size was 384, which was rounded to 400 CBCT scans. CBCT scans of the second premolars, first molars and second molars with good diagnostic quality were included in the study. Patients in the age range were scanned, both male and female. Patients who were edentulous mandibles, patients who had any pathology of the mandible that affected the position of the canal, patients whose scans were distorted and patients who were under 26 years of age or over 65 years of age were excluded from the investigation. CBCT scans were acquired using an 8×8 cm field of view and a voxel size of less than 200 μm. Imaging parameters were set at 90 kV, 9–12 mA, 200-degree rotation and exposure time of 12–16 seconds. New Tom's NNT digital software was used to reconstruct images. Image analysis was performed in the multi-planar reconstruction mode (axial, sagittal, coronal and cross-sectional views). The course of the mandibular canal was followed from the mental foramen to the posterior part of the body of the mandible. The distance between the apex of each tooth and the superior border of the mandibular canal was measured at 1:1 magnification with the measuring tool in millimeters.

The following measurements were taken:

- [1] The root apex of the second premolar of the lower jaw.
- [2] The first molar of the lower jaw has a root on the inside of the mouth.
- [3] Distal root of the first molar of the mandible
- [4] The mesial root of the second molar of the lower jaw.
- [5] Distal root of mandibular second molar

To enhance the accuracy of measurements, orthogonal slices with a thickness of 1 mm were used. Each scan was independently assessed by experienced and calibrated observers and the average of the measurements was used for statistical analysis to reduce interobserver variability.

The participants were divided into four age groups:

- [1] 26–35 years
- [2] 36–45 years
- [3] 46–55 years
- [4] 56–65 years

Subjects were also divided into males and females. Data were analyzed statistically with SPSS version 24 software. The data for continuous variables was presented as mean and standard deviation and for categorical variables as frequencies and percentages. The comparisons between age groups were made using one-way ANOVA with Tukey post hoc test, while gender comparisons were made using independent t-test. A p value of ≤ 0.05 was deemed to be statistically significant.

Results:

A total of 400 CBCT scans were analyzed in the present investigation to evaluate the relationship between mandibular posterior root apices and the mandibular canal in the Chhattisgarh population. The majority of study participants belonged to the 26–35 years age group comprising 44.5% of the total population. The least represented group was 46–55 years accounting for 13.75%. The mean age of the study population was 41.71 ± 12.56 years. Gender distribution was nearly equal, with females representing 50.5% and males representing 49.5% of the sample population (**Table 1**). Among all evaluated teeth, the distal root of the mandibular first molar demonstrated the greatest mean distance from the mandibular canal with a value of 5.37 ± 2.41 mm. The mesial root of the first molar also showed considerable separation from the canal with a mean distance of 5.25 ± 2.35 mm. In contrast, the distal root of the second molar showed the least mean distance of 3.93 ± 2.11 mm, indicating closer proximity to the mandibular canal and potentially greater risk of inferior alveolar nerve injury during surgical or endodontic procedures (**Table 2**). Statistically significant differences were observed in all root apex-to-canal distances among different age groups ($p < 0.001$). A progressive increase in mean distance was noted with advancing age for all evaluated teeth. Participants aged 56–65 years consistently demonstrated the greatest root apex-to-canal distances. The mesial root of the first molar in the 56–65 years group exhibited the highest recorded mean distance of 7.95 ± 2.11 mm. Younger individuals aged 26–35 years demonstrated comparatively shorter distances, especially for second molar roots. These findings suggest that age-related changes in alveolar bone architecture and mandibular remodeling may influence the spatial relationship between tooth roots and the mandibular canal. No statistically significant gender differences were observed for any evaluated tooth root ($p > 0.05$) (**Table 3**). Although males demonstrated slightly greater mean distances compared with females for most teeth, these variations were minimal and statistically insignificant. The mesial root of the first molar showed a mean distance of 5.27 ± 2.49 mm in males and 5.22 ± 2.20 mm in females. Similarly, distal roots of second molars demonstrated mean distances of 3.99 ± 2.17 mm and 3.88 ± 2.06 mm among males and females respectively. These findings indicate that gender may not significantly influence the anatomical relationship between mandibular posterior root apices and the mandibular canal in the studied population (**Table 4**).

Table 1: Distribution of demographic characteristics

Variable	Category	Frequency	Percentage
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Age	26–35 years	178	44.5%
	36–45 years	79	19.75%
	46–55 years	55	13.75%
	56–65 years	88	22.0%
Sex	Male	198	49.5%
	Female	202	50.5%

Table 2: Overall mean distance between root apices and mandibular canal

Tooth root	Mean distance (mm)	SD
2nd premolar	4.16	2.71
Mesial root of 1st molar	5.25	2.35
Distal root of 1st molar	5.37	2.41
Mesial root of 2nd molar	4.19	2.33
Distal root of 2nd molar	3.93	2.11

Table 3: Comparison of root apex-to-canal distance among different age groups

Tooth	26–35 years	36–45 years	46–55 years	56–65 years	P value
2nd premolar	3.06 ± 3.12	3.69 ± 1.06	4.46 ± 1.19	6.69 ± 1.60	<0.001
Mesial root of 1st molar	3.85 ± 1.65	4.89 ± 1.25	5.85 ± 1.58	7.95 ± 2.11	<0.001
Distal root of 1st molar	4.20 ± 1.89	5.10 ± 1.38	5.72 ± 1.71	7.68 ± 2.64	<0.001
Mesial root of 2nd molar	2.92 ± 1.39	3.93 ± 1.53	4.61 ± 1.65	6.79 ± 2.62	<0.001
Distal root of 2nd molar	2.99 ± 1.55	3.81 ± 1.41	4.05 ± 1.68	5.92 ± 2.51	<0.001

Table 4: Comparison of root apex-to-canal distance between genders

Tooth	Male (Mean ± SD)	Female (Mean ± SD)	P value
2nd premolar	4.09 ± 2.06	4.23 ± 3.22	0.616
Mesial root of 1st molar	5.27 ± 2.49	5.22 ± 2.20	0.852
Distal root of 1st molar	5.46 ± 2.57	5.27 ± 2.25	0.444
Mesial root of 2nd molar	4.26 ± 2.42	4.11 ± 2.23	0.535
Distal root of 2nd molar	3.99 ± 2.17	3.88 ± 2.06	0.590

Discussion:

Clinically, the relationship of the roots of the posterior teeth with the mandibular canal is important because of the possibility of injury to the inferior alveolar nerve during surgical and endodontic treatment. The present CBCT based retrospective study aimed to evaluate the distance between the apices of the posterior roots of mandible and the mandibular canal in the Chhattisgarh population and to check the effect of age and gender on the position of the canal. The present study showed that the mean distance of the distal root of the first molar was the greatest while the mean distance of the distal root of the second molar was the least from the mandibular canal. The results of this study suggest that the second molars have greater anatomical relationship with the inferior alveolar canal and hence are at a higher risk during extraction, apical surgery, and root canal instrumentation and implant placement. Razumova *et al.* reported that the inferior alveolar canal was the most common relationship with the posterior mandibular teeth, particularly the second molars [1]. In the present study, CBCT imaging was able to give a three-dimensional view of the root-canal relationships. CBCT has been advocated by several investigators due to its ability to avoid superimposition and magnification errors and provide accurate linear measurements, which are advantages over conventional panoramic radiography. CBCT has been shown too greatly aid in the accuracy of diagnosis in the posterior mandible during presurgical planning by Chen *et al.* [2]. This present study noted statistically significant increases in root apex-to-canal distances with age. The distances were significantly higher in the age group 56-65 years than in younger age groups. This could be due to age-related remodelling of the mandible, secondary dentin

deposition, compensatory eruption and changes in alveolar bone morphology. Aksoy *et al.* reported that the canal separation increased with age due to continuous skeletal remodelling, which is similar to the changes described above [3]. The distances between the posterior root apices and the mandibular canal were comparatively shorter in younger age groups of the present study. This is clinically relevant because younger patients may be more susceptible to injury of the inferior alveolar nerve during surgical or endodontic treatment. Neurosensory complications can be caused by over instrumentation or extrusion of obturation materials in teeth that are closely related to the canal [4]. The present study did not reveal any statistically significant gender differences. The mean distance was slightly greater in males than in females but was not significant. The same results were obtained by Pucilo *et al.*, who did not find any significant difference between the proximity of the mandibular canal of the molars in males and females on CBCT analysis [5]. The present study involved a relatively large number of 400 CBCT scans which increased the reliability of the results. Demographic validity was further enhanced by equal representation of both genders. Additionally, use of calibrated independent observers minimized measurement bias and improved reproducibility of the results. The clinical significance of the present study is great in the field of conservative dentistry, oral surgery, implantology and endodontics. The use of endodontic treatment in molars of the mandible can sometimes result in the extrusion of irrigants, sealers, medicaments, or obturation materials beyond the root apices. These materials can damage the inferior alveolar nerve and cause paresthesia or anesthesia when the roots are in close proximity to the canal. Pre-treatment CBCT evaluation can thus

help the clinician to identify high-risk cases [6]. When performing oral surgery, it is important to know the anatomy of the canal when extracting molars from the mandible and placing implants. Inadequate assessment of the position of the mandibular canal can result in nerve trauma, hemorrhage and postoperative sensory disturbances, as previously reported. CBCT imaging is therefore now an integral part of contemporary pre-operative planning [7]. Mandibular variations in terms of ethnicity and population have also been well documented. The present study provides useful anatomical information about the Chhattisgarh population that can be useful to the clinicians working in the region. The significance of such regional anatomical databases is that the morphology of the craniofacial region varies between populations as a result of both genetic and environmental factors [8-10]. The study had some limitations, even though it had a lot of strengths. The study was retrospective and did not have a longitudinal follow-up. In addition, only posterior teeth of the mandible were assessed. Larger populations and other anatomical parameters in future multicentric studies may yield more complete data [11-13]. The results of the present study highlight the need for a pre-procedure assessment of the anatomical structures in the posterior mandible using CBCT prior to any invasive procedure. Correct knowledge of root apex-to-canal relationships can greatly minimize the risk of inferior alveolar nerve complications and enhance the safety of treatment [13-15].

Conclusion:

The mandibular second molar roots were close to the mandibular canal, while first molar roots showed greater separation in the Chhattisgarh population. Root apex-to-canal distance increased significantly with age, with no significant gender differences, highlighting important anatomical variations for posterior mandibular procedures. CBCT provides accurate

three-dimensional assessment of this relationship and may aid safer endodontic and surgical treatment of mandibular posterior teeth.

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