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Cone-Beam CT Evaluation of the Mandibular Incisive Nerve Canal: A Cross-Sectional Analysis

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Abstract

Background: The mandibular incisive canal (MIC) is an anterior extension of the mandibular canal that houses neurovascular bundles supplying the anterior mandibular teeth. Accurate identification of the MIC is critical in implantology, endodontics, and maxillofacial surgeries to minimize intraoperative complications. Cone-beam computed tomography (CBCT) offers high-resolution imaging for detailed visualization of mandibular anatomy, yet the MIC is frequently underdiagnosed in routine radiographic evaluations.

Aim: To assess the presence, course, and morphometric variations of the mandibular incisive canal using CBCT and to evaluate its clinical significance in surgical and implant planning.

Materials and Methods: This cross-sectional study analyzed CBCT scans of patients obtained from the radiology database of a dental institution. Scans with clear visibility of the mandibular anterior region were included. Parameters assessed included: prevalence of MIC, canal diameter, distance from alveolar crest, distance from buccal and lingual cortical plates, and its course relative to mandibular midline. Data were stratified by gender and age groups and subjected to statistical analysis.

Results: The MIC was identified in a majority of the scans, with variations in diameter and course. The canal was generally located closer to the buccal cortical plate and showed significant morphometric differences between males and females. The mean distance from the alveolar crest varied across age groups, with a tendency for reduced bone height in older individuals. These anatomical variations underline the importance of precise pre-surgical assessment.

Conclusion: CBCT is a reliable imaging modality for identifying and assessing the mandibular incisive canal. Recognition of its anatomical variations is essential for safe implant placement, anterior mandibular surgeries, and endodontic procedures, thereby reducing the risk of neurovascular injury.

Keywords: Mandibular incisive canal; Cone-beam computed tomography (CBCT); Mandibular anatomy; Inferior alveolar nerve; Dental implant planning; Neurovascular variations

Introduction

The mandibular interforaminal region has traditionally been regarded as a safe zone for dental implant placement and various surgical procedures. However, recent evidence indicates that the presence of the mandibular incisive canal (MIC) challenges this assumption. Earlier, clinicians relied primarily on two-dimensional (2D) radiographs for preoperative evaluation in this area. Such imaging methods provide limited information and often fail to adequately display critical anatomical details, which may result in complications. Clinical reports describing neurosensory alterations after anterior mandibular osteotomies have emphasized the anatomical and clinical significance of the incisive nerve and its canal [1,2]. The inferior alveolar canal (IAC) houses the inferior alveolar nerve, artery, and vein. It begins at the mandibular foramen, travels through the mandibular body, and exits at the mental foramen adjacent to the second premolar. Beyond this, the canal continues forward as the MIC, transmitting terminal branches of the inferior alveolar nerve that innervate the mandibular incisors and canines [3]. The MIC demonstrates variability in its morphology and pathway, making its identification essential for procedures such as implant placement, bone harvesting, and local anaesthesia within the interforaminal region. Although this anterior mandibular zone is often chosen for implant therapy and chin block grafting due to favourable bone quality and relative distance from the IAC, inadvertent damage to the MIC can cause sensory disturbances in the lower anterior teeth, mucosa, and overlying tissues. Thus, careful evaluation of the MIC is critical in preoperative surgical planning [4].

Conventional panoramic radiography, particularly orthopantomography (OPG), remains a common tool for assessing dentition, jaw structures, and related pathologies. However, its diagnostic ability is limited by issues such as magnification, distortion, and image superimposition, which restrict accurate visualization of the MIC [5]. The introduction of three-dimensional (3D) imaging technologies, especially cone beam computed tomography (CBCT), has transformed maxillofacial diagnostics. CBCT provides high-resolution, distortion-free images, enabling precise identification and measurement of the MIC [6–9]. Due to its superior accuracy, reproducibility, and minimally invasive nature, CBCT is now considered the gold standard for preoperative assessment of the MIC [10–13]. Identifying its location and dimensions is vital for minimizing intraoperative neurovascular complications and achieving predictable clinical outcomes. Accordingly, the present study was designed to assess the prevalence of the mandibular incisive canal and evaluate its position and morphometric characteristics using CBCT in a defined patient population

Materials and Methods

Study Design: This research was designed as a cross-sectional observational study aimed at assessing the presence, course, and morphometric characteristics of the mandibular incisive canal (MIC) using Cone Beam Computed Tomography (CBCT). The study protocol was reviewed and approved by the Institutional Ethical Committee, ensuring adherence to ethical standards for biomedical research involving human data.

Study Population: A total of 250 CBCT scans were retrospectively selected and analyzed. The study population consisted of both male and female patients, aged between 30 and 50 years, who had undergone CBCT imaging for various clinical diagnostic or treatment-related indications. The choice of this age group was made to minimize confounding factors such as growth-related mandibular changes in younger individuals and severe resorption or degenerative changes in elderly patients.

Inclusion Criteria

• Patients aged between 30–50 years
• Patients of Indian origin
• CBCT scans obtained for diagnostic purposes in routine clinical practice

Exclusion Criteria

• Patients not belonging to Indian origin
• Patients with congenital craniofacial anomalies (e.g., cleft lip/palate)
• Patients with syndromic conditions affecting craniofacial development
• Poor quality CBCT scans with motion artifacts or inadequate resolution for accurate measurement

Data Collection: The CBCT scans were retrieved from the departmental imaging database. Only high-quality scans that met the diagnostic standards for mandibular visualization were included. A total of 250 scans formed the final sample size, which was considered adequate to generate statistically significant results based on prior studies assessing similar parameters.

Results

Table 1. Morphometric parameters of Mandibular Incisive Canal (MIC) observed in CBCT scans

Parameter	Overall Mean ± SD (mm)	Male (n=125) Mean ± SD	Female (n=125) Mean ± SD	*p*-value	Right Side Mean ± SD	Left Side Mean ± SD	*p*-value
Distance from MIC to Mental Foramen	4.21 ± 0.82	4.35 ± 0.79	4.08 ± 0.84	0.041*	4.18 ± 0.83	4.24 ± 0.81	0.62
Distance from MIC to Cortical Plate	2.95 ± 0.64	3.01 ± 0.66	2.89 ± 0.61	0.12	2.98 ± 0.65	2.92 ± 0.63	0.34
Distance from MIC to Alveolar Crest	7.32 ± 1.15	7.58 ± 1.18	7.06 ± 1.12	0.009*	7.29 ± 1.14	7.35 ± 1.17	0.55
Length of MIC	9.85 ± 1.74	10.12 ±1.82	9.58 ± 1.64	0.016*	9.81 ± 1.72	9.89 ± 1.76	0.48
Diameter at Origin	1.42 ± 0.27	1.49 ± 0.25	1.36 ± 0.29	0.002*	1.43 ± 0.26	1.41 ± 0.28	0.66
Diameter at Apex	0.89 ± 0.18	0.91 ± 0.19	0.87 ± 0.17	0.14	0.90 ± 0.18	0.88 ± 0.17	0.39
Distance from MIC to Inferior Border of Mandible	9.12 ± 1.36	9.24 ± 1.41	9.00 ± 1.32	0.21	9.15 ± 1.38	9.09 ± 1.35	0.67

The morphometric analysis showed that males had significantly greater distances of the MIC from the mental foramen, alveolar crest, and overall canal length compared to females ($p < 0.05$). The canal diameter at origin was also larger in males, while no significant gender differences were noted at the apex or in distance from the inferior border. No significant side-to-side differences were found, indicating bilateral symmetry.

Table 2. Presence of Mandibular Incisive Canal by Gender and Side

Variable	Presence of MIC (%)	Absence of MIC (%)	*p*-value
Male (n=125)	112 (89.6%)	13 (10.4%)	0.27
Female (n=125)	108 (86.4%)	17 (13.6%)	
Right Side (n=250)	218 (87.2%)	32 (12.8%)	0.61
Left Side (n=250)	220 (88.0%)	30 (12.0%)	

The MIC was present in about 87–89% of cases, with no significant difference between males and females or between right and left sides ($p > 0.05$). This suggests the MIC is consistently present across populations.

Discussion

This cross-sectional investigation utilized cone-beam computed tomography (CBCT) to evaluate the morphology and prevalence of the mandibular incisive canal (MIC) in 250 adult participants. The analysis demonstrated that the MIC could be identified in more than 85% of the examined cases. These findings are consistent with CBCT-based studies by Ramesh et al., Sahman et al., and Parnia et al., who reported MIC detection rates ranging from 80% to 95%, thereby confirming the superior capability of CBCT in visualizing fine anatomical structures that may not be evident on conventional radiographs [14–16].

Sex-Based and Dimensional Variations

The present study identified significant gender-related differences in MIC parameters, including canal length, diameter at the origin, and proximity to the mental foramen and alveolar crest. Male subjects demonstrated consistently higher measurements than females. Similar observations were reported by Pereira-Maciel et al. and Barbosa et al., who attributed these variations to generally larger craniofacial dimensions and mandibular size in males compared with females [17,18].

In contrast, no statistically significant differences were observed between the right and left sides of the mandible, indicating bilateral symmetry of the MIC. This finding is in agreement with previous CBCT-based investigations and clinical imaging analyses reported by Scarfe et al. and other authors [19].

Clinical Implications

The high prevalence of the MIC in the anterior mandible underscores the importance of identifying this structure during preoperative planning. Surgical procedures such as dental implant placement, chin bone harvesting, and periapical surgery pose a risk of neurovascular injury if the MIC is overlooked. Reported complications include altered sensation, paresthesia, and unexpected intraoperative hemorrhage, as described by Barca et al. and Tepper et al. [20,21]. Consequently, routine CBCT evaluation prior to surgical intervention is strongly recommended to minimize complications and enhance procedural safety.

Correlation with Previous Literature

The present study further demonstrated that the mean distance of the MIC from the inferior border of the mandible and its apical diameter did not show statistically significant gender differences. This observation aligns with the findings of de Oliveira-Santos et al., who similarly reported minimal gender-based variation in these parameters using CBCT imaging [22]. Collectively, these results suggest that although the MIC is highly prevalent, its dimensions and spatial relationships vary among individuals, reinforcing the necessity for patient-specific anatomical assessment.

Strengths and Limitations

A major strength of this study is the relatively large sample size combined with standardized CBCT imaging protocols, ensuring reliable and reproducible morphometric measurements. However, certain limitations must be acknowledged. The study population was confined to Indian adults aged 30–50 years, which may limit the generalizability of the findings. Multicenter studies involving broader age groups and diverse populations are recommended to establish comprehensive anatomical reference standards.

Conclusion

This study confirmed that the mandibular incisive canal (MIC) is highly prevalent in the examined Indian adult population, with notable gender-related differences in its dimensions but no significant variation between the right and left sides. The results highlight that the MIC should be regarded as a consistent anatomical feature, and its evaluation through CBCT imaging is crucial before planning surgical procedures in the anterior mandible. Accurate identification of the canal and its proximity to adjacent structures plays a vital role in minimizing the risk of neurovascular injury during surgery and contributes to safer clinical outcomes. Future investigations involving larger cohorts and diverse ethnic groups are recommended to develop more comprehensive anatomical reference standards for clinical application.

Conflict of Interest: Nil

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