RESEARCH PAPER

A Radiological Investigation of Inferior Alveolar Nerve with Respect to Various Anatomical Landmarks in The Mandible

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ABSTRACT

Background: Accurate identification of the Inferior Alveolar Nerve (IAN) is critical in mandibular surgery and implant placement to avoid neurosensory complications. Conventional two-dimensional radiographs are limited by distortion and superimposition, whereas Cone Beam Computed Tomography (CBCT) provides high-resolution three-dimensional imaging with lower radiation exposure than conventional CT.

Aim: To determine the spatial relationship of the IAN to the buccal cortical plate (BCP), lingual cortical plate (LCP), and crest of the alveolar ridge in an Indian population using CBCT.

Materials and Methods: A retrospective analysis of 100 hemimandibles from 50 patients was performed. CBCT scans were evaluated with Carestream 3D Light software (v3.10.33). Linear measurements from the IAN to the alveolar crest, BCP, and LCP were obtained bilaterally. Statistical comparisons across gender and age groups were conducted using one-way ANOVA, with significance set at $p < 0.05$.

Results: The IAN was consistently farthest from the alveolar crest (mean 12–13 mm) and closest to the lingual cortical plate (mean 1.6–2.3 mm). Differences across gender and age groups were statistically nonsignificant ($p > 0.05$).

Conclusion: CBCT provides reliable three-dimensional assessment of the IAN relative to mandibular landmarks. In this population, nerve position showed consistent spatial relationships unaffected by gender or age. These findings highlight CBCT's value in preoperative planning to reduce the risk of iatrogenic nerve injury during mandibular implant procedures.

Keywords: *Inferior Alveolar Nerve, Mandibular canal, Cone Beam Computed Tomography, Dental implants, Bucal and Lingual cortical plate, Alveolar ridge.*

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INTRODUCTION

Anatomical landmarks play an important role in surgical procedures, where it is mandatory to locate and preserve these structures to avoid any injury to them. The Inferior Alveolar Nerve (IAN) is a vital anatomical structure in the mandible, whose injury during surgical or implant procedures can result in neurosensory disturbances ranging from transient paresthesia to permanent dysesthesia. Reported incidence of IAN injury varies widely, from 8.3% to 77.8%, depending on the surgical modality. Accurate preoperative localization of the nerve is therefore indispensable.

Traditional radiographic techniques such as panoramic and periapical radiographs provide limited two-dimensional information, often compromised by superimposition and distortion. Cone Beam Computed Tomography (CBCT), however, offers high-resolution three-dimensional imaging with reduced radiation exposure compared to conventional CT. Several studies have validated CBCT's accuracy in

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depicting mandibular anatomy, including the mandibular canal and its relation to cortical plates.

This study aimed to evaluate the position of the IAN relative to three anatomical landmarks—the buccal cortical plate (BCP), lingual cortical plate (LCP), and crest of the alveolar ridge—in an Indian population, thereby providing clinically relevant data for implant planning and mandibular surgeries.

MATERIALS AND METHODS

This retrospective observational study was conducted at the Department of Prosthodontics, Crown and Bridgework, and Oral Implantology, Faculty of Dental Science, Dharmsinh Desai University, Nadiad, India. The study population consisted of patients who had previously undergone Cone Beam Computed Tomography (CBCT) imaging for diagnostic or treatment planning purposes. A total of 50 patients, representing 100 hemimandibles, were included in the study, with equal distribution of males and females. Each hemimandible was analyzed independently to maximize the sample size and statistical validity. Eligibility criteria included fully or partially dentulous patients of any age and gender, with resorbed, fair, or good ridge types, and absence of radiological or clinical malocclusion. Patients with unilateral tumors or other unilateral pathology were included, while those with bilateral cysts or tumors, congenital mandibular anomalies, history of maxillofacial surgery or trauma, or pregnancy were excluded. CBCT scans were acquired using the Carestream 3D Neo CBCT machine (Carestream Dental LLC, Atlanta, GA, USA) and analyzed with Carestream 3D Light software, version 3.10.33 (Carestream Dental LLC, Atlanta, GA, USA), on a Lenovo laptop (Model LAPTOP-LTLBQEK8, Intel Premium R N4200 processor, Lenovo Group Ltd., Beijing, China). Nerve tracing was performed using the software's linear and angular measurement tools, with the mandibular first molar region serving as the reference point for nerve entry and the second premolar region for nerve exit; in cases of missing teeth, the centre of the alveolar crest was used as a substitute reference. Distances from the Inferior Alveolar Nerve (IAN) to the crest of the alveolar ridge, buccal cortical plate, and lingual cortical plate were measured bilaterally, and mean values with standard deviations were calculated. [Fig.1] Statistical analysis was performed using G-Power Software, version 3.1.9.4 (Heinrich Heine University, Düsseldorf, Germany), with one-way ANOVA employed to compare measurements across gender and age groups. A p-value of less than 0.05 was considered statistically significant.

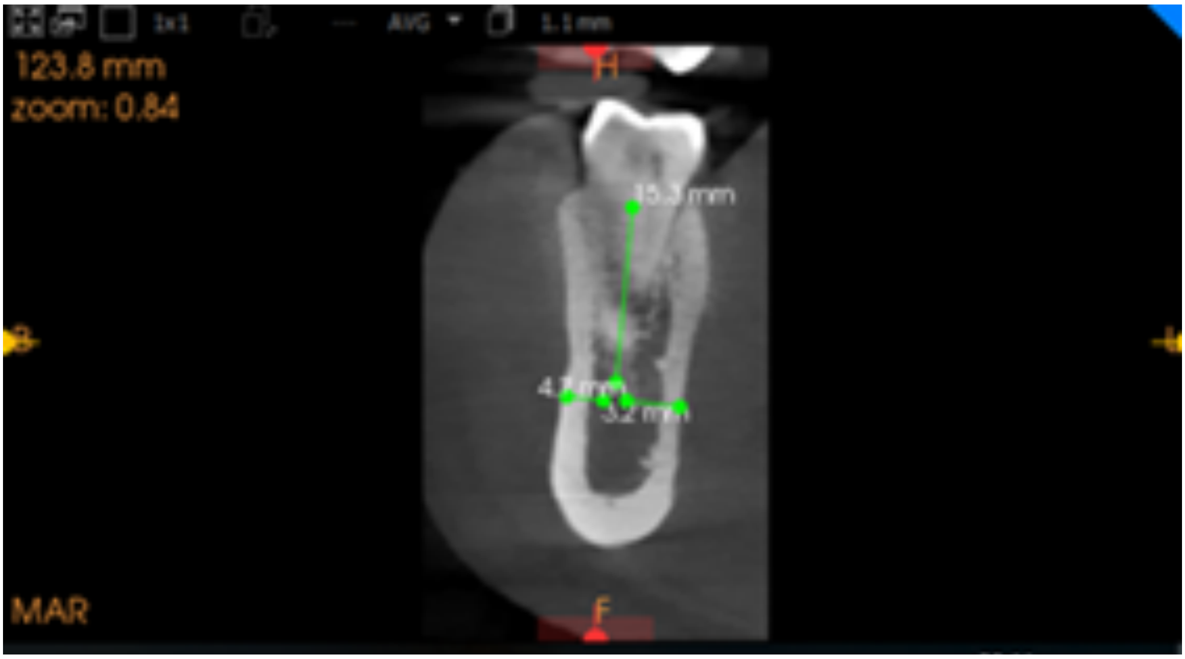


Fig.1 A linear measurement was made from crest till the upper border of IAN, from that two perpendicular distances were measured on buccal and lingual side.

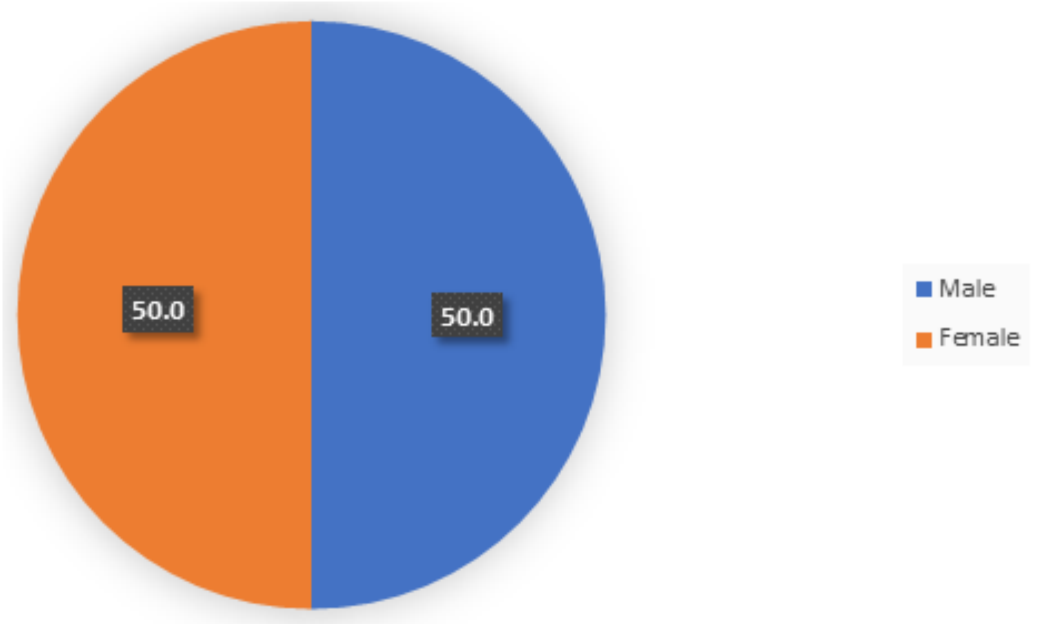
RESULTS AND DISCUSSION

A total of 50 patients (100 hemimandibles) were included in the study, comprising 25 males (50%) and 25 females (50%). The age distribution showed that 22 participants (44%) were between 10–30 years, 11 participants (22%) between 30–50 years, 16 participants (32%) between 50–70 years, and 1 participant (2%) between 70–90 years

Table 1: Distribution of study participants based on the gender

Gender	N	%
Male	25	50.0
Female	25	50.0

Graph 1: Distribution of study participants based on the gender

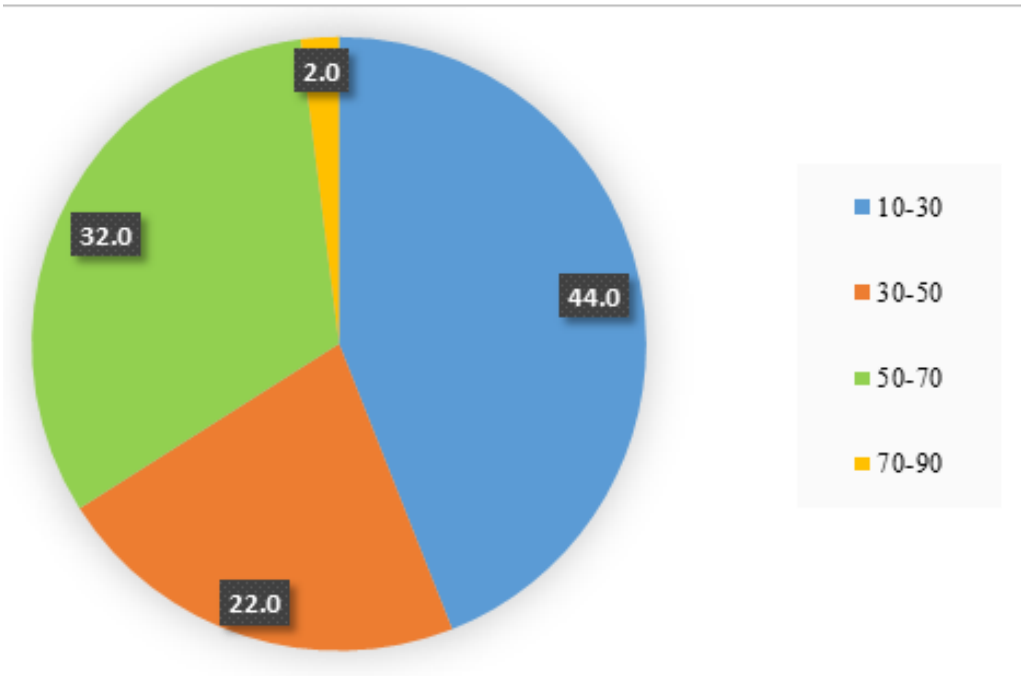


Graph 1 shows the distribution of the study participants based on their gender. Out of the total 50 participants, equal distribution of male (50.0%) and female (50.0%) was observed in the study.

Table 2: Distribution of study participants based on the age group

Age group	N	%
10-30	22	44.0
30-50	11	22.0
50-70	16	32.0
70-90	1	2.0

Graph 2: Distribution of study participants based on the age group



Graph 2 shows the distribution of the study participants based on their age group. Out of the total 50 participants, maximum participants fall under the age group of 10-30 years i.e 22(44.0%), followed by 50-70 years 16(32.0%) and 30-50 years 11(22.0%) .Only 1 participant (2.0%) belongs to the age group of 70-90 years.

Across all participants, the Inferior Alveolar Nerve (IAN) was consistently farthest from the crest of the alveolar ridge, with mean values of approximately 12–13 mm bilaterally. For example, on the left side, males measured 12.95 ± 3.15 mm and females 12.78 ± 2.71 mm, while on the right side, males measured 13.32 ± 2.91 mm and females 12.96 ± 2.69 mm. These differences were statistically non-significant ($p > 0.05$). The mean distance from the IAN to the buccal cortical plate was shorter, ranging between 4.3–5.2 mm. On the left side, males measured 5.15 ± 1.8 mm and females 4.41 ± 1.3 mm, while on the right side, males measured 5.17 ± 1.81 mm and females 4.36 ± 1.5 mm. No statistically significant differences were observed between genders ($p > 0.05$). The IAN was closest to the lingual cortical plate, with mean distances ranging between 1.6–2.3 mm. On the left side, males measured 2.22 ± 1.04 mm and females 2.32 ± 0.96 mm, while on the right side, males measured 1.66 ± 0.66 mm and females 2.02 ± 0.79 mm. These differences were also statistically non-significant ($p > 0.05$). When analyzed by age group, the IAN position showed minor variations but no statistically significant differences. For example, the mean distance from the alveolar crest on the left side was 13.7 ± 2.72 mm in the 10–30 year group, 12.7 ± 4.04 mm in the 30–50 year group, 11.5 ± 2.87 mm in the 50–70 year group, and 9.9 mm in the single participant aged 70–90 years ($p = 0.14$). Similar non-significant trends were observed for buccal and lingual cortical plate measurements.

Table 3: Comparison of mean difference between Inferior alveolar nerve entering mandibular foramen with respect to three reference points (Alveolar ridge, Buccal and Lingual cortical plate) based on the gender.

Reference points		Male		Female		P value
		N	Mean (SD)	N	Mean (SD)	
LEFT	Distance from Crest of the Alveolar ridge	25	12.95±3.15	25	12.78±2.71	0.84**
	Distance from Buccal cortical plate	25	5.15±1.8	25	4.41±1.3	0.10**
	Distance from Lingual cortical plate	25	2.22±1.04	25	2.32±0.96	0.73**
RIGHT	Distance from Crest of the Alveolar ridge	25	13.32±2.91	25	12.96±2.69	0.65**
	Distance from Buccal cortical plate	25	5.17±1.81	25	4.36±1.5	0.09**
	Distance from Lingual cortical plate	25	1.66±0.66	25	2.02±0.79	0.09**

*- *statistically significant*, **- *statistically non-significant*

Table 4: Comparison of mean difference between Inferior alveolar nerve exiting mandibular foramen with respect to three reference points (Alveolar ridge, Buccal and Lingual cortical plate) based on the gender.

Reference points		Male		Female		P value
		N	Mean (SD)	N	Mean (SD)	
LEFT	Distance from Crest of the Alveolar ridge	25	12.66±3.31	25	13.33±2.09	0.40**
	Distance from Buccal cortical plate	25	2.49±0.74	25	2.11±0.66	0.06**
	Distance from Lingual cortical plate	25	4.4±1.51	25	4.14±1.08	0.49**
RIGHT	Distance from Crest of the Alveolar ridge	25	12.65±3.3	25	13.4±2.66	0.38**
	Distance from Buccal cortical plate	25	2.44±0.89	25	2.19±0.79	0.31**
	Distance from Lingual cortical plate	25	4.26±1.61	25	3.87±1.11	0.33**

*- *statistically significant*, **- *statistically non-significant*

Table 5: Comparison of mean difference between Inferior alveolar nerve entering mandibular foramen with respect to three reference points (Alveolar ridge, Buccal and Lingual cortical plate) based on the age group.

REFERENCE POINTS	AGE GROUP				P-value
	10-30	30-50	50-70	70-90	

	N=22	**N=11**	**N=16**	**N=1**	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Left Distance from Crest of the Alveolar ridge	13.7±2.72	12.7±4.04	11.5 ±2.87	9.9 ±0.0	0.14**
Left Distance from Buccal cortical plate	5.6 ±1.52	4.08 ±1.33	5.25 ±4.26	2.3±0.0	0.34**
Left Distance from Lingual cortical plate	2.12 ±0.94	3.14 ±3.86	2.5 ±0.88	5.5 ±0.0	0.25**
Right Distance from Crest of the Alveolar ridge	13.86 ±2.06	12.89 ±3.43	12.01 ±3.49	9.7 ±0.0	0.18**
Right Distance from Buccal cortical plate	5.28 ±1.3	4.26 ±2.2	4.2 ±1.84	4.3 ±0.0	0.22**
Right Distance from Lingual cortical plate	1.86 ±0.73	2.61 ±3.63	1.98 ±0.85	2.1±0.0	0.73**

**- statistically significant, **- statistically non-significant*

Table 6: Comparison of mean difference between Inferior alveolar nerve exiting mandibular foramen with respect to three reference points (Alveolar ridge, Buccal and Lingual cortical plate) based on the age group.

REFERENCE POINTS	**AGE GROUP**				**P-value**
	10-30	**30-50**	**50-70**	**70-90**	
	N=22	**N=11**	**N=16**	**N=1**	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Left Distance from Crest of the Alveolar ridge	13.9(±2.17)	12.7(±4.03)	11.8(±2.71)	4.7(±0.0)	0.008*
Left Distance from Buccal cortical plate	2.4(±0.68)	2.2(±0.9)	2.3(±0.8)	2.7(±0.0)	0.87**
Left Distance from Lingual cortical plate	4.5(±1.05)	4.8(±3.32)	4.3(±1.56)	3.1(±0.0)	0.83**
Right Distance from Crest of the Alveolar ridge	13.6(±2.3)	12.5(±4.54)	12.3(±3.43)	6.1(±0.0)	0.12**
Right Distance from Buccal cortical plate	2.3(±0.88)	2.6(±1.1)	2.3(±0.8)	2.9(±0.0)	0.73**
Right Distance from Lingual cortical plate	4.2(±1.14)	3.7(±1.33)	4.1(±1.79)	3.7(±0.0)	0.82**

**- statistically significant, **- statistically non-significant*

DISCUSSION

The inadvertent damage to the Inferior alveolar nerve (IAN) is the one of the most severe complications in implant dentistry which can occur during local anesthesia, implant placement, third molar extractions, sagittal split osteotomies etc. Thorough knowledge of anatomy, surgical procedures, implant systems and proper treatment planning is the key to reduce such unpleasant complications. Awareness of key anatomical features and structures is crucial while implant placement. The longer path of the IAN within the neurovascular bundle makes implant placement in the posterior mandibular region even more challenging. Implant related IAN injury is the most common complication which ranges from 0 to 40% in prevalence. In contrast, post-implant dysesthesia was found in 1.7–43.5% of cases, and 5–15% of cases had sustained sensory disturbances. In light of this, clinicians can prevent the difficulties linked to impingement or compression of the IAN by doing a pre-operative evaluation of the mandibular nerve path. The pre-operative phase of the implant surgery can be made easier with the help of different imaging modalities. With the advent of Cone beam computed tomography (CBCT) in dental implant imaging, lower radiation with more volumetric data was yielded. Interactive software associated with the CBCT allows for the nerve tracing, measurements and even facilitates in mock implant surgeries. Pre-procedural planning uses CBCT to determine the location of the IAN and the amount of bone that is available, which aids in choosing an appropriate implant location. In this present study, CBCT images in the form of DICOM files were studied for the position of inferior alveolar nerve with respect to the crest of the ridge, buccal cortical plate and the lingual cortical plate. The method of measurement implemented in this study was similar to that of a study by Chaudhary ML et al[17] where the distance of the nerve was measured from the crest of the ridge, buccal cortical plate and lingual cortical plate. The results showed that there was no significant difference when the mean and standard deviation were calculated for males and females of different age groups, on left and right side. The mean distance of the nerve from the crest of the ridge was 12.8 in males and 13.11 in females on left and right sides when the nerve entered and exited the mandible. In this study, the distance of buccal cortical plate (BCP), lingual cortical plate (LCP) and the crest of the alveolar ridge to the IAN showed no statistically significant difference with respect to gender. When compared with different age groups, 50 to 70 years patients represented the crest of the alveolar ridge closest to the IAN (Table 4). The results of this study were congruous with the study by Kwon et al[18] which revealed that the distance from buccal cortical bone to the inferior alveolar nerve canal showed no statistically significant difference in males and females. A similar study was conducted by Sanam Mirbeigi et al[19] in Iranian population in which different age groups were compared and the results showed no statistical significance. A study by Shokry et al[20] concluded that there was no significant difference in males on the right and left side when the IAN was measured from the inferior border of mandible while females showed statistical significance on right and left side. The results of this study were opposed by Wong et al[21], Prakash et al[22] and Kherweichua M et al[23] where there was statistical significance with respect to gender and age. The sample size selected for this study was small and was collected from a single CBCT center, thus the results may not be the same for general population. Also the results were correlated on the basis of gender and side but they were not correlated with masticatory load as the increased masticatory load results in increased resorption which could have affected the alveolar height and mandibular cortical width by activating the periodontal ligament and musculature involved[17]. The systemic conditions of the patients were not known and hence further studies could refine better results.

CONCLUSION

Within the limitations of this retrospective CBCT-based study, the inferior alveolar nerve demonstrated a consistent spatial relationship with the alveolar crest, buccal cortical plate, and lingual cortical plate in the evaluated Indian population. The IAN was located at the greatest distance from the alveolar crest and in closest proximity to the lingual cortical plate. No statistically significant differences were observed in the measured distances with respect to gender, while age-related variations were also largely nonsignificant. These findings emphasize the importance of three-dimensional assessment of the mandibular canal and its relationship to surrounding anatomical landmarks during preoperative planning. CBCT with accurate nerve tracing can therefore serve as a valuable adjunct for implant placement and other mandibular surgical procedures, potentially reducing the risk of iatrogenic injury to the inferior alveolar nerve. Further studies involving larger, multicentric populations and additional anatomical and clinical variables are warranted to establish more generalizable reference values.

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