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Original Article

Anatomy Section

Evaluation of Inferior Alveolar Canal and its Variations using Cone Beam CT-scan

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ABSTRACT

Introduction: The knowledge of the precise location of anatomical landmarks such as mandibular foramen, Inferior Alveolar Canal (IAC), mental foramen and the course of the inferior alveolar neurovascular bundle is mandatory to obtain the desired outcome of different mandibular surgical procedures and overcome various surgical complications.

Aim: To document a clinically relevant position of the Inferior Alveolar Nerve (IAN) in completely dentate patients, to identify the linear relationship of the IAC to the buccal and lingual cortex (BCP/LCP) of the mandible and to the peri apex of the teeth as well as to assess the presence and course of the anterior loop in the mental foramen region according to the gender and side, using Cone Beam Computerised Tomography (CBCT).

Materials and Methods: This cross-sectional study utilised 378 CBCT images from 232 patients (one patient may has images of both side of mandible which are counted as two separate images) to obtain quantifiable data to localise the IAC. Measurements to the IAC were made from the BCP and LCP and the root apices of the mandibular premolars and molars.

Results: In 15 subjects, 18 Accessory Mental Foramina (AMF) were detected. Anterior loop in the mental region was detected in 91% of the scans. The IAC was noted to be closest to the buccal cortical plate in the region of premolars on both sides. The distance between the lingual outer cortex to outer surface of the IAC along lingual side, distance between buccal outer cortex to outer surface of the IAC along buccal side, distance between the peri apex to the superior surface of IAC were recorded to assess accurately the position of the IAN within the IAC.

Conclusion: CBCT may be utilised to meet the increasing demand for accurate preoperative assessment and planning prior to surgeries of the maxillofacial region by obtaining information on the appearance, location and course of the IAC and its relation to other anatomical structures in the mandible.

Keywords: Accessory mental foramina, Inferior alveolar canal, Inferior alveolar nerve, Mental foramen

INTRODUCTION

The inferior alveolar neurovascular bundle containing the IAN is located in the IAC of the lower jaw and leaves the canal from the mental foramen in the anterior wall of the premolar region of the alveolar bone. The IAN forms the anterior loop of the mandibular canal in the anterior region of the mental foramen and splits into two nerve branches: mental and incisive [1,2].

There is considerable variation in the course of the nerve as well as the terminal segment of IAN, which complicates the regional anatomy, thus impeding proper preoperative planning and increasing chances of nerve related surgical complications [2-4]. The knowledge of the precise location of the above anatomical landmarks such as mandibular foramen, IAC and mental foramen and the course of mandibular neurovascular bundle is mandatory to obtain the desired outcome of different mandibular surgical procedure [2].

Risk of inadvertent IAN injury is associated with various surgical interventions in the area including sagittal split osteotomies, dental implant insertion, bone grafting or placement of fixation screws. It has been reported that IAN damage may causes sensory deficits up to 8.3% to 77.8% depending on the type of surgery [5,6].

The evaluations of Accessory Mental Foramen (AMF) are also clinically important as they may reduce the rates of haemorrhage, postoperative pain and paraesthesia risk in surgical procedures [7,8].

Previous attempts to describe the IAN anatomy have significant limitations. Cadaver findings cannot be translated to patient population owing to differences in age or disease. Skull based studies lack demographic data or use clinically inconsistent and anatomically irrelevant landmarks [5,9].

Use of two dimensional imaging modalities and CT has their own limitations. Conventional radiographs have limited reproducibility, magnifications and distortion and only represent a two dimensional position of the canal [7,10].

CBCT is new accurate modality of 3D reconstruction of the imaging of the dental and maxillofacial structure without any superimposition or magnification. It produces high resolution, artifact free, non magnified and undistorted 3D images of the maxillofacial anatomy that can be reformatted in any desired plane for interactive viewing and image manipulation. The radiation dose is significantly less than that of conventional medical grade CT-scans [11].

All of the above reasons make this study extremely clinically significant. Thus, this study was conducted to use the CBCT to document the clinically relevant position of the IAN in completely dentate patients normal variations of mandibular and mental foramen, IAC and AMF position and to identify the linear relationship of canal to buccal and lingual cortex and to the peri apex of the molar teeth as well as to assess the presence and course of the anterior loop in the mental foramen lesion according to the gender and side.

MATERIALS AND METHODS

This cross-sectional study was conducted on 378 CBCT images the data collected from a private CBCT centre in Ahmedabad. All the CBCTs were taken by same trained personnel in the same machine (Newtom Giano), at the same settings. The said data was then analysed in the Department of Anatomy at Dr. MK Shah Medical College and Research Centre, Ahmedabad, with the help of the Department of Maxillofacial Surgery, Government Dental College and Hospital, Ahmedabad, India for the duration of one year between August 2016-17.

Using the axial, coronal and sagittal sections, the exact location of the position of the IAC and AMF if present, was identified for the study. Linear measurements were made in cross-sections [Table/Fig-1].

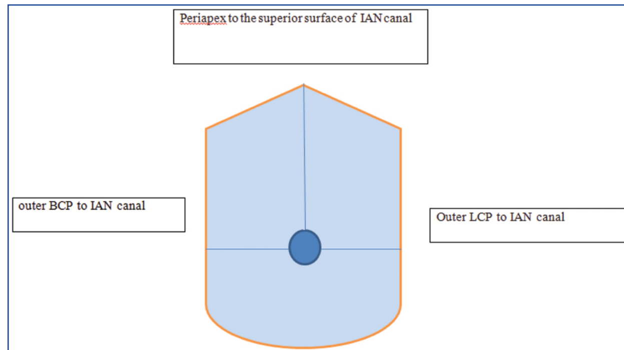
Patients consent was not required as this was only data collection and analysis study from a private CBCT centre. At no point patient contact was required for the study. For the same reason ethical approval also was not required.

Inclusion Criteria

1. Patients with complete sets of teeth.

2. Absence of radiological evidence of skeletal or dental malocclusion that could have altered the position of mandibular molars and premolars or IAN.

3. Radiographically, bilaterally completely corticised IAN canal.



[Table/Fig-1]: Schematic representation of various parameters.

Exclusion Criteria

1. Patients with evidence of bone disease, relevant drug consumption, skeletal asymmetries or trauma, congenital disorders and pathological disorders of the mandible as well as syndromic patients or any previous surgery which could change the position of the mandibular canal.

2. Low quality images, e.g., ones that contained scattering or insufficient accuracy of bony borders.

The measurements were distance between the lingual outer cortex to outer surface of the IAC along lingual side; distance between buccal outer cortex to outer surface of the IAC along buccal side; and distance between the peri apex to the superior surface of IAC [Table/Fig-1].

Presence or absence of anterior loop of mental nerve, distance from medial margin of mental foramen to proximal edge of anterior loop, presence or absence of AMF and mean distance of AMF from mental foramen were also studied.

STATISTICAL ANALYSIS

All the above parameters were calculated in males, females and right and left side and along the second premolar, first molar and second molar of the mandible. Data will be cleaned, validated and analysed on the Epi info 7. For continuous variables range, mean and standard deviation will be calculated and for categorical variables proportion and percentage will be obtained.

RESULTS

A total of 378 CBCT scans from 232 numbers of subjects were studied. In these subjects 110 were male and 122 were females, aged 15-64 years, with mean age of 31.6 years and 34 years. The number of right side mandible scans was 190 and left side was 188.

In 15 subjects, 18 AMF were detected, so its prevalence was 6.46%. Nine of these subjects were male with mean age of 34.6 years and six were females with mean age of 35.2 years. Bilateral AMF were present in two females and one male subject. Mean distance of AMF from mental foramen, genderwise and sidewise is shown in [Table/Fig-2]. Significant differences were found in the anatomic variation of mental foramen regarding gender (p=0.046) but not in case of side [left (p=0.228) and right side (p=0.191)].

Anterior loop in the mental region was detected in 91% (343) of the scans. Prevalence of anterior loop in females 188 out of 199 scans (94.47%) was found higher than found in males, 155 out of 179 (86.59%).

The mean length from the medial margin of the Mental Foramen to the proximal edge of the anterior loop ranged from 2.6 to 3.6 mm (mean 3.15 mm). Anterior loop on the right side was found in 174 out of 190 cases (91.6%) and on the left side in 171 out of 188 cases (89.9%). The prevalence of anterior loop regarding gender in the left and right side is presented in [Table/Fig-3].There were no significant difference in the prevalence of anterior loop regarding gender and both sides of the mandible (p=0.215 and p=0.167) [Table/Fig-4].

The IAC was noted to be closest to the buccal cortical plate in the region of the premolars on both sides with the mean distance of 2.83 mm [Table/Fig-5]. The canal courses toward the LCP (Lingual Cortical Plate) and the Inferior Border of Mandible (IBM) as it moves posterior toward the distal root of the second molars. Mean distance from the LCP to the canal at the level of the molars was 2.73 mm [Table/Fig-6].

The canal was also closest to the distal root of the second molar. The roots of the second molar were in direct contact with the IAC in 23.5% of the cases on the right side and 22.6% of the cases on the left side.

Gender	Number of AMF	Mean age	Mean distance between MF and AMF on right side in mm	Mean distance between MF and AMF on left side in mm
Male	9	34.6	3.6±1.2 mm	3.78±0.9
Female	6	35.2	2.5±0.9	2.43±1

[Table/Fig-2]: Accessory mental foramen.

	Right		Left	
	Male	Female	Male	Female
Mean Length from the medial margin of the mental foramen to anterior loop	3.22	3.15	3.28	3.26

[Table/Fig-3]: Mean (in mm) values of distance from medial margin of mental foramen to proximal edge of anterior loop according to gender and side.

	Male (n=110)		Female (n=122)	
Region	Right	Left	Right	Left
2nd Premolar	3.1	2.9	2.7	2.6
1st Molar	5.2	5.57	4.85	4.94
2nd Molar	5.64	6.02	4.93	5.03

[Table/Fig-4]: Mean distance (in mm) between buccal outer cortex to outer surface of the IAC along buccal side.

	Male (n=110)		Female (n=122)	
Region	Right	Left	Right	Left
2nd Premolar	5.9	5.8	5.65	5.5
1st Molar	5.79	5.75	5.54	5.34
2nd Molar	5.95	5.83	5.67	5.58

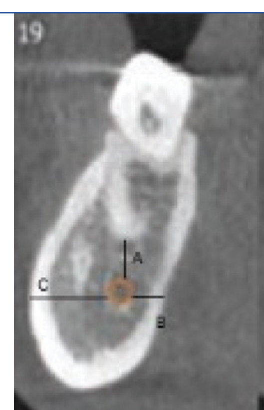
[Table/Fig-5]: Mean distance (in mm) between the peri-apex to the superior surface of IAC.

	Male (n=110)		Female (n=122)	
	Right	Left	Right	Left
2nd Premolar	4.3	4.5	3.9	3.7
1st Molar	3.42	3.21	3.17	3.03
2nd Molar	2.78	3.02	2.34	2.78

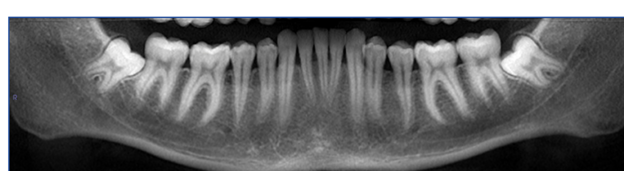
[Table/Fig-6]: Mean distance (in mm) between the lingual outer cortex to outer surface of the IAC along lingual side.

There was a statistically significant variance (p=0.042) between genderwise comparison of the linear distance between the lingual outer cortex to the outer surface of the IAC along lingual side, distance between buccal outer cortex to outer surface of the canal along buccal side and the distance between the peri apex to the superior surface of the canal, but sidewise, no such statistically significant difference was found (p=0.122).

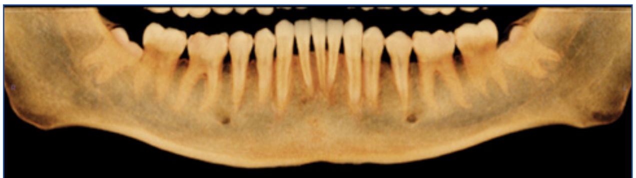
Measurements were recorded by two observers and repeated by interval of one week. Repeated evaluation and measurements indicated no significant intraobserver (p=0.142) or interobserver (p=0.138) differences in their evaluations and measurements (p>0.05) [Table/Fig-7-11].



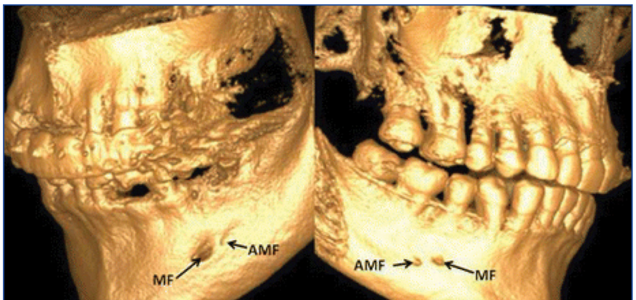
[Table/Fig-7]: A-Distance between the peri apex to the superior surface of IAN canal; B-Distance between lingual outer cortex to lingual outer surface of IAN canal; C-Distance between buccal outer cortex to outer to buccal outer surface of IAN canal.



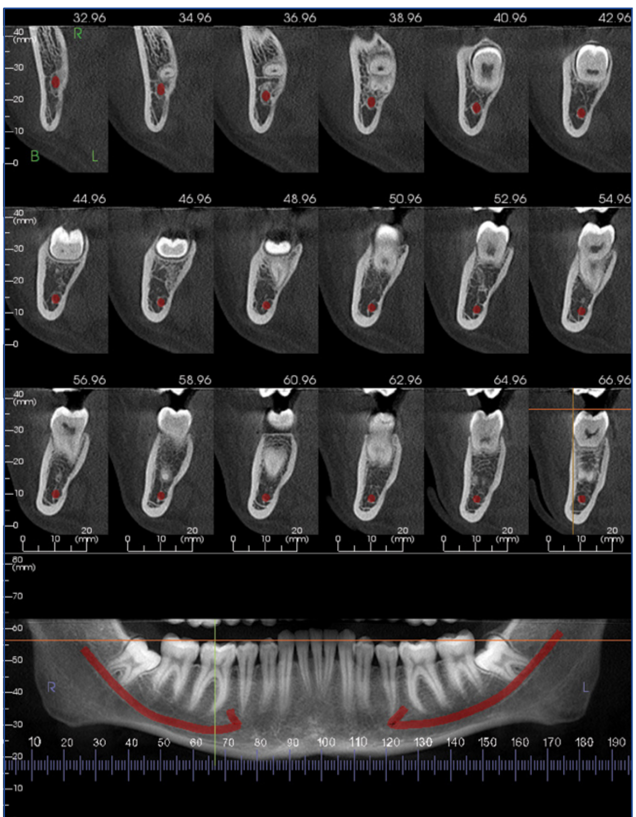
[Table/Fig-8]: CBCT image of mandible showing the IAC and mental foramen in relation to various anatomical landmarks.



[Table/Fig-9]: CBCT mandible in a different contrast showing the IAC and mental foramen in relation to various anatomical landmarks.



[Table/Fig-10]: Accessory mental foramina, and mental foramina over left and right side of mandibular body region.



[Table/Fig-11]: Anterior loop, IAC and IAN in relation to various anatomical landmarks of mandible and their precise measurements over digital scale.

DISCUSSION

The variations in the course, shape, curve, and direction of the IAN complicates the regional anatomy. Most previous attempts to describe the IAN anatomy too have not been accurate. Hence, there is an increased risk of inadvertent IAN injury with various surgical interventions in the area. CBCT is the new accurate modality of imaging of the maxillofacial structures without any superimposition or magnification thus, making this study very clinically relevant.

Naitoh M et al., compared the identification of an accessory mental foramen in panoramic radiographs and in reconstruction images (CBCT) [7]. After examining the 365 patients, the authors detected 37 AMF with the aid of CBCT and only 18 accessory mental foramina on panoramic radiographs. Katakami K et al., in a study of 150 patients, observed the presence of 17 AMF by CBCT [12]. On the basis of these findings, the present study agreed with literature as 18 AMF were detected in 15 subjects, so its prevalence was 6.46%.

Apostolakis D et al., showed that, anterior loop could be identified in 48% of the cases with a mean length of 0.89 mm [13]. The present study is not in agreement with their study as anterior loop in the mental region was detected in 91% (343) of the scans and the mean length from the medial margin of the mental foramen to the anterior loop proximal edge ranged from 2.6 to 3 mm (mean 3.15 mm) The difference could be because of more detailed evaluation of anterior loop and measurement. However, the results are in the line of some other studies like Eren H et al., [14] [Table/Fig-12,13].

The study shows that the lingual cortex is thicker at the first molar level, while the buccal cortex is much thicker at the second molar level. This could be due to consistent remodelling due to the muscles attached in this region. The mylohyoid line here is oriented at a higher position in 2nd molar region than 1st molar region, thus explaining the greater thickness of lingual

Studies	Total Subjects	Subjects having accessory mental foramina n (%)
Naitoh M et al., [7]	365	37 (10.13%)
Katakami K et al., [12]	150	17 (11.33%)
Kalender A et al., [15]	386	25 (6.5%)
Present	232	15 (6.46%)

[Table/Fig-12]: Comparison between the findings of the present study and other similar studies.

Studies	Total subjects	Subjects having anterior loop n(%)	Mean distance from mental foramen
Apostolakis D et al., [13]	93	52 (48%)	0.89 mm
Eren H et al., [14]	328	282 (86%)	3.14 mm
Uchida Y et al., [16]	96	87 (84%)	-
Edurada H et al., [17]	500	208 (41.6%)	1.1 mm
Present	376	343 (91%)	3.15 mm

[Table/Fig-13]: Difference between the findings of the present study and other similar studies.

cortex at the first molar level. On the buccal surface, the attachment of the masseter at the 2nd molar region causes the greater thickness there. The canal was closest to the second molar roots in 61.6% of the cases, on average. The difference between the right side and the left side was not remarkable, indicating that the right and left halves are mostly symmetrical. But in the literature the right half value is noted to be slightly higher than the left half values.

LIMITATION

However, the sample size (number of images) taken for this study was small and that too from a single private CBCT centre. Thus, the results may not be the same for general population. Also, results were correlated on the basis of gender and side but they were not correlated with occlusal load and habits of patients, as the patients were not contacted primarily. Both these factors could have affected the alveolar height and mandibular cortical width by activating the periodontal ligament and musculature involved. Systemic conditions of any patient also were not known. Hence, further studies could be done in this direction for more refinements of the results.

CONCLUSION

CBCT cross-sectional images are more accurate on the appearance, location and course of the canal and their relation to other anatomical structures in the jaw bone including the apex of the tooth which is very useful in preoperative assessment and planning prior to surgeries. CBCT provides an effective tool for presurgical evaluation of the neurovascular structures and its variations. This study will be helpful to get rid of iatrogenic injuries which tend to occur during the surgical procedure of this region, as the presence of anatomical variation is frequently neglected. However, the sample size (number of images) taken for this study was small and that too from a single private CBCT centre. Thus, the results may not be the same for general population. Also results were correlated on the basis of gender and side but they were not correlated with occlusal load and habits of patients, as the patients were not contacted primarily. Both these factors could have affected the alveolar height and mandibular cortical width by activating the periodontal ligament and musculature involved. Systemic conditions of any patient also were not known. Hence, further studies could be done in this direction for more refinements of the results.

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