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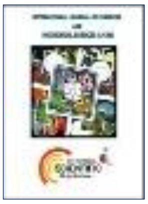

Evaluation of Anterior Mandibular Anatomy for Implant Placement Using Cone Beam Computed Tomography: A Cross Sectional Observational Study

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Abstract

The therapy of dental implantation is encroaching, highly dependent on precision and time. At the outset of implant therapy, anterior mandible was observed as secure zone for dental implants. The three critical anatomic structures in anterior mandibular area that are of interest in implant placement are the lingual foramen (LF), mental foramen (MF) and the mandibular incisive canal (MIC). At present, there exists a lacuna pertaining to the average measurements of these anatomic structures and the possibility of standardizing these measurements. A total of 104 CBCT scans of patients were selected based on the inclusion and exclusion criteria. The distance of the MF, LF and MIC were measured from the mandibular base along with the prevalence of location possibility and number of foramens. In all the selected cases, the LF, MF and MIC were located. It was discerned that 13.47 ±2.07 mm, was the mean distance from the inferior border of mandible to the LF. The mean distance from the inferior border of mandible to the superior border of MF was 16.06 ±2.11 mm. The mean distance from the inferior border of mandible to the superior border of MIC at the lateral incisor region was 13.45 ±2.43 mm. Pear shaped cross section was most prevalent pertaining to the mandibular cross section. It was concluded in this study, that an average measurement of anatomical landmarks was achievable for anterior mandible in the Indian population and dental implants a possibility with conventional imaging.

Keywords: Implant planning, CBCT, Anterior mandible, Imaging, Anatomy

Full-length article **Corresponding Author*, e-mail: Yesoda.aniyan@gmail.com

1. Introduction

For multiple decades, dental implants have been reinstated in the absence of natural or loss of natural teeth. The functionality and the aesthetics that it endows has allowed it to be placed on a pedestal in the field of dentistry for a long time to come [1]. On the other side, dental implant therapy demands precision, time and is highly invasive [2]. At the outset of implant therapy, anterior mandible was observed as secure zone for dental implants. This was grounded on the supposed lack of intense innervation and cortical bone structure. Added was the observed the lack of adverse effects post operatively as opposed to the maxillary and mandibular posterior region. Nevertheless, the acute evolution of Cone Beam Computed Tomography (CBCT), its numerous generations and the ease of accessibility has brought to light, a multitude of anatomic variations if unaccounted for can cause complications. However, the cost of the machinery and the area required, has hindered every practitioner from having one in the operatory [3,4].

The implant placement therapy is not exclusive of errors. The non-success was attributed to the deficiency surgical planning or critical anatomical structure's location. To elaborate on a few, the complications include meagre distance between the implant and anatomical structures, cortical plates rupture, and anatomical landmarks invasion. The resulting clinical complication may demonstrate a failed osseointegration, bone defects or bleeding to neurosensory disorders. This in turn may necessitate additional reparatory surgical procedures buoying both the initial procedure cost and patient non-compliance [1,2,3]. The three critical anatomic structures in anterior mandibular area that are of critical interest in implant planning are the lingual foramen (LF), mental foramen (MF) and the mandibular incisive canal (MIC). The presence of the three-dimensional imaging akin to CBCT augmented the perception of the prevalence, location, and the number of these structures and its variability in location in the bone, deterministic of procedural success rate. At present, there exists a lacuna pertaining to the average measurements of these anatomic structures. While these structures can be viewed with accuracy on a CBCT scan, a compulsory CBCT is often not required for implant surgery in the anterior mandible [4-6].

Also, there is considerable variation between studies from different countries in terms of the study sample size, sample ethnicity and measurement methods. Most of the studies only focused on one anatomic structure, since all three structures have a significant impact on causing severe complications with implant surgery. This study aimed to detect the positions of LF, MF and MIC to supply the reference data of the surgical safe zone for the clinicians.

2. Materials and Methods

This observational study was approved by the Institutional Review Board and informed consent obtained from the patients. A CBCT machine (NewTom VG) with technical parameters 110 kVp and 3.05 mA pulsed, an exposure time of 3.6 s and field of view (FOV) 20 cm×25 cm. A total of 104 CBCT scans of patients were selected based on the inclusion and exclusion criteria.

Inclusion Criteria

- Patient's age group of 18-70 years.
- Field of view covering anterior mandible from canine to canine.
- CBCT scans with no field cuts, diagnostic resolution and quality.

Exclusion Criteria

- Patients with bony pathology (cyst and tumors) in the anterior mandible.
- Patients with bony metabolic disorder on radiologic examination.

The demographic data was first recorded followed by the detailed study of each scan. The scan study was performed by an experienced oral and maxillofacial radiologist specialised in CBCT reporting. Initially, data such as sex, age, presence of bone canals, and the number of canals (lingual foramen-non-existent, 1, 2, 3, or more canals) were obtained. The distance of the MF, LF and MIC were measured from the mandibular base (Figure 1, 2 and 3). An implant planning software was used to assess the Digital Imaging and Communications in Medicine (DICOM) files. The images were oriented with the hard palate parallel to the horizontal axis during analysis for the purpose of standardisation. Within in the software program, a standardized measurement tool was used to evaluate the dimensions of the structures of interest to the nearest hundredth of a millimetre. The LF, MF and MIC were identified and the presence recorded on a spreadsheet format (EXCEL). Thereafter, measurements were recorded from the inferior-most border of the mandible to the superior most border of the LF and MF whenever they were visualized. The MIC was measured from the inferior-most border of the mandible to the superior-most border of the MIC at the lateral incisor region bilaterally. The lateral incisor region was classified at 5mm from the midline for uniformity in scan measurement. On perception of the cross-section of the MIC, the maximum diameter dimension of the mandibular incisive canal was measured to the nearest hundredth of a millimetre at the lateral incisor and canine regions bilaterally. Finally, the anterior mandible cross-section at the midline was identified, categorized, and the prevalence was determined post the scan analysis.

In descriptive analysis, each categorical variable was summarized with frequencies and percentages. As per the data distributions, the results were chronicled as the means and their standard deviations (mean±SD) and percentages. The results of Normality tests Kolmogorov-Smirnov and Shapiro-Wilks tests demonstrate the normal distribution of variables. Therefore, analysis was completed with data parametric methods. For the comparison of mean values between genders, independent samples t-test was applied. The comparison of mean values between age groups was done using one-way ANOVA, followed by Tukey's HSD post-hoc test. And the comparison of proportions between genders was arrived with Chi-Square test was applied. Further, the cross-sectional shape of the anterior mandible and the distribution of each mandibular shape were compared by using the Fisher exact test.

3. Results

The patients ranged in ages from 18-60 years. The age group categorisation was 18-30 years, 31-45 years and 46-60 years with 34, 45 and 25 subjects each. The sex distribution was 53% female and 46% male (Table 1). The prevalence of LF, MF, and MIC are tabulated in Table 1. The average distance from the inferior border of the mandible to the superior border of LF and MF are presented in Table 2. It was discerned that 13.47 ±2.07 mm, was the mean distance from the inferior border of mandible to the LF. This value was representative of the three age groups and the gender distribution. Also, 80.76% of the subjects demonstrated a second LF. The mean distance of location from the inferior border of mandible to the second LF was 6.36 ±1.72mm. Finally, 37.5% of the subjects demonstrated a third LF at a mean distance of 2.12 ±0.88mm. Thus, it was derived that, from the inferior border of mandible to the LF, neither the age groups nor gender caused significant variations in measurement.

The mean distance from the inferior border of mandible to the superior border of MF was 16.06 ±2.11 mm (Table 3). The mean distance from the inferior border of mandible to the superior border of MIC at the lateral incisor region was 13.45 ±2.43 mm. These values were representative of the three age groups and the gender distribution. Also, 100% of the subjects demonstrated the MF and MIC. Based on commonly occurring morphological shapes, a classification system was developed for the anterior mandibular cross-sectional shape which categorized them into groups: hourglass, pear and sickle. This last comparison explored whether any association existed between patients' age, gender and the mandibular cross-sectional morphological shape. However, no statistical significance was elicited. Pear shaped cross section was most prevalent in both the groups, followed by sickle and hourglass.

4. Discussion

The safe zone was a characterisation for the anatomical area anterior to the mental foramen in the mandible. It was attributed to the lack of neurovascular alterations of the lip and chin areas post -surgical procedures. However, the presence of critical anatomical structures in this area has validated the need for caution, pre-op anatomical knowledge and imaging[6]. The aim and objective of this observational cross-sectional study was to exact the prevalence of LF, MF, and MIC on CBCT scan images of the anterior mandible and to determine whether standardized average values could be obtained for the location of these structures in patients. This in turn would aid in approximation to prevent procedural errors similar to knowing the root canal length of a tooth when performing an endodontic therapy. Additionally, as an imaging modicum, CBCT is fraught with benefits inclusive of operator ease, image precision, minimal artifacts, economy and controlled radiation dose compared to computed tomography (CT).

Table 1. Summary of demographic, prevalence, and average measurement data for noted anatomic structures in CBCT scans

AGE	N	PERCENTAGE
18-30 years 31-45 years 46-60 years	34 45 25	32.7% 43.3% 24%
SEX		
Female	56	53%
Male	48	46%
LF Visualization One Two Three	 17 84 3	 16.34% 80.76% 2.8%
MF Visualization	104	100%
MIC Visualization	104	100%

Table 2. Summary of mean distance and standard deviations and 95% confidence intervals data obtained from inferior border of mandible to superior aspect of LF, MF, and MIC in 104 scans

In millimeters	Male	Female	P value
Distance from IB to LF One Two Three	 13.1 6.26 2.26	 13.8 6.45 2.02	 0.103 0.624 0.397
Distance from IB to MF	16.3	15.8	0.225
Distance from IB to MIC	13.2	13.7	0.368

Table 3. Chi-Square test to compare proportions between genders

	Gender						p-value
	Male		Female		Total		
	N	%	N	%	N	%	
Pear	39	81.3	49	87.5	88	84.6	0.249*
Hour glass	2	4.2	4	7.1	6	5.8	
Sickle	7	14.6	3	5.4	10	9.6	
Total	48	100.0	56	100.0	104	100.0	

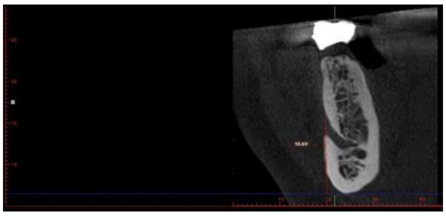

Figure 1: Measurement of Mental foramen

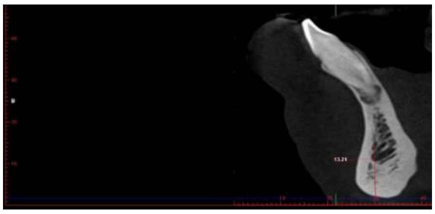

Figure 2: Measurement of incisive canal at the widest diameter

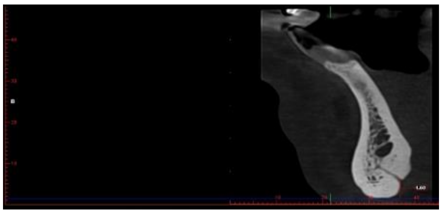

Figure 3: Measurement of lingual foramen

In this observational research, as a viable reference point for measurement, the base of mandible was opted. The unaffected nature of this anatomical landmark during the course of life, irrespective of the existence or absence of teeth and subsequent alveolar resorption or periodontal changes, was the determining factor [7].

In this study, the lingual foramen (LF) was located and measured in 100% of the patients in the sample. Also, 80.7 % of patients demonstrated the existence of two canals, followed by the presence of a single canal (16.34%) and the presence of three canals was determined in 2.88 % cases, which was congruent with the results reported by Santos et al[8].There was no significant alteration in the number of foramina between the gender and age sub-groups. These findings were in accordance with those of Scaravilli MS et al[6]. On an average, the LF was 13.1 mm from the inferior border of the mandible in males and 13.8 mm from the inferior border of the mandible in female patients. This was consonant with the findings of Sener et al[11]. Additionally, this measurement was prevalent despite the age grouping from 18-30 years,31-45 years and 46-60 years respectively. This observation was quite unique to the current study and concluded that in the current population set, lingual foramen is located between 13-14mm and implants planned above this level is deemed safe [8-12].

The MF was found on average to be 16.06 ±2.11 mm from the inferior border of mandible. The superior border of MIC at the lateral incisor region was 13.45 ±2.43 mm. Both these perceptions were complementary to that reported by JD Prados-Fructos et al[12]. Thus, these measurements from the inferior border of the mandible can serve as a guideline during treatment planning for implants in the anterior mandible before obtaining a CBCT scan. This study also investigated the average cross-sectional shape of mandible, in which pear shape was found to be most common. The other classified variants used were hourglass, pear, sickle, ovoid, and triangular. The findings were corroborated by the reports of Wright et al. This is of interest to the clinician because implant-supported rehabilitation in the anterior mandible may be compromised in patients with unfavourable cross-section[4].

5. Conclusions

It was concluded in this study, that an average measurement of anatomical landmarks was achievable for anterior mandible in the Indian population. Though the study sample consisted of Indian ethnicity, the literature review demonstrated the findings to be similar to findings from other ethnicities. Though a CBCT is mandatory for accuracy, the availability of average measurements would ensure a safety margin and significantly reduce a greater fraction of error. The limitations noted during the course of the study included the effects of ethnicity, environmental factors and economic status on the anatomic variations.

Conflicts

There were no conflicts in the course of study.

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