Innovations

Nerve Tracing and Bone Measurements for Implant Placement Using Cone Beam Computed Tomography (CBCT)

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Abstract

Aim: *With technological advancements in dentistry, the approach to treatment plan has been improvised for the betterment of the patients. CBCT is a 3-dimensional radiographic advancement used for implant placements, identification of pathologies, in periodontics, etc.The objective was to analyze the accuracy in tracing the IAN, and its canal, and bone measurements for implant placement using CBCT between two researchers of varied experience.* ***Materials and methodology:*** *CBCTs of 30 patients between September 2019 to December 2019 were taken from the archives of the Department of Maxillofacial radiology at Saveetha Dental College and Hospital.* ***Result:*** *The study showed excellent inter and intra-examiner agreements with highest agreement in nerve tracing which were all proven statistically.* ***Conclusion:*** *Thorough knowledge and practice in using the CBCT for implant planning must be emphasized to avoid implant failures or associated serious complications.*

Keywords: 1.*Cone-beam computed tomography, 2.dental implants, 3.maxillofacial radiology, 4. 3-D imaging*

Introduction

Since the discovery of x-rays 120 years ago, dental radiographs have been aprominent and frequently advised source of diagnostic information in the oral and maxillofacial complex. The first employed are the 2-

dimensional radiographs, namely, Intraoral periapical radiographs (IOPA), occlusal radiographs, orthopantomogram (OPG) and so on.

In the 90s, when the growing tendency for 3-dimensional images were around the corner, the cone-beam computed tomography (CBCT) was introduced in the maxillofacial diagnosis and treatment for presurgical planning and dental implant placements. [1–4] The ultimate reasons for the victory of CBCT are its capabilities of volumetric bone imaging at reasonable costs and doses, with the advantage of having an in-house equipment. As dental implants are in increased popularity, the factors determining the successful outcomes are based on the accurate assessment of the patient's anatomy and to reduce surgical complications, one must be knowledgeable about the bone anatomy involving the maxillofacial region, so that any osseous topography and bone volume discrepancies i.e., excesses or deficiencies can be rectified before implant therapy. [5–8]

Systems that can help with diagnosis, treatment planning, and surgical management have been made possible by advancements in the technologies. With the use of templates or surgical guides, the computer-assisted implant planning software may accurately translate the intended virtual surgical treatment plan into reality with the precision needed for foreseeable clinical application. The imaging data and planning software with radiographic guide to transmit the prosthetic outcome, and surgical guide are all necessary for guided implant procedures. With the help of these components a successful implant placement in the bone is achieved. [9]

The study aimed to analyze the accuracy in tracing the inferior alveolar nerve canal and bone measurement such as length and width for implant placement using cone-beam CT. Our research and knowledge have resulted in high-quality publications from our team. [10-23] Our recent research highlights numerous articles from various reputed journals and based on this experience we planned to pursue the nerve tracing and bone measurement for implant placement using CBCT. [24-28]

Materials and Methodology

This study was done retrospectively with the archived CBCT data of 30 patients reported to the department of oral and maxillofacial radiology at Saveetha Dental College and Hospital between the period September 2019 to December 2019. The institutional ethical number is IHEC/SDC/OMED-2107/20/497. Two researchers of varied experiences examined the CBCT of patients with single or multiple missing teeth requiring dental implants which were included in the study. Patients with evidence of bone diseases or other pathologies or with previous implants were all excluded.

The CBCTs were taken with Orthophos XG 3D machine at 80 kV, 10 mA, and 12 s of exposure, with 8x8cm FOV, and Galileo implant planning software was used. The data was processed in DICOM format on a PC (IntelR Core i5-2500 CPU with Windows 7 os). Analysis of parameters were done separately by researchers with measurements taken twice in a week's interval and the findings were stored in Microsoft excel 2019 v.16 software. The intraclass correlation coefficient was used to determine the intra and inter-examiner agreement and all the statistical analyses were carried out in SPSS v20.0.

Results

A total of 30 CBCTs were taken, of which 19 were male and 11 were female. (Table 1)

Study population	Frequency	Percentage
Male	**19**	**63.33%**
Female	**11**	**36.67%**
Total	**30**	**100%**

Table 1: frequency distribution of the study population

The tracing of the inferior alveolar nerve (IAN) on both sides of the mandible (Figure 1 and 2) and the accuracy in tracing them from the origin to the point where the IAN forms the anterior loop of the mandibular canal in the anterior region of the mental foramen and splits into two branches: mental and incisive. [29,30]

Figure 1: IAN traced on the right side of the mandible

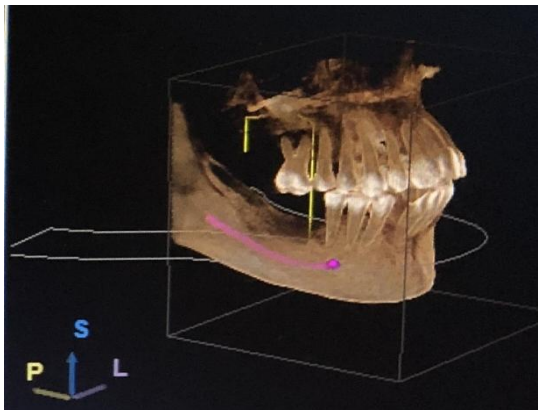

Figure 2: 3D of the IAN tracing

Distance between the lingual cortex and the surface of the IANC along lingual side and distance between buccal cortex and the surface of the IANC along buccal side were measured. From the superior surface of IANC, a safe distance of 2mm is kept constant while measuring to avoid pressure on the IANC leading to complications. (Figure 3) [31]

Figure 3: Distance between the lingual cortex and the surface of IAN canal and distance between buccal cortex and the outer surface of IAN canal

The pink color denotes the IANC, and yellow color denotes the distance from the surfaces of the nerve to the outer cortex - lingual and buccal (Figure 3). The mean distance between buccal cortex and the surface of the IANC along the buccal side and the mean distance between the lingual cortex and the surface of the IANC along the lingual side were calculated. (Table 2 and 3) The mean distance between the buccal cortex and the surface of the IANC in 2nd premolar was 4.2mm and 4.7mm in male and 3.9mm and 3.4mm in female respectively. The mean distance between the lingual cortex and the surface of the IANC along the lingual side in 2nd premolar was 2.1 mm and 2.7mm in male and 2.4mm and 1.9mm in female.

Region	Male (n=19)		Female (n=11)	
	Right (mm)	Left (mm)	Right (mm)	Left (mm)
II premolar	2.1	2.7	2.4	1.9
I molar	4.8	5.17	5.04	4.33
II molar	5.23	5.55	5.46	4.7

Table 2: mean distance between the lingual cortex and the surface of the IAC along the lingual side.

Region	Male (n=19)		Female (n=11)	
	Right (mm)	Left (mm)	Right (mm)	Left (mm)
II premolar	4.2	4.79	3.91	3.4
I molar	3.33	3.89	3.6	3.03
II molar	2.8	3.54	2.1	1.81

Table 3:mean distance between the buccal cortex and the surface of the IANC along buccal side.

The bone height for the implant was calculated from the crest of the alveolar bone to the point which is 2mm short of the superior surface of IANC. (Table 4) The bone width is calculated from the facial and lingual plates at the crest of the potential implant site. The sub crestal bone width is calculated 2mm from the midpoint of the crestal bone. The ideal spacing guideline for implant states there should be 1.5mm space from the adjacent tooth and 3mm space from the adjacent implant.

Region	Male		Female	
	Upper (mm)	Lower (mm)	Upper (mm)	Lower (mm)
Anterior	8.67	9.8	7.9	9.0
Posterior	9.12	11.04	9.43	10.3

Table 4: mean bone height in male and female

The inter-examiner and intra-examiner were excellent in all the cases with 0.96 and 0.98 inter- and intra-examiner agreement determined in nerve tracing denoting the highest level of agreement. (Table 5)

	Bone measurement	Nerve tracing	Inferior alveolar nerve canal measurement
Inter-examiners	0.8590	0.9677	0.9238
Intra-examiners	0.9199	0.9861	0.9969

Table 5: intra-class correlation coefficients for the intraand inter-examiner agreement of the measurements

Discussion

CBCT is the new technology which can help in accurate modality of imaging without any superimposition or magnification. Implants placed over the nerve canal or in proximity can cause discomfort and lead to implant failure and many other complications. [32]

Incisive canal located in the anterior mandibular region, extends bilaterally from both the mental foramen. Romanos GE et.al., discovered that certain patients had variable incisive canal sizes and locations which altered the treatment plan and cases with large incisive canal, implants were avoided between the two mental foramen. [33] Similar to the incisive canal, the lingual foramen in the anterior region of the mandible is often ignored as it appears to be of low clinical risk associated.

The sublingual arteries passing through the lingual foramen can be damaged leading to oedema. In such cases, pressure is applied to the lingual aspect of the mandible to arrest the bleeding and medications are prescribed to prevent further bleeding. Hence, as a precaution measurement of diameter of the lingual foramen should be calculated in CBCT and if the diameter is more than 1mm, the clinicals should be aware of possible vascular damage. [34,35]

Damages to the IAN can range from 0-40%. [36–39]According to Seddon, different nerve injuries are existent such as neurapraxia, axonotmesis, and neurotmesis, which are based upon the severity of damage to the tissues, prognosis, and time required or taken for recovery. With neurapraxia being the mildest form with best prognosis, neurotmesis is found to be the most severe, which also has poor prognosis. [40]Studies have proven to show that sufficient space around the implants must be advised to avoid unnecessary loss of adjacent hard and soft tissues. Leaving a 1.5mm crestal bone interproximally, can aid in development for a healthy papilla. [41]

The measurement of bone height at the time of placement can suitably provide maximum support and distribution of masticatory forces. While the canine eminence region in the maxilla and 1st premolar region in the mandible offer the greatest bone height, the posterior regions of maxilla and mandible due to the presence of limiting structures such as maxillary sinus and IAN can provide a lesser height than other regions. In such conditions the usage of shorter and wider implants is recommended. [42]

Conclusion

Our retrospective study conducted between two researchers with vast differences in experience showed an excellent agreement and the accuracy in locating and tracing the nerves and bone measurements between shows the implication of the knowledge they have in understanding the concept of implant placement guided using CBCT.

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