Evaluation and Measurement of Anterior Loop Length of Inferior Alveolar Nerve to Avoid Nerve Damage During Implant Surgery- A Cone Beam Computed Tomographic Study

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Abstract:-

Dental implant surgeries carry a risk of injury to the terminal branches of the trigeminal nerve. Among these branches, the mandibular division is particularly susceptible compared to the maxillary nerve. Anatomical variations in the anterior loop of the inferior alveolar canal (IAN) are commonly observed.

Aim:-

The objective of this study was to evaluate different anatomical variations of the anterior loop of the IAN using cone beam computed tomography (CBCT), considering age and gender. Additionally, the study aimed to measure the length of the anterior loop to facilitate safe implant placement in the most distal area of the interforaminal region.

Material and Methods:-

The study analyzed 50 CBCT scans obtained from patients. The length of the anterior loop of the IAN was measured using the measuring tool provided by the EZ 3Di imaging software. Descriptive and analytical tests were conducted to analyze the data.

Results:-

The prevalence of anterior nerve looping in the IAN was 57.0%, with Type III being the most common pattern. Prevalence was highest in the 20-40 years age group, and males had a higher prevalence than females.

Conclusion:-

CBCT and preplanning are recommended to prevent nerve injury during implant surgery by identifying and accommodating the loop, ensuring safer implant placement.

Keywords:- *Anterior Loop, Cone Beam Computed Tomography, Dental Implant, Inferior Alveolar Nerve, Mental Loop.*

I. INTRODUCTION

The trigeminal nerve, the largest cranial nerve, consists of three main branches: ophthalmic (V1), maxillary (V2), and mandibular (V3). Among these branches, the mandibular segment is the largest and provides innervation to various structures, including the mandibular lip, chin, teeth, adjacent soft tissues, mandible, and a portion of the external ear.[1,2]

During dental implant surgical procedures, there is a potential risk of injury to the terminal branches of the trigeminal nerve. Among these branches, the mandibular division is more susceptible to injury compared to the maxillary nerve. The inferior alveolar nerve (IAN), a branch of the trigeminal nerve, is the most commonly affected, followed by the lingual nerve (LN).[3,4]

The IAN divides into two branches before exiting the mandibular foramen. One branch emerges through the mental foramen and is referred to as the mental nerve, providing sensation to the lip and chin. The other branch, known as the incisive branch, travels within the bone to supply sensation to the anterior teeth. In some cases, the IAN may exhibit an anterior loop, where it curves back anteriorly after exiting the mental foramen. This anatomical variation, known as the anterior loop of the IAN or mental loop, can present challenges during implant surgery.[5,6,7]

Solar et al. proposed a classification system for anterior loops, identifying three types. Type I exhibits a Y-shaped anatomy with no anterior loop, and the thickness of the incisive branch is similar to that of the main branch. Type II shows a T-shaped anatomy without an anterior loop, with the incisive branch perpendicular to the main branch and the mental branch entering the mental foramen perpendicularly. Type III displays a Y-shaped anatomy with a detectable anterior loop, and the incisive branch is thicker than the main branch. Failure to identify this anterior loop may result in complications such as nerve injury and sensory disturbances in the lower lip. Therefore, a precise evaluation of its anatomy, position, and length before surgery is crucial.[8,9]

Various diagnostic technologies, including three-dimensional (3D) cone-beam computed tomography (CBCT), computed tomography (CT), and direct anatomical analysis, are used for pre-surgical evaluation. Among these, CBCT has proven to be slightly superior in assessing the position and precise location of the anterior loop. It provides detailed information, minimizes patient exposure to radiation compared to CT, and offers clear images without overlap or distortion.[10,11,12]

The purpose of this study is to evaluate different anatomical variations of the anterior loop with respect to age and gender and measure the length of the anterior loop using CBCT. The study aims to prevent nerve injury during implant surgery and facilitate the safe placement of implants in the most distal area of the inter-foraminal region. By analyzing a significant number of patients, this comprehensive study aims to provide valuable insights into the prevalence, dimensions, and spatial relationships of the anterior loop. Additionally, the research aims to establish guidelines and recommendations for implant surgeons to minimize the risk of nerve damage during implant surgery.

II. MATERIAL AND METHODS

A retrospective CBCT study was conducted over a period of 3 months, utilizing CBCT images obtained from a CBCT center in Hingoli, Maharashtra. The study aimed to evaluate the presence of the mental nerve loop in 50 individuals (27 males and 23 females). The mean age of the participants was 41.82 ± 11.42 years, ranging from 20 to 60 years. The CBCT scans of these individuals were divided into right and left sides, resulting in a total of 100 sites being analyzed.

The CBCT examination focused on the mandibular premolar and molar regions, as well as the anterior area mesial to the mental foramen. Individuals with a history of developmental anomalies, pathological lesions, inadequate diagnostic quality, or mandibular trauma were excluded from the study.

The CBCT images were acquired using the Vatech A9 computed tomography X-ray system, providing three-dimensional (3D) imaging. The imaging parameters were set to a voltage of 94kV, a current of 7.3mA, and an exposure time of 15 seconds. The images had a field of view of 8cm × 8cm, 200 microns image field of view with a voxel size of 0.2 mm and interslice distances of 1 mm. Axial, sagittal, and coronal sections were obtained for analysis. Standardization of the evaluation process was achieved by reconstructing the axial slices parallel to the lower border of the mandible, ensuring visibility of both right and left mental foramina. (Fig.1) Panoramic curves were drawn from the right to the left mental foramen, and cross sections were generated based on these panoramic sections.(Fig.2,3)

Subsequently, the most anterior parts of the mental foramen and the inferior alveolar nerve (IAN) were marked, and their lengths were measured. The measuring tool of the EZ 3Di imaging software was used for accurate measurements. The measurements were performed by two trained and calibrated observers. Additionally, three observers trained in evaluating the IAN loop and its different types reassessed all the scans. The data were reviewed by a professor of Periodontics and Implantology to ensure inter and intra-examiner reliability.

This rigorous methodology was employed to ensure accurate measurements and reliable data collection, minimizing any potential bias in the study.

III. RESULTS

A total of 100 CBCT scans were evaluated, involving 50 patients with 27 males (54%) and 23 females (46%). Age distribution revealed 48% in the 20-40 years group and 52% in the 41-60 years group (Table 4). The overall prevalence of anterior nerve looping was 57.0%, with the right side showing a prevalence of 62.0% (31 cases) and the left side 52.0% (26 cases). (Table 5). Type III pattern was the most prevalent on both sides (62.0% on the right, 52.0% on the left), followed by types I and II. (Table 6). In the age category of 20-40 years, the prevalence of anterior looping was 58.06% on the right and 50.0% on the left, while in the 41-60 years age category, it was 41.93% on the right and 50.0% on the left. (Table 7). Males exhibited a higher prevalence of anterior looping on the right side (61.29%) and an equal prevalence on the left side (50.0%). No significant differences were observed between genders (p-value 0.068 on the right, p-value 0.921 on the left).

IV. DISCUSSION

When addressing multiple missing teeth extending beyond the pentagon segment, it is crucial to strategically place key implants in each segment. The primary sites for implant placement typically include the canine, distal end of the first molar, second premolar, and central incisor. It is noteworthy that the mental foramen, a landmark in this region, is most frequently located between the premolars, typically positioned greater than 2mm below the apex of the second premolar. Studies conducted by Tebo & Telford (1950), Wang et al. (1986), and Santini & Land (1990)[13] reported prevalence rates of the mental foramen's position below the apex of the second premolar as 49%, 58.98%, and 52.9% respectively. So, implant placement in the premolar region is susceptible to cause injury to IAN.[14]

The success of implant surgery relies heavily on accurate assessment of the anatomy, position, and length of the anterior loop of the inferior alveolar nerve (IAN) prior to the procedure. In the current study, cone beam computed tomography (CBCT) was employed to evaluate the prevalence and average extension of the anterior nerve loop of the IAN. While many studies suggest that panoramic radiography is suitable for visualizing the mandibular canal, Vazquez et al. specifically examined the efficacy of panoramic radiographs for treatment planning in implant surgery.[15]

While panoramic radiographs effectively assess bone height for posterior mandibular implants, they are inadequate for evaluating the morphology of the anterior nerve loop due to processing errors, patient positioning, and inability to visualize intermedullary structures like the anterior loop of the inferior alveolar nerve (IAN).[16] Therefore, 3D imaging, such as cone beam computed tomography (CBCT), is essential for accurate evaluation.[17,18] CBCT offers advantages of easy technique, precise images, reduced artifacts, lower costs, and lower radiation dose compared to CT.[19,20]

The present study reported a prevalence of 57.0% for anterior nerve looping of the IAN, consistent with findings by Sitaraman (2019)[21] and Puri et al. (2020).[22] It observed a higher prevalence on the right side, similar to Sinha et al. (2019)[23] and Mishra et al. (2021)[24]. However, Nascimento EHL et al.[25] and Puri et al. found no difference between right and left sides, potentially attributable to racial variations.

Type III anterior nerve looping was most prevalent, followed by types I and II on both sides, consistent with Shaban et al. (2017)[26] and Prakash et al. (2018).[27] The length of the anterior nerve loop ranged from 2 to 7 mm, with an average of 2.03 mm. No significant variations were observed in prevalence or mean length based on gender or age.

In conclusion, the study found a significant prevalence of anterior nerve looping in the evaluated CBCT scans, with an overall prevalence of 57.0%. Type III pattern was the most common, followed by types I and II. The prevalence of anterior looping was observed in both the 20-40 years and 41-60 years age groups, with higher prevalence in males compared to females on the right side. No significant differences were found between genders on the left side. These findings emphasize the importance of preoperative evaluation and awareness of anterior nerve looping to ensure safe implant placement. The study highlights the usefulness of CBCT imaging in assessing anterior loop variations and supporting treatment planning for dental implant surgeries.

This study is unique as the first of its kind conducted in the population of Hingoli, Maharashtra. Its findings contribute valuable data on the prevalence of anterior nerve looping of the IAN in Maharashtra and the broader Indian population.

V. CONCLUSION

This study presents a thorough examination of the evaluation and measurement of the anterior loop length of the IAN using cone beam tomography. The study's findings aim to improve the understanding of the anterior loop's anatomical variations and guide implant surgeons in ensuring safe and successful implant procedures while prioritizing patient well-being.

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- *Declarations:*

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Conflict of interest: None declared

Ethical approval: Not required

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FIGURES

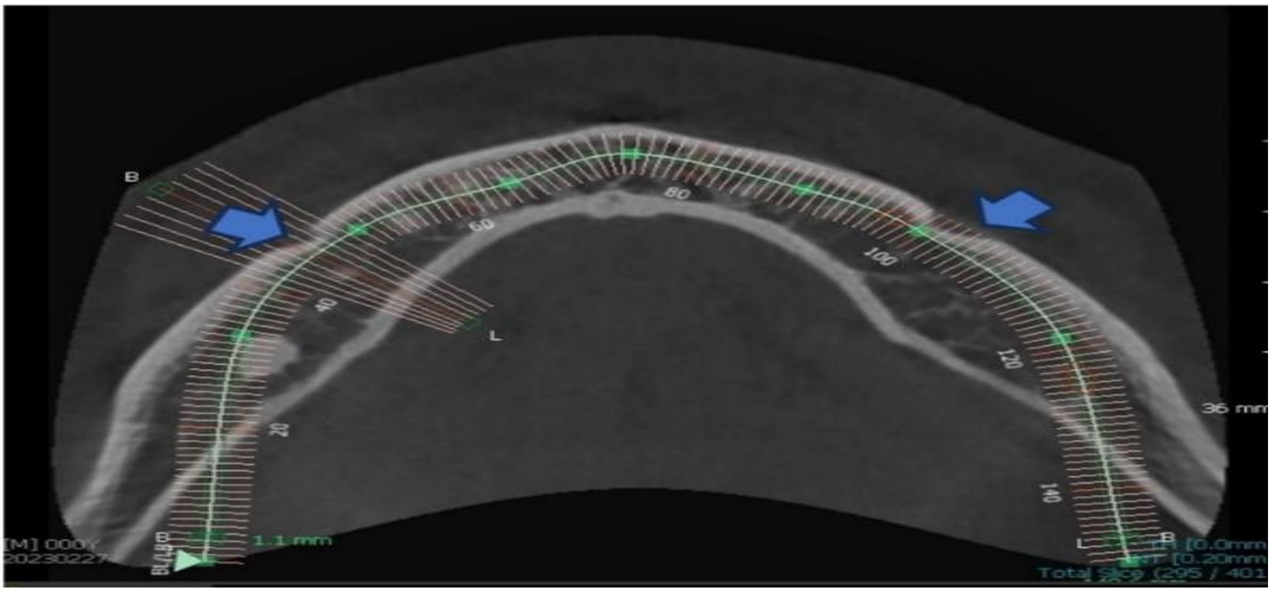


Fig 1 Axial Section Showing the Right and Left Mental Foramen

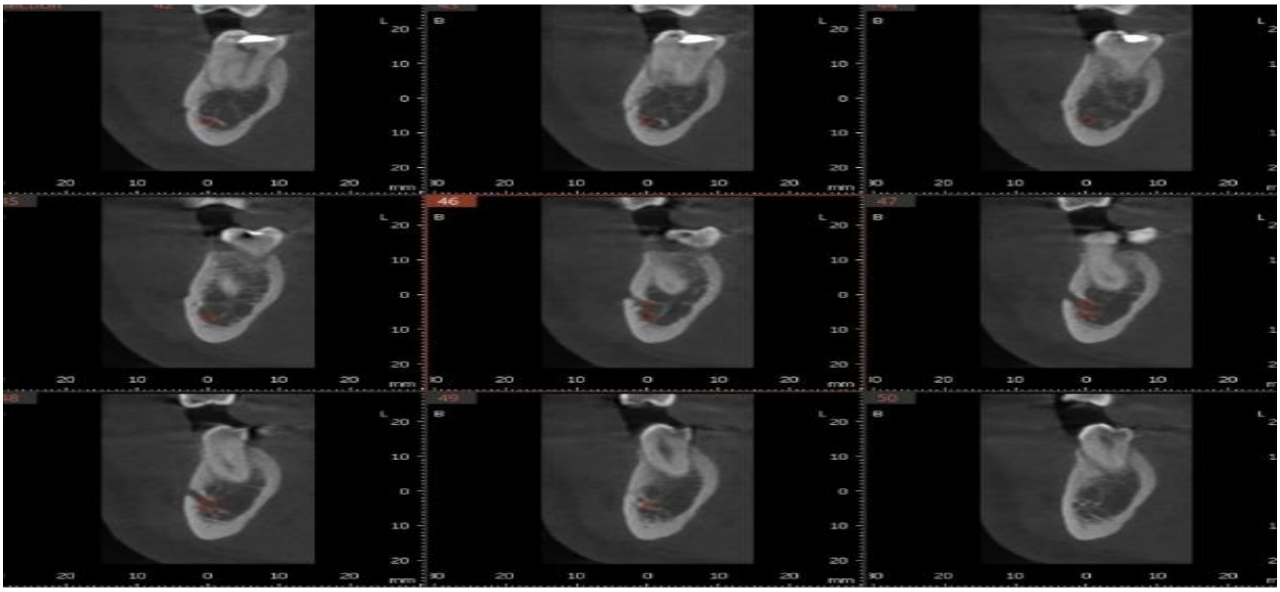


Fig 2 Coranal Sections Showing Type III Pattern

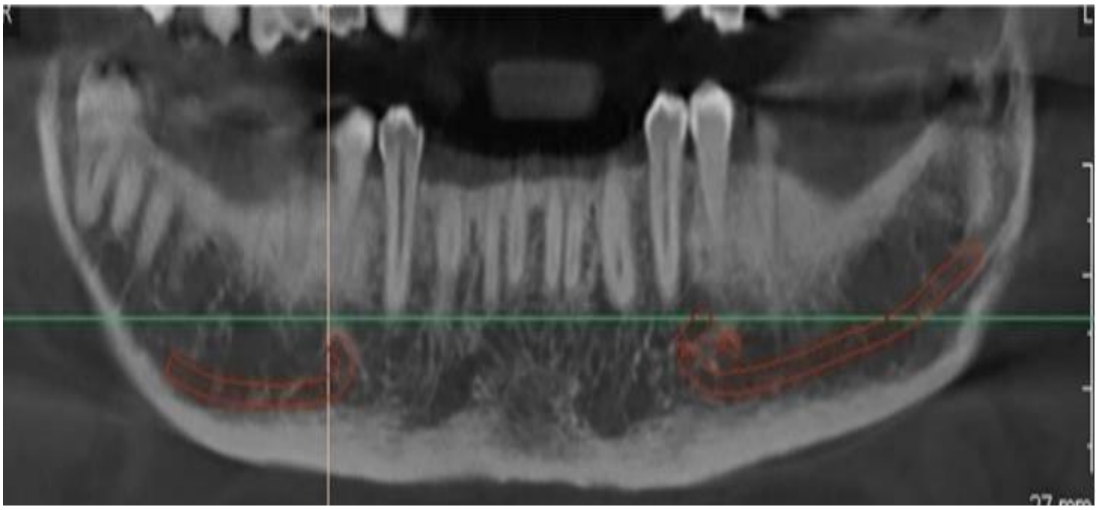
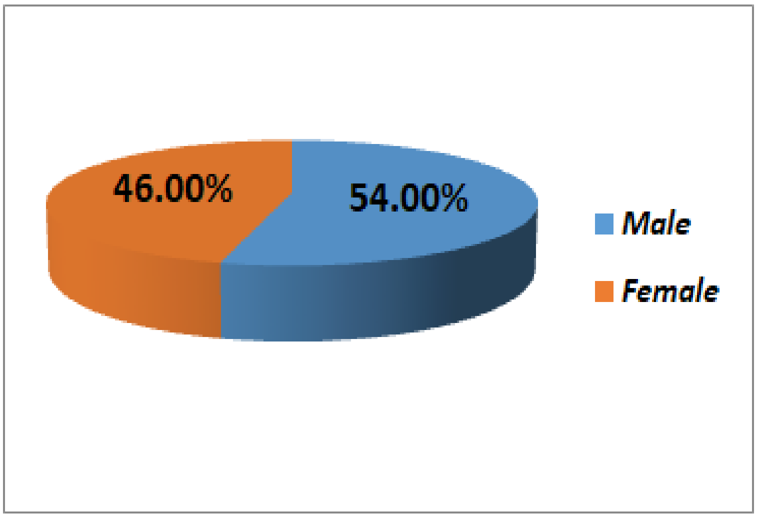
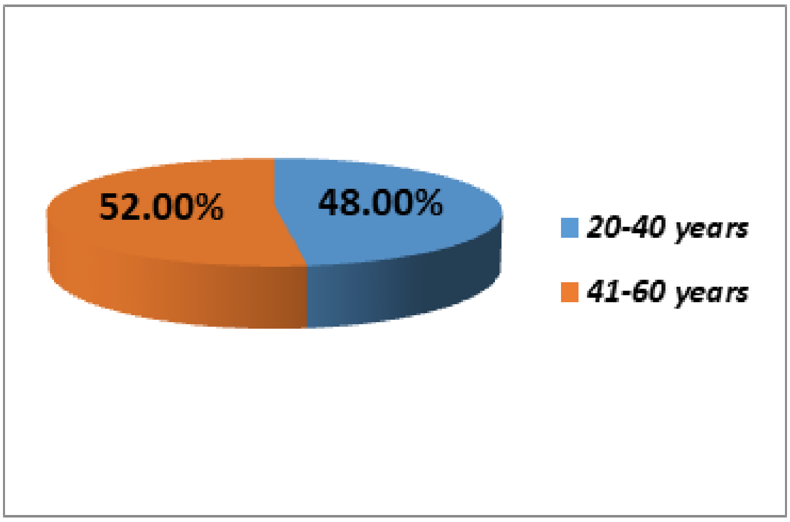


Fig 3 Panoramic Section Displaying Inferior Alveolar Nerve Canal

➢ *Gender*



➢ *Age Groups*



➢ *Age (Mean ± SD)*

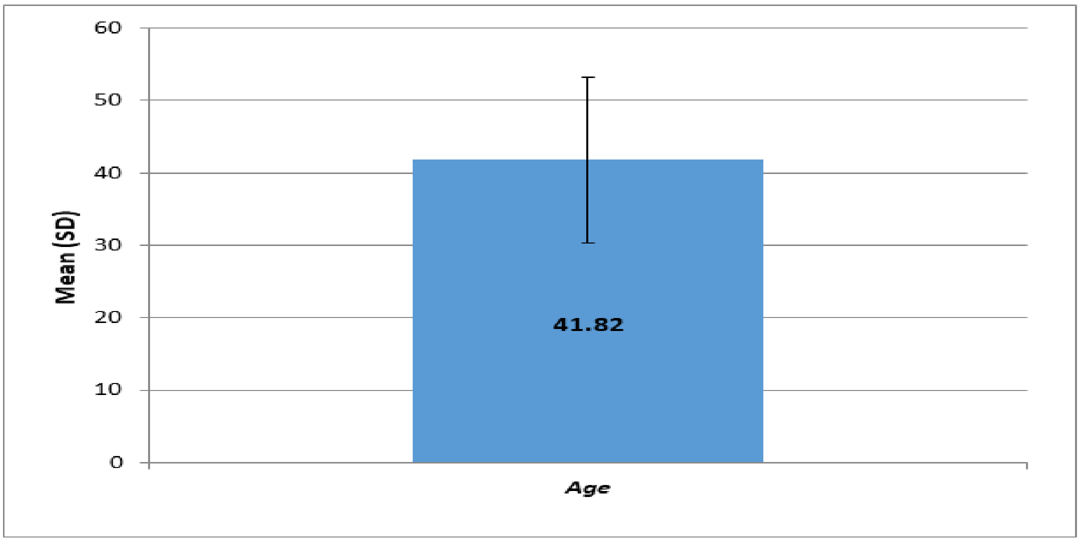


Fig 4 Demographic Characteristics of the Study Participants (N=50)

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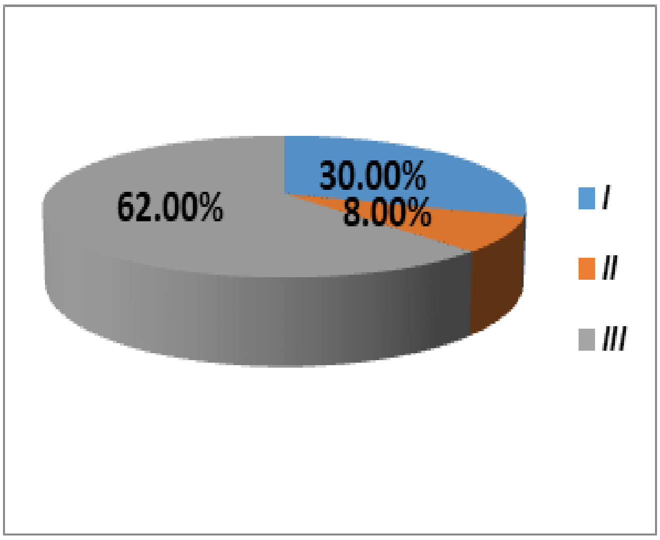
➢ *Right (Type)*



➢ *Left (Type)*

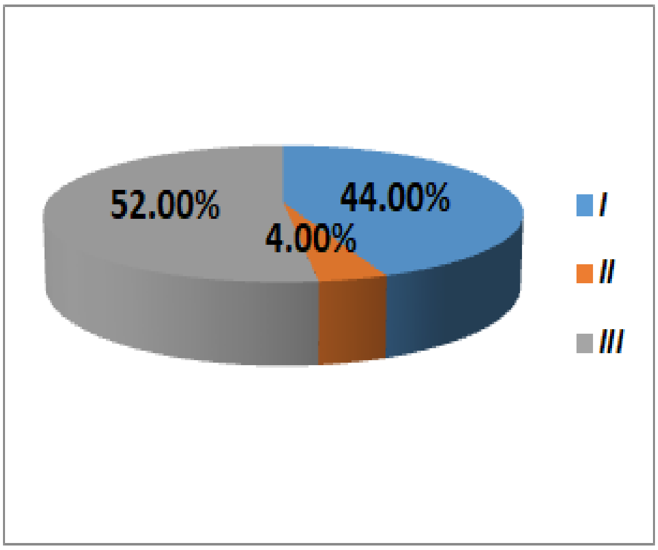
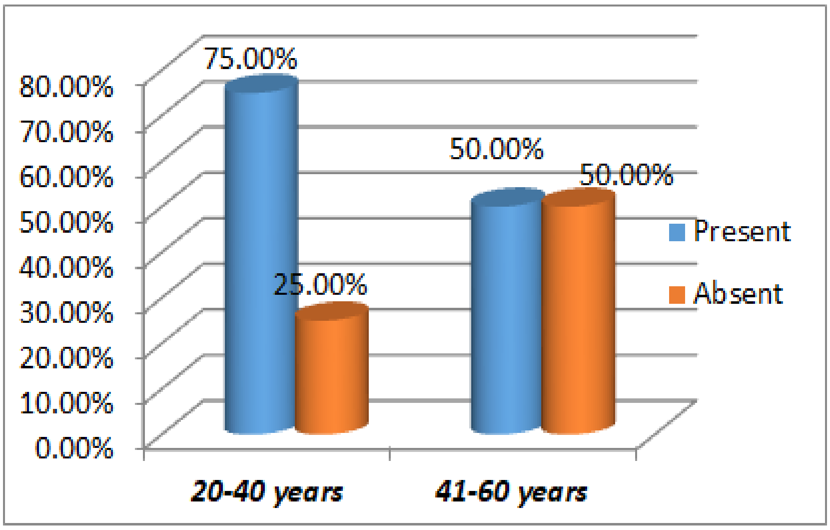
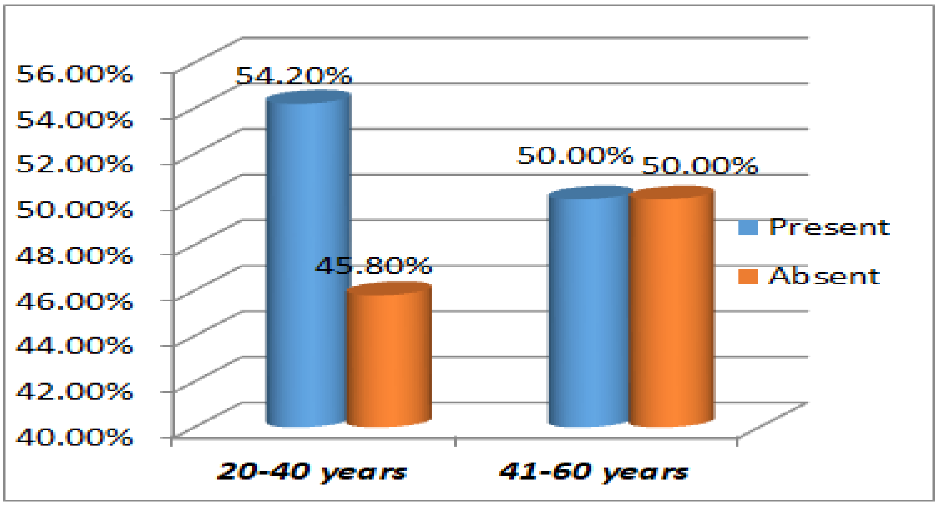


Fig 5 Descriptive Statistics (N=50)

➢ *Right (Type)*



- *Left (Type)*



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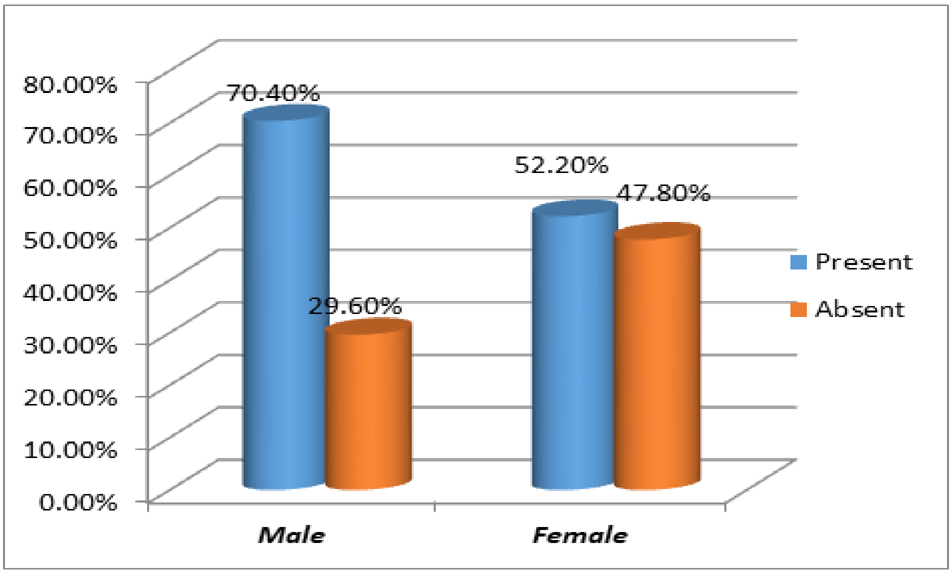


- *Left (Type)*

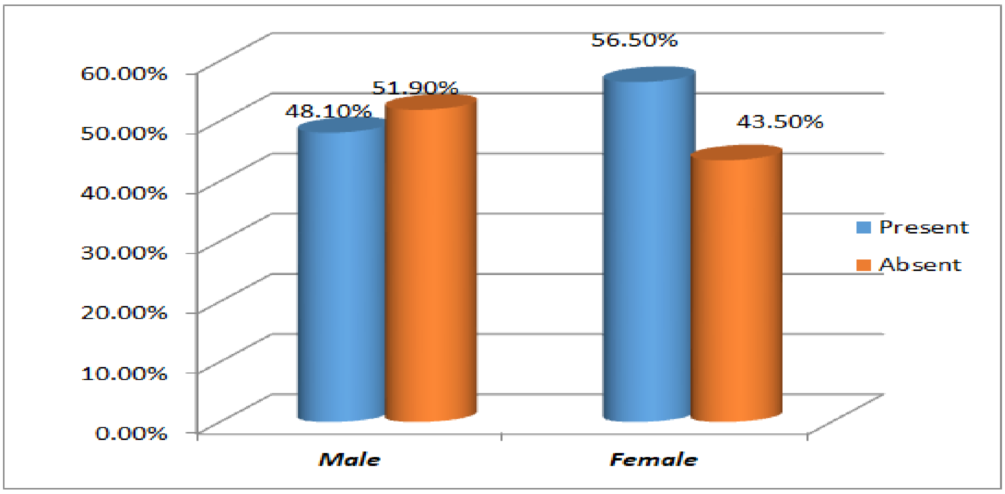
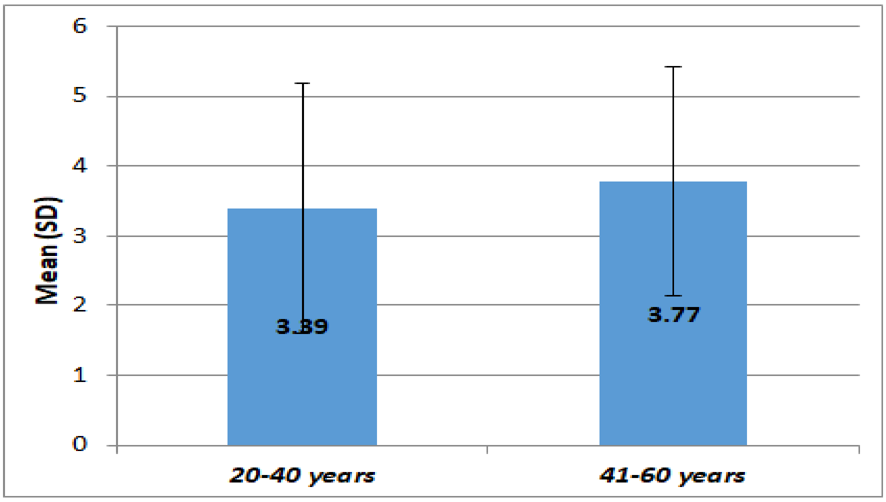


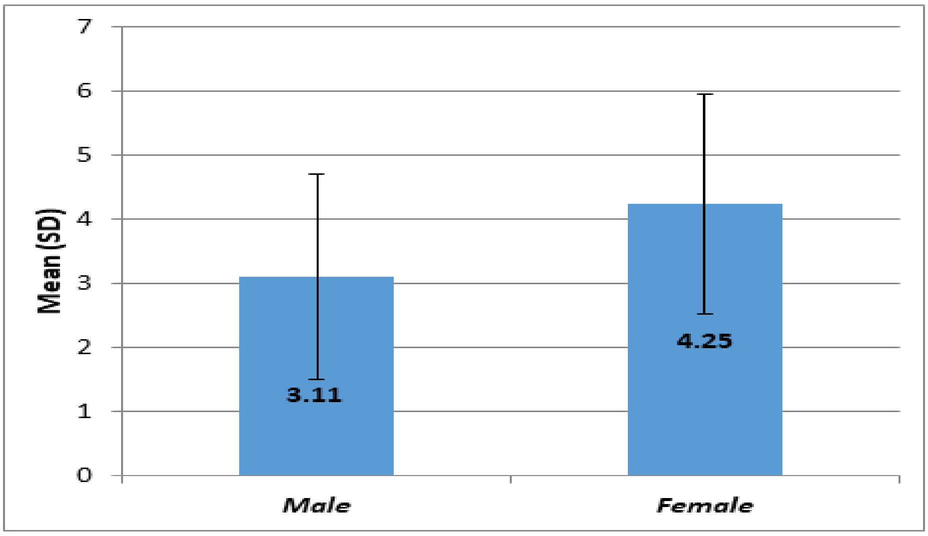
Fig 6 Distribution of Study Population According to the Prevalence of Anterior Looping of Alveolar Nerve on Right and Left Sides Among Different Age Groups and Gender using Chi Square Test

➢ *(Right Side)*

- *Age Group*

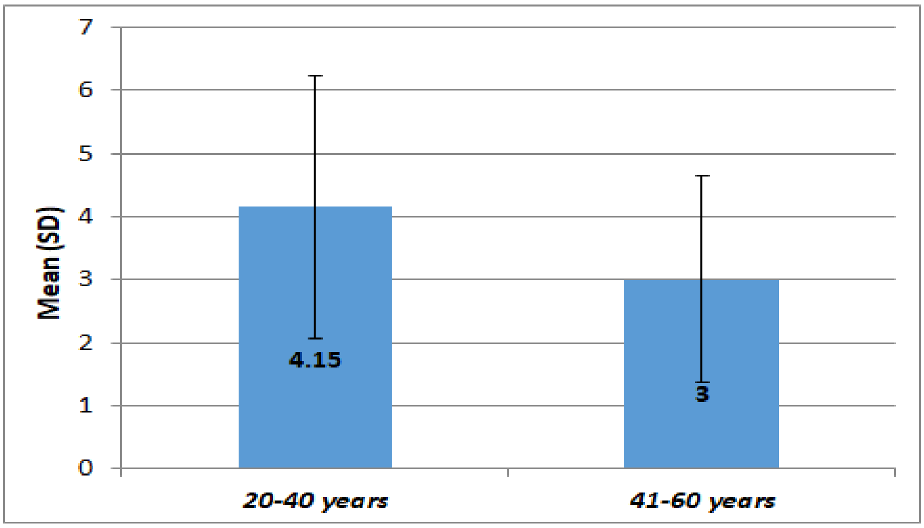


- *Gender*



➢ *(Left Side)*

- *Age Group*



- *Gender*

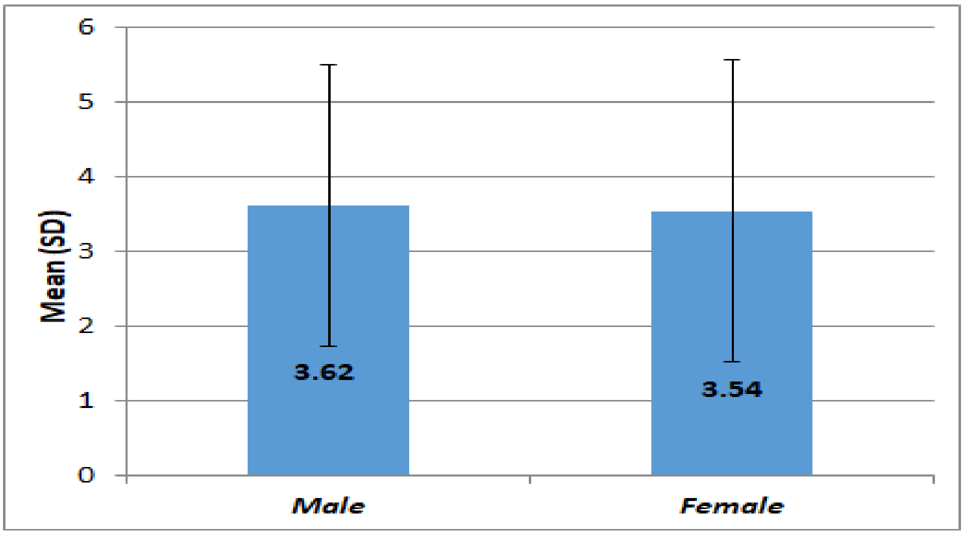


Fig 7 Comparison of Length of Anterior Extension of Alveolar Loop in Terms of {Mean (SD)} Both Right and Left Side Among Different Age Groups using Unpaired T Test

REFERENCES

[1]. A. Auersvald and L. A. Auersvald, “Management of the submandibular gland in neck lifts,” Clinics in Plastic Surgery, 2018;45(4):507–25.

[2]. K. Al-Qahtani, A. Mlynarek, J. Adamis, J. Harris, H. Seikaly,T. Islam. Intraoperative localization of the marginal mandibular nerve: a landmark study. BMC Research Notes. 2015;8(1): 382.

[3]. Liu X, Daugherty R, Konofaos P. Sensory Restoration of the Facial Region. Ann Plast Surg 2019;82:700-7.

[4]. Juodzbalys G, Wang HL, Sabalys G. Injury of the Inferior Alveolar Nerve during Implant Placement: a Literature Review. J Oral Maxillofac Res 2011;2:e1.

[5]. Pogrel MA, Smith R, Ahani R. Innervation of the mandibular incisors by the mental nerve. J Oral Maxillofac Surg. 1997;55:961-3.

[6]. Mraiwa N, Jacobs R, Moerman P, Lambrichts I, van Steenberghe D, Quirynen M. Presence and course of the incisive canal in the human mandibular interforaminal region: Two-dimensional imaging versus anatomical observations. Surg Radiol Anat 2003; 25:416-423.

[7]. Chávez-Lomeli ME, Mansilla Lory J, Pompa JA, Kjaer I. The human mandibular canal arises from three separate canals innervating different tooth groups. J Dent Res. 1996;75:1540-4.

[8]. Solar P, Ulm C, Frey G, Matejka M. A. Classification of the intraosseous paths of the mental nerve. Int J Oral Maxillofac Implants. 1994;9:339-44.

[9]. D. Apostolakis, J. E. Brown. The anterior loop of the inferior alveolar nerve: prevalence, measurement of its length and a recommendation for interforaminal implant installation based on cone beam CT imaging,” Clinical Oral Implants Research. 2012; 23(9):1022–30.

[10]. Suomalainen A, Kiljunen T, Käser Y, Peltola J, Kortesniemi M. Dosimetry and image quality of four dental cone beam computed tomography scanners compared with multislice computed tomography scanners. Dentomaxillofac Radiol. 2009;38:367-78.

[11]. Kaya Y, Sencimen M, Sahin S, Okcu KM, Dogan N, Bahcecitapar M. Retrospective radiographic evaluation of the anterior loop of the mental nerve: comparison between panoramic radiography and spiral computerized tomography. Int J Oral Maxillofac Implants. 2008;23(5):919-25.

[12]. Uchida Y, Noguchi N, Goto M, Yamashita Y, Hanihara T, Takamori H, Sato I, Kawai T, Yosue T. Measurement of anterior loop length for the mandibular canal and diameter of the mandibular incisive canal to avoid nerve damage when installing endosseous implants in the interforaminal region: a second attempt introducing cone beam computed tomography. J Oral Maxillofac Surg. 2009;67(4):744-50.

[13]. SINGH R, SRIVASTAV A. K. Study of position, shape, size and incidence of mental foramen and accessory mental foramen in Indian adult human skulls. Int. J. Morphol.2010; 28(4):1141-6.

[14]. M. R. Moghddam, Z. Davoudmanesh, N. Azizi, V. Rakhshan, M. Shariati. Prevalence and length of the anterior loop of the inferior alveolar nerve in Iranians. J Oral Implantol. 2017;43(5):333–6.

[15]. Vazquez L, Saulacic N, Belser U, Bernard JP. Efficacy of panoramic radiographs in the preoperative planning of posterior mandibular implants: a prospective clinical study of 1527 consecutively treated patients. Clin Oral Implants Res 2008;19:81-5.

[16]. Wismeijer D, van Waas MA, Vermeeren JI, Kalk W. Patients' perception of sensory disturbances of the mental nerve before and after implant surgery: a prospective study of 110 patients. Br J Oral Maxillofac Surg. 1997;35:254-9.

[17]. Chen JC, Lin LM, Geist JR, Chen JY, Chen CH, Chen YK. A retrospective comparison of the location and diameter of the inferior alveolar canal at the mental foramen and length of the anterior loop between American and Taiwanese cohorts using CBCT. Surg Radiol Anat 2013;35:11-8.

[18]. Parnia F, Moslehifard E, Hafezeqoran A, Mahboub F, Mojaver- Kahnamoui H. Characteristics of anatomical landmarks in the mandibular interforaminal region: a cone-beam computed tomography study. Med Oral Patol Oral Cir Bucal 2012;17:e420-5.
[19]. Danforth RA, Dus I, Mah J. 3-D volume imaging for dentistry: a new dimension. J Calif Dent Assoc. 2003;31:817-23.
[20]. Koh KJ, Kim KA. Observation of the anterior loop and mental foramen of the mandibular canal using cone beam computed tomography. Korean J Oral Maxillofac Radiol 2009;39:81-7.
[21]. M. A. Sitaraman. Prevalence and length of anterior loop of inferior alveolar nerve. J Oral Implantol. 2019;10(11): 3504–8.
[22]. Puri A P, Verma P, Mahajan A, Bansal S, Kohli S, Faraz A. CBCT evaluation of the vital mandibular interforaminal anatomical structures. Annals of maxillofacial surgery. 2020;10(1):149–57.
[23]. S. Sinha, S. Kandula, N. C. Sangamesh, P. Rout, S. Mishra, A. A. Bajoria. Assessment of the anterior loop of the mandibular canal using cone-beam computed tomography in eastern India: a record-based study. J Int Soc Prev Commu Dent.2019;9(3):290–5.
[24]. Mishra SK, Nahar R, Gaddale R, Chowdhary R. Identification of anterior loop in different populations to avoid nerve injury during surgical procedures-a systematic review and meta-analysis. Oral Maxillofac Surg. 2021;25(2):159-74.
[25]. E. H. L. do Nascimento, M. L. Dos Anjos Pontual, A. Dos Anjos Pontual et al. Assessment of the anterior loop of the mandibular canal: a study using cone-beam computed tomography. Imaging Science in Dentistry.2016; 46(2):69–75.
[26]. Shaban B, Khajavi A, Khaki N, Mohiti Y, Mehri T, Kermani H. Assessment of the anterior loop of the inferior alveolar nerve via cone-beam computed tomography. J Korean Assoc Oral Maxillofac Surg. 2017 Dec;43(6):395-400.
[27]. Prakash O P, Srivastava K B, Jyoti R, Mushtaq T, Vyas, Usha P. Radiographic evaluation of anterior loop of inferior alveolar nerve: a cone-beam computer tomography study. Nigerian J Surg. 2018;24(2):90–94.