Original Article

Variations in inferior alveolar nerve, roots, course, and communication with auriculo-temporal nerve using Cone Beam Computed Tomography

Mohamed Abdallah Hasaballah Abdelrazig[1*], Omer Ahmed Awad Abdelaziz 1, Mohammed A.A .Abdelmotalab [2] , Ammar Mohammed Ali[2], Abdelaziz Elshafie Awadalla Mohamed[3].

1. Anatomy Department, Faculty of Medicine and Health Science, Omdurman Islamic University, Sudan.

2. Anatomy Department, Faculty of Medicine, International University of Africa, Sudan

3. Radiology Department, Moalem and Al Saha Hospitals, Khattoum City,Sudan.

*__Corrsponding author:__ Mohamed Abdallah Hasaballah Abdelrazig. Email: mohamed.abdallah.99454@gmail.com Tel: 0918199454 Orcid: 0009-0000-0973-4615

Abstract

Background: The frequent anatomical variations of the inferior alveolar nerve (IAN) course should be considered prior to any treatment in this area. These variations may be associated with faulty techniques of dental anesthesia. Objectives: The aim of this study was to assess the anatomical variation of inferior alveolar nerves in the Sudanese population using CBCT. Materials & Methods: This is a retrospective cross-sectional study conducted to evaluate a sample of 81 cone-beam computed tomography (CBCT) examinations. A structured data sheet was used for the collection the information. The data were collected using cone-beam computed tomography (CBCT) images from the archives. The study was conducted from September 2021 to March 2022 at a 3D dental X-ray center in Khartoum City, Sudan. Results: This study was carried out on 3D dental X-ray centers at Al Moalem and Al Saha Hospitals, Khattoum City,Sudan. The finding shows that a higher prevalence of the inferior alveolar nerve was seen in the age category of (64–74) (34%). The alveolar nerve originated from the posterior division of the mandibular nerve and was found to be by one root in (81.5%). This study showed that the inferior alveolar nerve had a long course before enteringthe mandibular canal (100%). The inferior alveolar nerve showed a

ISSN: 2948-300X (print) 2948-3018 (online)

communicating branch to the auriculotemporal nerve in about 9.9% of the study group. Conclusion: In conclusion, the inferior alveolar nerve was situated below the root apex (100%) and also that the inferior alveolar nerve was located lateral to the lingual nerve (100%). In addition, the inferior alveolar nerve was situated superficial to the maxillary artery Recommendation: Understanding anatomical variations of inferior alveolar nerve is .(%92.5) .crucial as it can affect a clinician's ability to achieve successful pain control

Keywords: Mandibular canal, inferior alveolar nerve, auriculotemporal nerve, cone beam computed tomography and variation.

Introduction:

The inferior alveolar nerve (n. alveolaris inferior; inferior dental nerve) is the largest branch of the mandibular nerve. The inferior alveolar nerve (inferior dental) passes down deep to the lower head of the lateral pterygoid on the lateral surface of the medial pterygoid. Lying between the mandible and the sphenomandibular ligament, it enters the mandibular foramen in front of the inferior alveolar artery and vein after giving off the nerve to mylohyoid (1). The branches of the inferior alveolar nerve are the mylohyoid, dental, incisive, and mental: The mylohyoid nerve (n. mylohyoideus) is derived from the inferior alveolar just before it enters the mandibular foramen. It descends in a groove on the deep surface of the ramus of the mandible, and reaches the undersurface of the Mylohyoideus supplies this muscle and the anterior belly of the Digastricus. The inferior dental branches supply the molar and premolar teeth. They correspond in number to the roots of those teeth; each nerve entering the orifice at the point of the root and supplying the pulp of the tooth; above the alveolar nerve they form an inferior dental plexus. They also give some branches (inferior gingival branches) to the buccal gingiva of the manidublar teeth (except the first molar tooth). The incisive branch is continued onward within the bone and supplies the canine and incisor teeth. (2) The mental nerve (n. mentalis) emerges at the mental foramen and divides beneath the triangularis muscle into three branches; one descends to the skin of the chin, and two ascend to the skin and mucous membrane of the lower lip; these branches communicate freely with the facial nerve. Two small ganglia, the otic and the submaxillary, are connected to the mandibular nerve. Variations in the branching pattern and abnormal communication among the lingual nerve, ATN, and IAN are extensively documented. The mandibular canal (MC) is a passage within the mandible that begins at the mandibular foramen. It descends obliquely downward and forward in the ramus and then runs horizontally forward in the body of the mandible.(4) Different anatomical variations may occur in the MC, such as being bifid or trifid, resulting from errors in embryological development(5). The existence of communication between the lingual nerve and IAN, which is a frequently reported variation in the literature, is thought to be

responsible for inadequate mandibular anesthesia . There have been reports indicating that the mental canal (MC) may have varying anatomic configurations in the horizontal plane. It could run from the lingual to the buccal side of the mandible, or be positioned midway between the buccal and lingual cortical plates of bone by the first molar(6,7) Cone-beam computed tomography (CBCT) is a relatively new imaging modality that provides multi-planar views of the facial skeleton with a reduced radiation dose compared to the most commonly used MDCT exposure protocols.

This study aimed to assess the anatomical variation of inferior alveolar nerves in a sample of Sudanese dental patients using CBCT.

Materials and methods:

Study design: This is a retrospective study conducted by reviewing images of CBCT from hospital archives, carried out during the period from September 2021 to March 2022. The study was conducted in 3D Dental X-Ray center at Khartoum, Sudan.

Study population:

The study was carried on dental records of 81 patients who attended the 3D Dental X-Ray center.

Sample size:

The sample size in this study was estimated by applying the following formula:

$n_{\circ} = Z^2\ pq\ /e^2$

Where; e: the desired level of precision, p: the estimated proportion of the population, which was set as 50%, q: 1-p According to the formula, the estimated sample size is eighty-one, randomly selected from the 3D Dental X-ray center

Where:

Z = Z-score which depends on the confidence level chosen by the researcher

$N=1.96\times1.96\times p(1\neg p)/\ e^2$

The Z-score for a confidence level of 95% = 1.96

p = Anticipated population = 0.056

e = margin of error or confidence interval = 0.05.

8=0.05×%0.5)0.056¬1(N=1.96×1.96×0.056

1

N = sample size = 81

Inclusion criteria:

The images of eighty-one subjects (who had undergone CBCT examination showing the mandibular premolar/molar region) were retrieved from the archival records and inspected for the presence of the mental nerve.

Exclusion criteria:

Any patient with evidence of bone disease, history of drug consumption that could affect the area, trauma or surgical history to the region, congenital disorders, a partially erupted mental region or unerupted teeth, pathologies at the mandibular premolars or molar areas, low image scan quality or artifacts, or images that did not show the mandible inferior border was excluded.

Data collection tools:

A structured data sheet was used for the collection the information. The data collected using CBCT images from the archives of the 3D Dental X-Ray Center at Khartoum City.

Data collection technique:

There are two phases in CBCT imaging: the acquisition phase and the reconstruction phase. During the acquisition phase, the patient is positioned into the machine with the head stabilized to avoid movement during the acquisition of the data volume. After patient positioning, a scout view will be acquired to verify that the area of interest is within the fieldfield of viewview (FOV). (FOV). Once the clinician has assessed the scout image and approved it, the scan begins with rotation around the patient's head, either 180 or 360 degrees, and the cone-shaped x-ray beam is directed through the center of the area ofinterest (mandibular interest (mandibular canal). The beam and the receptor rotate simultaneously around the patient's head during the acquisition. During this rotation, basis images are acquired in intervals as the radiation passes through the patient and is captured by the receptor.First step to interpretation of the CBCT image,image, we virtually reorient the patient set until the arch is in a suitable position and the head is not tilted. tilted. The occlusal plane should be level with the horizontal plane. It is very important to systematically read the entire comprehensive data volume. Key ideas to remember are to assess for symmetry and continuity of

osseous borders. In the coronal view, we can see the mandibular canal and inferior alveolar nerve by tracing the canal and measuring the length ofthe nerve the nerve using a ruler. a ruler. Other options typically found are zoom, magnification, brightness,brightness, or contrast.

Data analysis:

Statistical analysis was conducted using .SPSS version 26The results then were presented in tables and figures.

Ethical consideration:

Approval was obtained from the Faculty of Medicine at the University of Omdurman Islamic University. Accordingly, permission was obtained from the ethical committee at 3D Dental X-Ray Center.

Result:

The data provided offers a detailed breakdown of age distribution within the surveyed population. It shows a diverse demographic spread across five distinct age brackets. The largest group falls within the 44-54 years category, comprising 32.1% of the total sample, followed closely by individuals aged 33-43 years, making up 29.6%. Together, these two groups represent the majority, indicating a significant middle-aged segment. Additionally, individuals aged 55-65 years account for 22.2%, demonstrating a substantial representation of older adults. The youngest cohort, aged 22-32 years, constitutes 8.6% of the population, while the oldest group, aged 66-76 years, makes up the smallest proportion at 7.4%, this distribution emphasizes the significance of understanding age demographics as shown in Table 1. The analysis of the frequency of occurrences of the IAN origin in different regions revealed that all instances originated exclusively from the posterior region. Out of the total 81-recorded cases, every single one represented 100% of the sample. In addition, the course of the inferior alveolar nerve is completely within the mandibular canal in all cases. However, the distribution of branches of the inferior alveolar nerve (IAN) before entering the canal exclusively is nerve to mylohyoid in all cases. Consequently, the analysis of 81 cases revealed that the inferior alveolar nerve (IAN) predominantly features a single root in 66 instances (81.5%). In 10 cases (12.3%), the IAN exhibited two roots, while in five cases (6.2%), it was found in conjunction with the lingual nerve. These findings underscore the prevalence of a single root in the majority of IAN cases, with

variations observed in a smaller proportion, as detailed in Table 4.3 and figure 4.3. However, regarding the relation of the inferior alveolar nerve (IAN) to root apex is completely below apex in all cases. Moreover, the inferior alveolar nerve lies lateral to the lingual nerve in all cases. Among the 81 cases studied, only eight cases (9.9%) exhibited a communicating branch between these two nerves. In contrast, the majority of cases, 73 (90.1%), did not show any such communication. This data indicates that while a communicating branch can occur, it is not commonly observed.

Table (1) frequency distribution age group:

Age group	Frequency	Percent %
22-32 years	7	8.6
33-43 years	24	29.6
44-54 years	26	32.1
55-65 years	18	22.2
66-76 years	6	7.4
Total	81	100.0

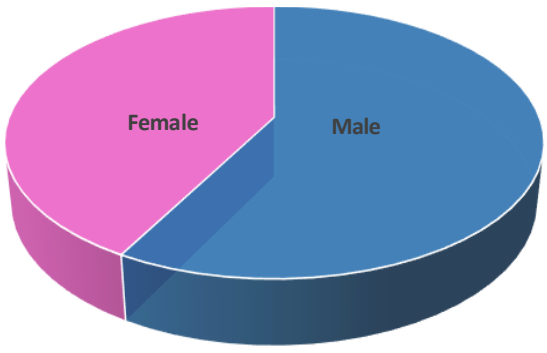

Fig (1): Demonstrating the frequency distribution of sex. The data shows that males make up 58.0% of the total sample, while females account for 42.0%.

Table (2): Frequency distribution course of Root of the inferior alveolar nerve (IAN):

The root of the inferior alveolar nerve (IAN)	Frequency	Percent%
By one root	66	81.5
By two root	10	12.3
Other(common with lingual nerve)	5	6.2
Total	81	100.0

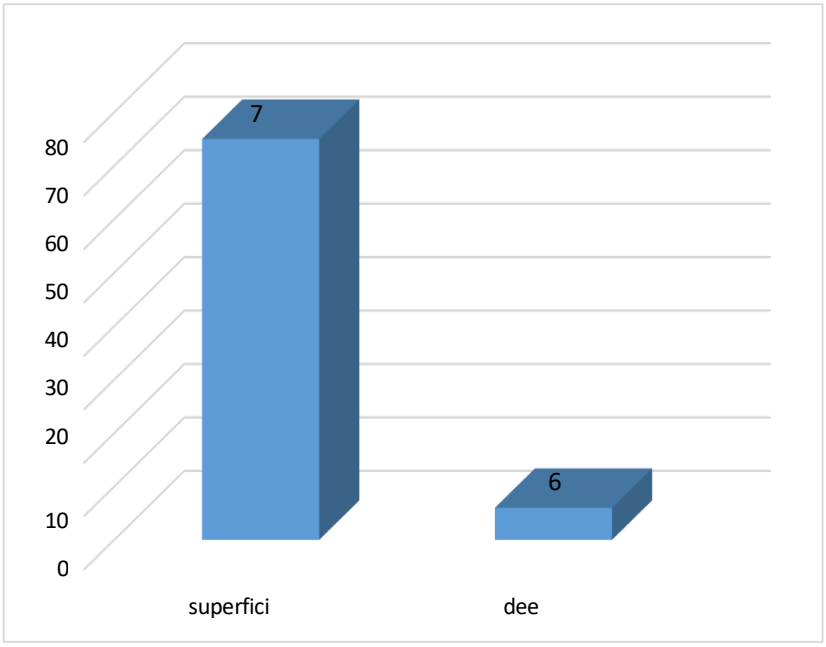

Fig (2): Showing frequency distribution of relation inferior alveolar nerve (IAN) to maxillary artery

The relationship between the inferior alveolar nerve (IAN) and the maxillary artery predominantly involves a superficial relation. Out of 81 cases examined, 75 instances (92.6%) showed the IAN positioned superficially relative to the maxillary artery. In contrast, only six cases (7.4%) demonstrated a deep relationship between the IAN and the maxillary artery. This data underscores that the vast majority of IAN cases involve a superficial position with the maxillary artery as shown in figure 2. The

presence of a communicating branch between the inferior alveolar nerve (IAN) and the auriculotemporal nerve is relatively rare.

Table (3): indicating frequency distribution of communicating branch between IAN and auriculotemporal nerve

Communicating branch between IAN and auriculotemporal nerve	Frequency	Percent%
Yes	8	9.9
No	73	90.1
Total	81	100.0

Discussion:

The inferior alveolar nerve (IAN) variation has been significantly noted in academic literature. This study examines the structural variations of the inferior alveolar nerve (IAN) in Sudanese patients utilizing CBCT images of the mandible from 81 patients, including 47 males (58%) and 34 females (42%). In uncommon cases, three separate branches emerged from the mandibular nerve and connected to the inferior alveolar nerve. In an examination of 50 IAN, researchers discovered an interesting variety in which the IAN came from the mandibular nerve via two roots. (9) A case report showed a branch from the auriculotemporal nerve traveled anteroinferiorly over the medial pterygoid muscle to join the inferior alveolar nerve in the infratemporal fossa. (10) Two uncommon variations observed in an elderly male cadaver. Another cadaveric case report showed a rare communicating branch connecting one of three roots of the auriculotemporal nerve and inferior

alveolar nerve just before entering the mandibular foramen on the right side, and three communicating branches between the IAN and (11) .lingual nerve on the left sideA study of 36 specimens revealed communication between the branches of the mandibular nerve's posterior division, as well as between the IAN and the auriculotemporal nerve in two specimens. (14) Muraleedharan et al. described a communicative branch. (13)This is consistent with the current studyexploration of a 9.9% incidence of such communications, highlighting the variety of nerve branching sequences. This illustrates the prevalence of anatomical variations in nerve branching, which can exacerbate surgical treatments if not expected. A histological and cad study, documenting that a blood vessel always lies superior to the IAN within the mandibular canal, with significant variability in the neurovascular bundles positioning (12). In comparison with other study Wolf et al. (15) reported a similar case and described an IAN split by the MA. In 3 subjects out of fifty of a MA splitting the IAN (16). In the upper part of the infratemporal fossa the interconnections between the lingual nerve and inferior alveolar nerve. (17) In consistent to present study, it was displayed that in five cases (6.2%) there is connection with the lingual nerve inside the infratemporal fossa. Simonton et al. (16) found gender-related differences in the position ofhis complements., the maxillary artery passing between these roots forming the IAN . (9) In this study the majority of IANs originated by one root, and the maxillary artery was predominantly superficial to the IAN in 92.5% of cases, reinforcing the need for thorough anatomical understanding during surgical i .interventionsThe IAN is associated with considerable age-related changes in the size of the mandible. While the current study revealed age-related occurrence, it concentrated on structural variances, giving a more comprehensive context for understanding

demographic influences on nerve placement.

Conclusion:

In conclusion, the prevalence of inferior alveolarnerve variations was significantly higher in the 64-74 age group, accounting for 34% of cases. In 81.5% of cases, the alveolar nerve offered from the posterior division of the mandibular nerve via a single root. Furthermore, all cases showed that the inferior alveolar nerve traveled a significant distance before entering the mandibular canal, with the nerve located below the root apex and laterally to the lingual nerve. Furthermore, the inferior alveolar nerve was found to be superficial to the maxillary artery in 92.5% of patients. The variations of the inferior alveolar nerve are of significant importance, as its accessory branches or connections with the auriculotemporal nerve can result in an incomplete nerve block during procedures such as extraction or surgeries, there is a risk of paresthesia or numbness. However, connections with the auriculotemporal nerve can cause pain in the ear or temporal area, which may result in misdiagnosis, unexpected bleeding and accessory canals may harbor vessels that can facilitate a spread of infection or .pathology

References:

1. .McMinnRMHLast's Anatomy .12thedChirchil living stone, singapore:pp764-766.

2. Moor, k. L., Dally, A, F., & Agur, A. (2017). Clinically oriented anatomy(8th ed.). Lippincott Williams and Wilkins.pp 931- 932.

3. Standaring, S.(2016). Gray's Anatomy (42st ed.). Edinburgh: Elsevier Churchill livingstone.pp 681-682.

4. Tammisalo T, Happonen RP, Tammisalo EH. Stereographicassessmentoftheman dibularcanalinrelationtotherootsofi mpacted lower third molars using multiprojection narrow beam radiography.*Int J Oral Maxillofac Surg.* 1992 Apr;21(2):85-9.

5. Gintaras J, Hom-Lay W, Gintautas S. Anatomy of MandibularVital Structures. Part I: Mandibular Canal and Inferior Alveolar Neurovascular Bundle in Relation with Dental Implantology. *J Oral Maxillofac Res.* 2010 Jan-Mar;1(1).

6. Miller CS, Nummikoski PV, Barnett DA, Langlais RP. Cross-sectional tomography: A diagnostic technique for determining the buccolingual relationship of impacted mandibular third molars and the inferior alveolar neurovascular bundle. *Oral Surg Oral Med Oral Pathol.* 1990 Dec;70(6):791-7.

7. Davis H. Mobilization of the Alveolar Nerve to Allow Placement of Osseointegratable Fixtures. In: Advanced Osseointegration Surgery: Application in the Maxillofacial Region. Chicago: *Quintessence Publishing Co.*; 2000. p. 129-141.

8.Shogo Maekawa, Mizuki Nagata, Yuki Matsushita, R. Shane Tubbs and Joe Iwanaga.An unusual anatomical variation of the inferior alveolar nerve. *Anat Cell Biol*. 2020. 31; 53(4): 519–521.

9. Sharma A, Kaban LB, Dodson TB. The inferior alveolar nerve and its topographical relation with the maxillary artery during routine dissection in the department of anatomy. *Indian Med J.* 2011 Mar;64(3):.21-1407

10. Tsakiris, E., Kitagawa, N., Fukino, K. et al. A rare case of the auriculotemporal and inferior alveolar nerves communication. Surg Radiol Anatomy. 2024;46, .194–191

11. Tritsch T, Shoja MM, Tubbs RS. Antegrade Auriculotemporal-Inferior Alveolar Nerve Communication in the Infratemporal Fossa. Cureus. .e50526:(12)15;14;2023

12.Thotakura B, Rajendran SS, Gnanasundaram V, Subramaniam. Variations in the posterior division branches of the mandibular nerve in human cadavers. *Singapore Med J. ;2013*54(3):149-151.

13. Muraleedharan A, Veeramani R, Chand P. Abnormal communications among the branches of the mandibular nerve, especially the posterior division, are significant due to various procedures undertaken in this region. *Indian Med J.* 2014 Mar;54(3):149-151.

.Matani JD, Kheur MG, Kheur SM, Jambhekar SS. The Anatomic Interrelationship of the Neurovascular Structures Within the Inferior AlveolarCanal:ACadavericandHistologicalStudy.*JMaxillofac. Oral Surg.* 2014 Oct-Dec;13(4):499-502. doi:10.1007/s12663-013-0563-y.

14. Wolf KT, Brokaw EJ, Bell A, Joy A. Variant inferior alveolar nerve and implications for local anesthesia. *Anesth Prog* 2016;63:84-90.

15. .Khan MM, Darwish HH, Zaher WA. Perforation of the inferior alveolar nerve by the maxillary artery: an anatomical study. Br J Oral Maxillofac Surg 2010;48:645-7.

16. Senem Erdogmus, Figen Govsa and Servet Celik. Anatomic Position of the Lingual Nerve in the Mandibular Third Molar Region as Potential Risk Factors for Nerve Palsy.TheJournal of Craniofacial Surgery. 2008; 19(1).

17. Simonton JD, Azevedo B, Schindler WG, Hargreaves KM. Age- andGender-relatedDifferencesinthePositionoftheInferiorAlveolar Nerve Using Cone Beam Computed Tomography. *J Endod.* 2015 Aug;35(7):944-9.