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Evaluation of Mandibular Lingual Foramina Using Cone Beam Computed Tomography

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ABSTRACT

Introduction: lingual foramina are important structures in anterior region of mandible and are a major cause of haemorrhage during surgical procedures. Its location, size and number has shown variations .hence we aimed to study its morphology using cone beam computed tomography (CBCT) and compared among gender.

Materials and Methods: a total of 103 images (females= 55 males= 48) satisfying the inclusion and exclusion criteria were selected from the archives and all sections of CBCT images were analyzed. The images were interpreted and evaluated for morphology of lingual foramina in the anterior region of mandible .It was analyzed for size, location and number and compared among genders.

Results: there was a significant anatomical variation in lingual foramen. Anatomical variations cannot be identified in 2D imaging. Common anatomical alteration is the presence of 2nd Foramina. Significant difference was found in size and distance from alveolar crest in males as compared to females.

Conclusion: in our study we have studied the relations of cephalic and deltoid veins in the deltopectoral groove which can be useful for successful catheter implantation and prevent damage to these important venous structures with scarce data on their topography.

Keywords: Anterior mandible; CBCT; Lingual foramen; Morphology.

Introduction

The lingual foramina (LF) are found on the cortical bone of the mandible on the lingual side providing blood and nerve supply to the mental region and contain important vascular and neural structures coming from the floor of mouth. Inspite of the complex vascularization of the floor of mouth and mental region, the mandibular region between the mental foramina is considered as the safest for surgery procedures. In Dental implantology, safe zone is a description for the region located anterior to the mental foramen of the mandible. This term is used because of the lesser number of neurovascular complications in the lip and chin region after surgical procedures as compared with the region posterior to the mental foramen. But, additional precautions are needed during surgery in this area due to the presence of critical structures.

The branches of the sublingual and submental arteries which supply the lingual surface of the mandible are located very near to the lingual cortical plate. This can have increased risk of bleeding if the lingual cortical bone is damaged during surgery or drilling for implant placement. The lingual mandibular foramina are accessory foramina on the anterior lingual surface of the mandible, where the median lingual canal pierces the lingual cortex at the region of the central incisors. They are small opening on the lingual surface of the mandible and often observed in the periapical region of incisors[1].

Lingual foramina are classified into two types according to their location median lingual canal (MLC) laterally lateral lingual canal (LLC). The structure of the lingual foramen, dimension and the location of the bony canals have to be considered with greater importance during any anterior dental surgeries such as grafting procedures, implant placement and genioplasty so as to avoid the major complications. Cadaveric studies have found that the mandibular lingual foramina from the midline are penetrated by branches from the sublingual artery (branch of the lingual artery) or sub mental artery (branch of the facial artery) or branches resulting from the anastomosis between these vessels.[2] Lingual foramen is typically visualized as a single round radiolucent canal with a well-defined opaque border. Although its development is uncertain, it forms a useful radiological landmark. The presence of lingual foramen was observed radio graphically in 28% of the mandibles.[3]

It is difficult to detect the lingual foramen, canal location, and extension with conventional 2D imaging modalities like periapical and panoramic radiograph due to many limitations as overlapping anatomical structures and difficulty in standardization. Computer-based imaging system- cone beam computed tomography (CBCT) is a 3D imaging modality and has superior advantages over the 2D imaging systems like removes superimposition, proper estimation of surgical sites, reduced possibility of

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surgical complications, and standardized images .It is widely used in the oral and maxillofacial regions due to its high resolution, fast image acquisition and low-dose radiation requirements. The error rate of CBCT displaying bony structures is less than 1%, whereas panoramic radiographs have an error rate of more than30%.[4] CBCT can offer high-resolution visualization of the structures of the jaw and dental measurements for quantitative analysis.

CBCT analysis has shown the presence of lingual foramina in the midline or canine/premolar regions in most of the cases. The artery is of sufficient size and may present a difficulty in controlling hemorrhage intraosseously .Sometimes, the arterial structures can be accompanied by very small nerves which are part of the arterial vasomotor supply[5].

The lingual foramen is found near the genial tubercle anatomically[5]. In some studies, it was also found at the apex of teeth.[1]It is also not constant in number and location. It has shown many variations between gender, age and geographic locations[2]. Dentists have to be aware of the presence of these anatomical structures in the anterior mandible and carefully examine the region when considering implant therapy or bone grafting techniques.

Many studies have used cone beam computed tomography as an imaging technique for evaluation of normal anatomic structures such as the lingual mandibular canal; but, only few studies were performed on the evaluation of the lingual mandibular canals in the Indian population. Thus, the objective of this cross sectional study is to evaluate the presence, size and location of the mandibular lingual foramen in an Indian subpopulation by the use of CBCT images.

Materials and Methods

The study was conducted in the Department of Oral Medicine and Radiology, Yenepoya Dental College, Mangalore, India. The samples were selected from the department archives of CBCT which were acquired from2014 to 2017. The selection of images for study was taken to fit in the inclusion criteria.

Inclusion Criteria

1. Mandibular CBCT images with visible lingual foramina
2. Mandibular CBCT images without any artifacts

Exclusion Criteria

1. Mandibular CBCT images with periapical pathologies in the anterior region
2. The mandibular CBCT images with known history of systemic disease involving the anterior region of the mandible
3. Mandibular CBCT images having any bone disorders.
4. Patient having a history of trauma or surgery in anterior region of mandible.

Ethical clearance was obtained from the Ethical Committee, Yenepoya deemed to be University before the onset of the study. T he CBCT volumes selected in the study include those of various FOVs (Field Of View). The scans were acquired using Planmeca Promax Proface 3D mid that uses Romexis software 3.8.3R for image reconstructions. The parameters for exposure in acquiring these images were 90kV, 10mA, and 12sec. The resolution of the images was 0.40mm, the bit depth of image being 12. (Fig. 1)

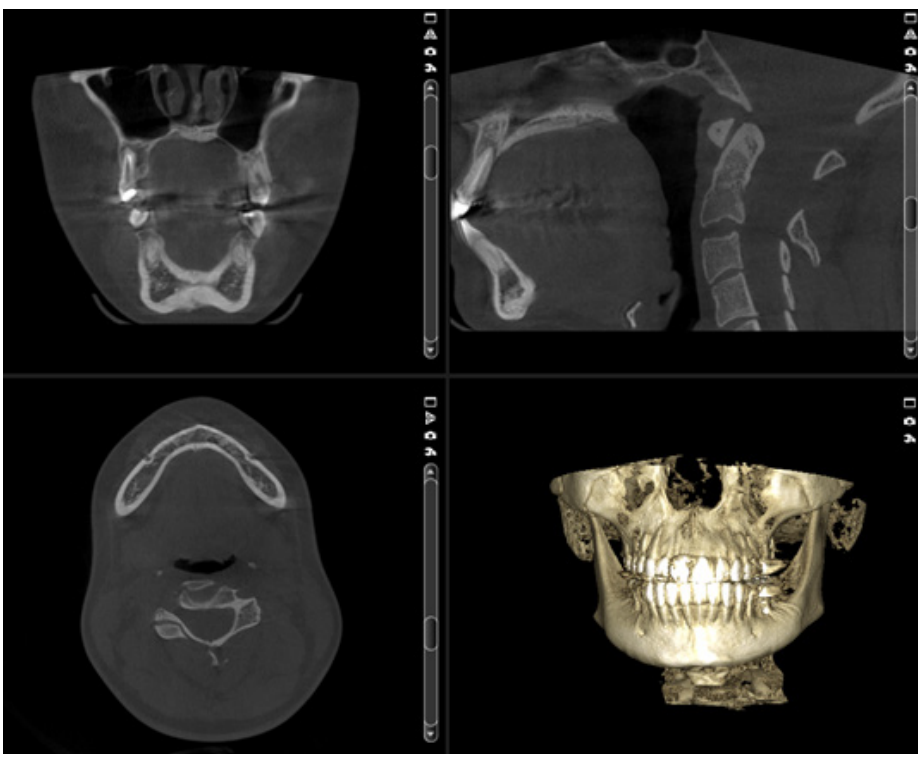


Figure 1. CBCT image of lingual foramen in all sections.

A total of 103 (females= 55 males= 48) images were examined from the archives of the Department of Oral Medicine and Radiology satisfying the inclusion and exclusion criteria were selected for the study The images were interpreted and evaluated for morphology of lingual foramina in the anterior region of mandible. All sections of CBCT images were analyzed i.e. the coronal, axial, sagittal and cross sectional views. A total of 116 foramina were found and analyzed for size, location and number and compared with gender.

Location of the lingual foramen was measured as the distance from the alveolar crest to the superior border of the lingual foramen in millimeters on the slope of the lingual surface of mandible. The size was measured from the superior border of the lingual foramen till the lower border in millimeters using the measurement tool of CBCT software (fig. 2) Positions of the canal were compared in between both the genders. All measurements were done by a single observer. The findings of the study were validated by 2 independent and experienced maxillofacial radiologists.

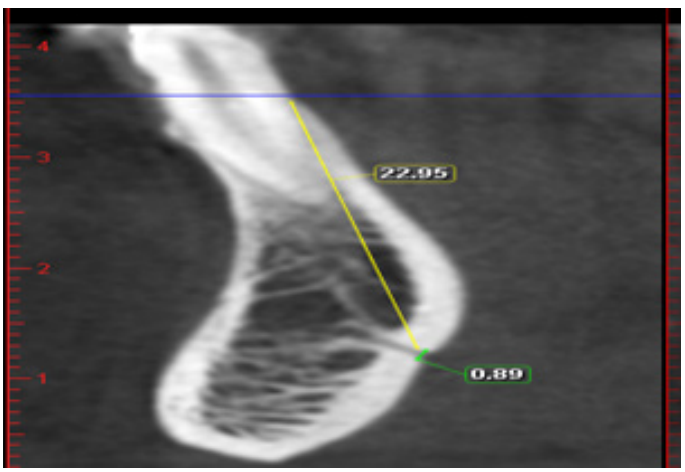


Figure 2. Measurement from the crest of alveolar ridge to the superior border of the lingual foramen.

Data was expressed as mean and standard deviation and discrete data was expressed in terms of frequency and percentages. Independent t test was used to compare the continuous parameters between the gender and chi-square test is used to check the association between the parameters. The data was analyzed with SPSS software version 22.0. p value less than 0.05 is considered significant.

Results

The mean age of females was 26.56 years and males were 30.69 years.

Table 1. The distribution of cases based on the age.

	Gender	N	Mean	Std. Deviation
Age (years)	female	55	26.56	13.31
	male	48	30.69	14.67

Table 2. Shows the distribution of lingual foramen.

		1	2	
Gender	Female	48	7	55
		87.3%	12.7%	100.0%
	Male	42	6	48
		87.5%	12.5%	100.0%
Total		90	13	103

Table 3. Shows number of the lingual foramina between the genders.

Chi-Square Tests	Value	df	p-value
Pearson Chi-Square	.001a	1	.972
N of Valid Cases	103		

Table 4. Shows size of the lingual foramina between the gender.

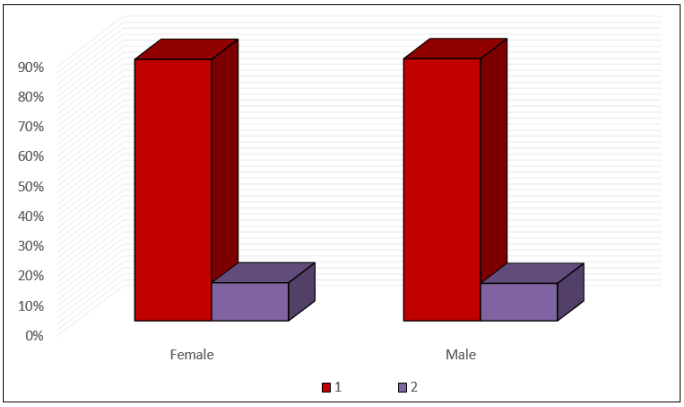
	Gender	N	Mean	Std. Deviation	p-value
Size of the lingual foramen (mm)	Female	55	1.0896	.35057	
	Male	48	1.2789	.48888	0.025
Size of 2nd foramen if present	Female	7	.8829	.37549	0.292
	Male	6	1.1367	.45222	

Table 5. Shows location of the lingual foramina between the gender.

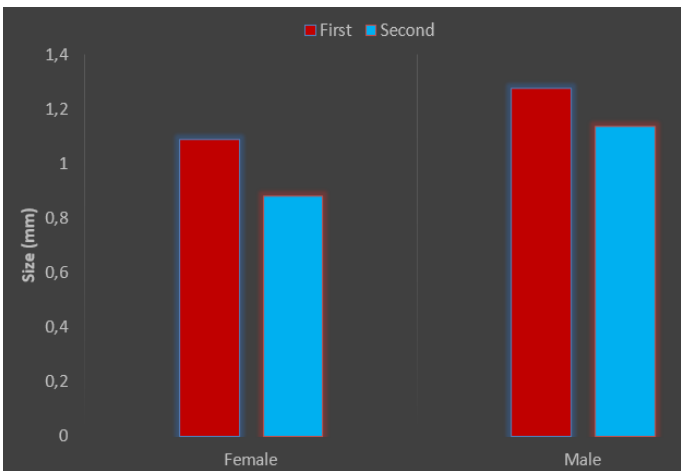
	Gender	N	Mean	Std. Deviation	p-value
Distance from alveolarcrest to first foramina (mm)	Female	55	17.9300	3.36740	0.001
	Male	48	20.3758	4.20874	
Distance from the alveolarcrest to second foramina if present (mm)	Female	7	25.2086	2.23387	0.984
	Male	6	25.2367	2.58018	

Observations

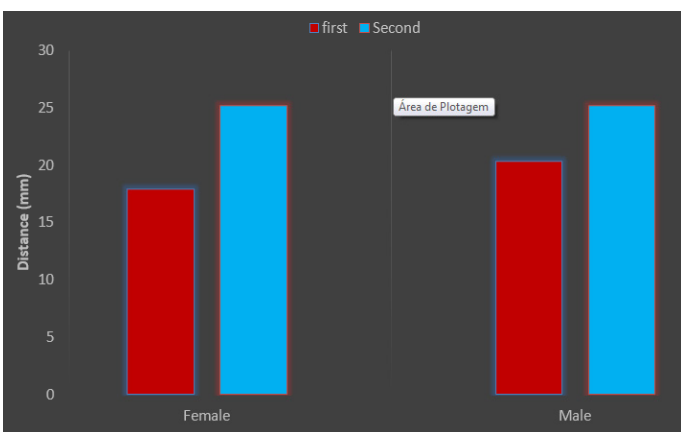
Table 1: shows the distribution of cases based on the age
Table 2 shows the distribution of lingual foramen
Table 3 shows number of the lingual foramina between the gender
Table 4 shows size of the lingual foramina between the gender
Table 5 shows location of the lingual foramina between the gender
Graph 1: distribution of lingual foramen among gender
Graph 2: size of lingual foramen among gender
Graph 3: location of lingual foramen among gender



Graph 1. Distribution of lingual foramen among gender.



Graph 2. Size of lingual foramen among gender.



Graph 3. Location of lingual foramen among gender.

Discussion

Diagnostic imaging is essential for dental treatment planning. Each location in the dental alveolus has unique morphologic characteristics owing to edentulousness and specific regional anatomic features that need to be identified and assessed in the diagnostic and treatment planning phase of dental-implant therapy or any surgical procedure[6]. The implant length is greatly influenced by the location of lingual foramen therefore the visibility of the lingual foramen on CT or CBCT scans is to prevent operative complications at mandibular implant sites.

Identification and preservation of bony structures is important in periapical surgery, implant surgery, maxillofacial trauma and orthognathic procedures. The presence of anatomical variations within the foramina may usually complicate the diagnosis. The presence of additional foramina or bifid/trifid lingual foramina has great clinical implication during surgical procedures, especially placement of dental implant.

Anterior mandibular (interforaminal) region is important in implant applications as it serves a basis for neurovascular bedding and holds the prosthesis for patients[7]. Knowledge about the anatomy of the anterior region of the mandible is very essential to prevent intraoperative and postoperative complications. Hemorrhage in the anterior mandible may occur due to the accidental perforation of the lingual cortex and resultant injury to the sublingual artery. The sublingual artery is a branch of the lingual artery, the branches of which supplies the floor of the mouth and enters the mandible through the lingual foramen situated in the midline of the mandible.

Several authors have reported serious complications, such as life threatening hematoma in the floor of the mouth due to injury to the lingual vessels, following implant placement in the mandibular anterior region[8,9,]. These midline canals showed a neurovascular content, which was not only related to their anatomical location, but also subject to anatomical variation. As previous studies have described, the lingual foramina were often found in the midline. Reports have suggested a close relationship between bleeding risk and mandibular lingual foramina[10].

Mc Donnel *et al*[11] evaluated dry specimens of 314 mandibles and noted that the lingual foramen in the mandibular midline was a consistent finding, being present in over 99% of the dried specimens examined.

Some authors describe the location, vascularization and innervations of the MLF, and warning about the possible risks that may have been caused from surgical damage[12.]

Liang *et al*[8] had previously reported that the lingual foramen could be identified in panoramic radiography in 71% of cases while 12% had adequate visibility.

Tepper *et al*[13] reported that lingual foramina in the midline were observed on CT images of all the 70 patients. The presence of the lingual vascular canal (MLVC) and the vascularity of the inter foramina region have been assessed in the literature. Kilic *et al*[14] evaluated 200 CBCT scans for the presence of mandibular lingual vascular canal (MLVC) and reported that the typical location of this canal was the midline region of the mandible. Similarly, Longoni *et al*[15] reported that a single midline vascular canal is consistently present in the anterior mandible and a CT examination should be performed prior implant

surgery to avoid the risk of hemorrhage during implant surgery.

The methodology (radiological vs. cadaver study), and the terminology might play the crucial role. All radiological studies vary in the type of radiological equipment and settings used, which may partly explain the differing results. Cadaveric studies are not affected by slice thickness, motion artifacts or image noise, and diameters down to 0.1 mm can be identified.

A retrospective study analysed 460 CT scans and concluded that the lingual foramen in the anterior mandible is a consistent finding irrespective of the age and gender of the patient[16].

In our study also, we found the lingual foramina in all 103 patients. 87% of the foramina were single in both males and females and only 12.5% had double canals. Ceena Denny[17] found single foramen in 69% of study group and 3 foramina in 2%. Natekar[18] found presence of the superior lingual foramen in 58%, inferior in 40% and that intermediate foramen in 8%. Jayabalan[1] found 30 images with double canals and Sheiki *et al*[19] found 2nd canal in 52.9%.

The second lingual foramen had smaller diameter in comparison with single lingual foramen. The mean diameter of the first and second lingual foramen in our observation were 1.09 (SD 0.35) and 0.89 (SD 0.39) among females and 1.28(SD 0.49) and 1.14 (SD 0.45) among males.

This is similar to study by Sheiki [19] who found mean diameter of the superior and inferior lingual foramen as 1.12 and 0.9 mm. But, there were no significant difference on the diameter of lingual foramen by gender.

Males had significantly larger single foramen as compared to females (p=0.025). But, second lingual foramen size difference was not significant (p=0.292).

The distance between the lingual foramina and the alveolar ridge crest is clinically relevant to implant surgery as it may limit the length of the implant to be placed. Therefore, the distance should be >12 mm to ensure that the lingual foramina and the canal contents will not be injured during implant surgery. Similarly we also found that the distance greater than 17 mm.

We found a significant difference in distance from alveolar crest to first foramina (p=0.001) between males 20.37 (SD 4.02) mm and females 17.9 (SD 3.37mm). This is similar to the study of Jayabalan etal[1] who found average distance of the 1st foramina from the alveolar crest as 21.08mm in males and 19.83 mm in females. Yildrim[20] observed 18.24 (SD 5.75) mm and he *et al*[2] found 20.64 (SD5.3 2) as mean distance between the mandibular crest and lingual foramen. This is greater than result of Babiuc[21] who found 14.20 (SD 4.34) mm; Sheiki[19] 14.39 (SD 4.82); and Choi *et al*[22] 2.58 (SD 2.49) mm.

An extreme variability has been reported in the number and topographic distribution of Lingual foramina and in the type and number of anastomosis between these two arteries[23]. Previous studies classified the diameters of foramina as ≤1 mm and >1 mm to determine the risk of severe hemorrhage. Of the lingual foramina identified in a study, 75.6% were ≤1 mm[20]. A study conducted by He *et al*[2] showed 0-8 foramina and most of the patients had 3 to 4 foramina in the anterior region of the mandible in our study up to 2 foramina were seen.

Conclusion

The study was done to assess the morphology of the lingual foramen in CBCT images and to evaluate the size location and number in both gender. We found that the lingual foramina demonstrated a significant difference in size and number among the study samples. Males had significantly larger foramen and distance from alveolar crest to the foramen was more as compared to females.

The size, location and number of lingual foramina should be assessed preoperatively to avoid any neurovascular disturbances and careful evaluation of the implant site is necessary to prevent impingement or violation of vital structures.

Limitations

Study sample size was limited to 103.

Age of the participants was not considered.

The distance from alveolar crest to top of the foramen was measured. Some studies have measured the distance to the lower border of the mandible.

Clinical relevance

Depiction of the lingual foramina on imaging tests is of fundamental significance and is a prerequisite for surgical procedures that involve anterior mandible particularly for endosseous implant placement and other surgeries involving the anterior mandible. Improper identification of this vital structure could lead to neurovascular complications.

The knowledge of the distance between the lingual canal and the alveolar ridge is important, as this area represents a site for invasive procedures such as implant placement. Immediate implants that are placed deeper than the natural socket and the preparation of implant platform may both damage the lingual canals. Presurgical assessment through CBCT examination of the sites prior to the implant procedure and other surgical procedures is very important to prevent damage to important anatomic structures.

References

1. Jayabalan J, Muthusekhar MR. a review on variations in lingual foramina of the mandible midline. Journal of Critical Reviews. 2020;7(14):948-52.
2. He X, Jiang J, Cai W, Pan Y, Yang Y, Zhu K, *et al*. Assessment of the appearance, location and morphology of mandibular lingual foramina using cone beam computed tomography. Int Dent J. 2016;66(5):272–9.
3. Vadgaonkar R, *et al*. Accessory neurovascular foramina on the lingual surface of mandible: Incidence, topography, and clinical implications. Indian J Dent Res. 2012;23(3):433.
4. Demiralp KO, Bayrak S, Orhan M, Alan A, Cakmak EK, Orhan K. Anatomical characteristics of the lingual foramen in ancient skulls: a cone beam computed tomography study in an Anatolian population. Folia morphologica. 2018; 77(3):514-20.
5. Von Arx T, Matter D, Buser D, Bornstein MM. Evaluation of location and dimensions of lingual foramina using limited cone-beam computed tomography. Journal of oral and maxillofacial surgery. 2011 Nov 1; 69(11):2777-85.
6. Soto R, Concha G, Pardo S, Cáceres F. Determination of presence and morphometry of lingual foramina and canals in Chilean mandibles using cone-beam CT images. Surgical and Radiologic Anatomy. 2018 Dec;40(12):1405-10.
7. Sener E, Onem E, Akar GC, Govsa F, Ozer MA, Pinar Y, Mert A, Sen BG. Anatomical landmarks of mandibular interforaminal region related to dental implant placement with 3D CBCT: comparison between edentulous and dental mandibles. Surgical and Radiologic Anatomy. 2018 Jun;40(6):615-23.
8. Liang X, Jacobs R, Lambrichts I, Vandewalle G. Lingual foramina on the mandibular midline revisited: a macroanatomical study. Clinical Anatomy: The Official Journal of the American Association of Clinical Anatomists and the British Association of Clinical Anatomists. 2007 Apr;20(3):246-51.
9. Elmasry RA, El-Fotouh MM, el Sadat SM, Aboelmaaty W. Cone beam computed tomography for evaluation of mandibular lingual canal in an Egyptian subpopulation. Egyptian Journal of Radiology and Nuclear Medicine. 2021 Dec;52(1):1-9.
10. Zhang C, Zhuang L, Fan L, Mo J, Huang Z, Gu Y. Evaluation of mandibular lingual foramina with cone-beam computed tomography. Journal of Craniofacial Surgery. 2018 Jun 1;29(4):e389-94.
11. McDonnell D, Nouri MR, Todd ME. The mandibular lingual foramen: a consistent arterial foramen in the middle of the mandible. Journal of anatomy. 1994 Apr;184(Pt 2):363.
12. Laçin N, Tatar B, Veli İ, Adıgüzel A. Evaluation of medial lingual foramen with cone-beam computed tomography in a Turkish adult population. International Dental Research. 2018 Dec 30;8(3):139-43
13. Tepper G, Hofschneider UB, Gahleitner A, Ulm C. Computed tomographic diagnosis and localization of bone canals in the mandibular interforaminal region for prevention of bleeding complications during implant surgery. International Journal of Oral & Maxillofacial Implants. 2001 Jan 1;16(1).
14. Kilic E., Doganay S., Ulu M., Celebi N., Yikilmaz A., Alkan A. Determination of lingual vascular canals in the interforaminal region before implant surgery to prevent life threatening bleeding complications. Clin Oral Implants Res. 2014;25(2):e90–e93.
15. Longoni S, Sartori M, Braun M, Bravetti P, Lapi A, Baldoni M, Tredici G. Lingual vascular canals of the mandible: the risk of bleeding complications during implant procedures. Implant dentistry. 2007 Jun 1; 16(2):131-8.
16. Trost M, Mundt T, Biffar R, Heinemann F. The lingual foramina, a potential risk in oral surgery. A retrospective analysis of location and anatomic variability. Annals of Anatomy-Anatomischer Anzeiger. 2020 Sep 1;231:15.
17. Denny CE, Natarajan S, Ahmed J, Binnal A, Jindal R. Anatomic variation in lingual foramen: a cone beam computed tomography study. World Journal of Dentistry. 2016 Oct 1;7(4):179-81.
18. Natekar PE, De Souza FM, Natekar P. Variations in position of lingual foramen of the mandible in reconstructive surgery. Indian Journal of Otology. 2011 Jan 1;17(1):12.
19. Sheikhi M, Mosavat F, Ahmadi A. Assessing the anatomical variations of lingual foramen and its bony canals with CBCT taken from 102 patients in Isfahan. Dental research journal. 2012 Dec;9(Suppl 1):S45.
20. Yildirim YD, Güncü GN, Galindo-Moreno P, Velasco-Torres M, Juodzbalys G, Kubilius et.al Evaluation of mandibular lingual foramina related to dental implant treatment with computerized tomography: a multicenter clinical study. Implant dentistry. 2014 Feb 1;23(1):57-63.
21. Babiuc I, Tarlungeanu I, Pauna M. Cone beam computed tomography observations of the lingual foramina and their bony canals in the median region of the mandible. Rom J Morphol Embryol.2011 Jan 1;52(3)827-9.
22. Choi DY, Woo YJ, Won SY, Kim DH, Kim HJ, Hu KS. Topography of the lingual foramen using micro–computed tomography for improving safety during implant placement of anterior mandibular region. Journal of Craniofacial Surgery. 2013 Jul 1;24(4):1403-7..
23. Taschieri, S., Corbella, S., Silnovic, A. *et al*. Frequency and anatomic variability of the mandibular lingual foramina: a cone-beam CT study. BMC Med Imaging 22, 12 (2022). https://doi.org/10.1186/s12880-022-00736-2.

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