



Lingual Foramen of the Mandible on Cone-Beam Computed Tomography Scans: A Study of Anatomical Variations in an Iranian Population

Mahkameh Moshfeghi¹, Shiva Gandomi^{1*}, Hamid Mansouri², Negin Yadshoghi³

1. Department of Oral and Maxillofacial Radiology, Shahid Beheshti University of Medical Sciences, Tehran, Iran
2. Department of Periodontics, Shahid Beheshti University of Medical Sciences, Tehran, Iran
3. Private Practice

Article Info

Article type:
Original Article

Article History:
Received: 14 Dec 2020
Accepted: 23 Mar 2021
Published: 4 Jun 2021

***Corresponding author:**
Department of Oral and Maxillofacial Radiology, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Email: sh_gandomi@hotmail.com

ABSTRACT

Objectives: Lingual foramen (LF) is an important landmark of the mandible, which should be considered in presurgical assessment. The purpose of this study was to assess the anatomical variations of the LF using cone-beam computed tomography (CBCT).

Materials and Methods: The study was conducted on 200 CBCT scans of Iranian adults. The lingual foramina (LFs) were classified into two groups by their location in the mandible namely the medial LFs (MLFs) and the lateral LFs (LLFs). The frequency of both the MLFs and the LLFs and their distance from the inferior border of the mandible were evaluated. Additionally, the diameter of the MLFs and the location of the LLFs were assessed. Data were analyzed separately for males and females.

Results: All 200 participants had at least one LF. Totally, 257 LFs were detected on 200 CBCT scans, including 223 MLFs (86.6%) and 34 LLFs (13.3%). The LLF was detected in 23 patients (11.5%). The prevalence of the LLF was higher in males and in the second premolar region. The diameter of the MLFs was less than 1mm in 81% of the cases, and males had a larger MLF.

Conclusion: There was a significant variability in the anatomy and location of the mandibular LF in Iranian adults. CBCT is recommended for preoperative imaging to determine the exact location and size of the LFs in the mandible to prevent possible surgical complications.

Keywords: Anatomy, Cross-Sectional; Mandible; Cone-Beam Computed Tomography; Radiology

- **Cite this article as:** Moshfeghi M, Gandomi Sh, Mansouri H, Yadshoghi N. Lingual Foramen of the Mandible on Cone-Beam Computed Tomography Scans: A Study of Anatomical Variations in an Iranian Population. *Front Dent.* 2021;18:20.

INTRODUCTION

Precise assessment of the location of anatomical structures is imperative prior to surgical procedures. Lingual foramen (LF) and its intra-osseous canal are important landmarks located in the anterior region of the mandible [1]. There may be one or more lingual foramina in an individual. This anatomical structure is usually

located in the lingual surface of the mandibular midline in the genial tubercle region [2]. However, it can have a more posterior position, referred to as the lateral LF (LLF) (Fig. 1). No consensus has been reached regarding its name, and studies refer to this anatomical landmark as the lingual vascular foramen, LLF, or accessory lingual foramen [3].

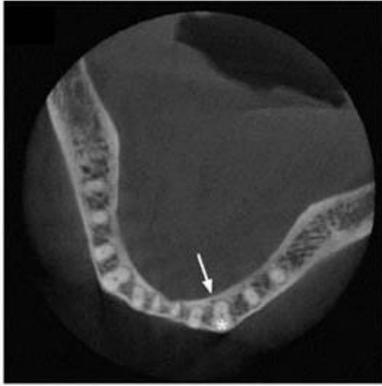


Fig 1: Lateral lingual foramen in the canine area

In general, surgical procedures of the mandibular anterior region are considered to be associated with low risk of injury to the critical anatomical structures. However, this assumption is not based on precise knowledge about the location of anatomical landmarks. As vascular branches of the submental and sublingual arteries pass through the lingual canals, excessive bleeding and neurosensory disturbances have been frequently reported during surgical procedures in the interforaminal region. According to previous studies, most complications are caused by lingual cortical perforation during implant placement in the canine region of atrophic edentulous ridges [4,5]. In the recent years, there has been an increasing demand to replace the missing teeth with dental implants. Hence, it is essential to have adequate knowledge about the variations in the location and morphology of the LF in order to prevent such complications [6]. The LF is seen as a single round radiolucent structure on panoramic radiographs. Panoramic imaging is often requested for preoperative assessment of the anterior mandible; however, it is unable to display the lingual foramina (LFs) and variations in their osseous canal. Cone-beam computed tomography (CBCT) is superior to panoramic radiography for visualization of these anatomical variations [7]. The present study was conducted to assess the prevalence and anatomical location of the LF on CBCT scans of an Iranian population.

MATERIALS AND METHODS

This was a retrospective cross-sectional study.

The study protocol was approved by the institutional review board of Shahid Beheshti University of Medical Sciences (code no: IR.SBMU.RIDS.REC.1395.338), and it was conducted in accordance with the declaration of Helsinki and its subsequent revisions.

The study was conducted on the available CBCT scans of adult patients referred to the Oral and Maxillofacial Radiology Department of Shahid Beheshti University for preoperative imaging prior to implant placement from 2017 to 2018. All CBCT scans had been obtained by New Tom VGI CBCT scanner (Quantitative radiology, Verona, Italy) with the exposure settings of 110 kVp, 3.3-20 mA, 12×8 cm field of view, and 0.3mm voxel size.

A total of 200 CBCT scans were selected by an oral and maxillofacial radiologist using convenience sampling. The inclusion criterion was age between 20 to 70 years, and the exclusion criteria were presence of pathological lesions or impacted teeth, history of mandibular fracture, and ongoing orthodontic treatment. The lingual foramina were classified into two groups by their location in the mandible: they were either at or adjacent to the midline, which were considered as the medial lingual foramen (MLF) or had a more posterior position, and classified as the LLF. The following parameters were measured for the MLFs:

1. Number of foramina
2. The size of foramen including its horizontal diameter and vertical diameter
3. The vertical distance between the lower margin of the foramen and the inferior border of the mandible (Figs. 2 and 3)

The following parameters were measured for the LLF:

1. The location and number of foramina in each tooth region (from the canine to the second molar on both sides of the mandible)
2. The vertical distance between the lower margin of the foramen and the inferior border of the mandible

All CBCT scans were evaluated by a calibrated oral and maxillofacial radiologist with 20 years of clinical experience.

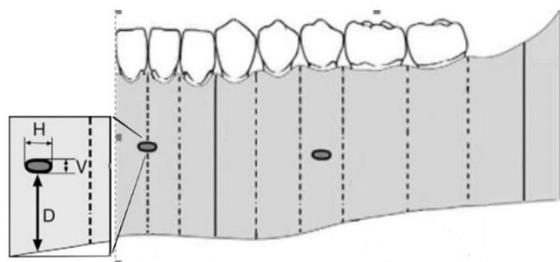


Fig 2: Schematic view of lingual foramina and the measured parameters



Fig 3: Cone-beam computed tomography image of a medial lingual foramen and the measured parameters

There were no restrictions on the use of image enhancement tools. The parameters were measured on the coronal plane and cross-sectional cuts using NNT Viewer software version 8 (NewTom; Verona, Italy), and recorded by gender. Data were analyzed by SPSS® version 21 (SPSS Inc., IL, USA). A generalized estimating equation model was used to assess the correlation of parameters with gender. $P \leq 0.05$ was considered statistically significant.

RESULTS

Of a total of 200 CBCT scans, 105 (52.5%) belonged to females and 95 (47.5%) belonged to males. The patients' mean age was 41.16 ± 14.6 years. All 200 cases (100%) had at least one LF. Most cases ($n=150$, 75%) had one LF; while three lingual foramina were the least prevalent, observed in 7 cases (3.1%). The remaining 43 patients (21.5%) had two LFs. A total of 257 LFs were observed on 200 CBCT scans, including 223 (86.6%) MLFs and 34 (13.3%) LLFs.

Medial lingual foramen:

A total of 223 MLFs were detected; 120 were observed in females and 103 in males. It should be noted that the number of females was higher than males in our study population. The diameter of the MF exceeded 1mm in 19%, and was <1 mm in 81% of the cases. The mean horizontal and vertical diameters of the MLF were 0.76 ± 0.22 mm and 0.79 ± 0.24 mm, respectively. The mean distance between the lower margin of the MLF and the inferior border of the mandible was 7.69 ± 1.92 mm. Table 1 shows these parameters according to gender.

Table 1: Medial lingual foramen parameters according to gender

	Gender	Mean (mm)	SD	SE	β	P
H	Male	0.80	0.24	0.01	0.03	0.02*
	Female	0.73	0.21			
V	Male	0.84	0.25	0.03	0.07	0.02*
	Female	0.76	0.23			
D	Male	7.94	1.90	0.27	0.44	0.09
	Female	7.49	1.94			

* $P < 0.05$

SD: Standard deviation; SE: Standard error; H: Horizontal diameter; V: Vertical diameter; D: Distance from the inferior mandibular border

The mean horizontal and vertical diameters of the MLF were significantly higher in males. The mean distance from the MLF to the lower border of the mandible was slightly greater in males, but not significantly.

Lateral lingual foramen:

The LLF was detected on 23 of the 200 CBCT scans (11.5%). Of all, 12 patients had one LLF and 11 had two. A total of 34 LLFs were observed; 15 were detected in females and 19 in males. In other words, the LLF was 1.36 times more common in males than in females. The majority of the LLFs were found in the second premolar region (55.8%). The highest prevalence of LLF was observed in the second premolar region in males with 11 cases (32.3%), and the lowest prevalence was detected in the second molar region in 0% of males (Table 2). Furthermore, the LLF was most prevalent on the right side of the mandible in males. The prevalence of LLF by the gender and jaw side is shown in Table 3.

Table 2: Frequency of lateral lingual foramen according to the location and gender

Gender	Location N(%)					Total (100%)
	Canine	First premolar	Second premolar	First molar	Second molar	
M	2(10.5)	4 (21)	11(57.9)	2(10.5)	0	19
F	2(13.3)	3 (20)	8(53.3)	1 (6.7)	1(6.7)	15
Total	4(11.7)	7(20.5)	19(55.8)	3 (8.8)	1(2.9)	34

Table 3: Frequency of lateral lingual foramen by jaw side and gender

Gender	Jaw side N(%)		Total (100%)
	Right	Left	
Male	14(73.6)	5(26.4)	19
Female	8(53.3)	7(46.6)	15
Total	22(64.7)	12(35.2)	34

The mean distance from the LLF to the inferior border of the mandible was 8.6 ± 2.2 mm. It was slightly greater in females. But no significant difference was found between males and females in this respect ($P=0.09$).

DISCUSSION

Many researchers have studied the anatomical features of the LF in different populations. In the present study, we investigated them in a selected Iranian population. Considering the reports regarding critical bleeding at the floor of the mouth during dental surgeries, knowledge about the anatomy of the anterior region of the mandible seems essential to prevent intraoperative and postoperative complications. In the present study, at least one LF was detected on all 200 CBCT scans, which was in agreement with the results of Babiuc et al, [8] Sheikhi et al, [9] Tagaya et al, [10] and Tepper et al, [11] who reported the presence of LF in 100% of their cases. However, our reported value was higher than that reported by Aoun et al, [12] (93.3%), Katakami et al, [2] (85%), Jacobs et al, [13] (82%) and Kim et al, [14] (58.8%). Differences in the results may be due to ethnic diversity and different sample sizes.

A single LF was the most common (75%) in this study, which was in accord with the findings of Tepper et al, [11] Babiuc et al, [8] Aoun et al, [12] and Liang et al, [15] but disagreed with the results of Choi et al, [16]

Kim et al, [14] and Sheikhi et al, [9] who reported that double foramina were the most frequent. He et al. [17] reported that most patients had three or four foramina. Moreover, they found a range of 0 to 8 foramina in each patient; while we detected up to three foramina in each individual.

Several studies reported variable frequencies for the LLF. We detected LLF in 23 out of 200 CBCT scans (11.5%). The prevalence of LLF was higher in males, which has not been reported in any previous study. Considering the results of other studies summarized in Table 4, we may conclude that Iranians have lower incidence of LLF. However, it is necessary to assess a larger group of people to achieve more reliable results. Another possible reason for variations in the incidence of LLF in the literature is the adopted method to classify an LF as an LLF.

Table 4: Review of studies about the frequency of lateral lingual foramen (LLF) in different populations

Author (year)	Population	Sample size	LLF N(%)
Xie et al. (2019) [19]	Chinese	1008	547(54.3)
Sanomiya Ikuta et al. (2016) [3]	Brazilian	100	39(39)
Sahman (2014) [18]	Turkish	500	124(24.8)
Tagaya et al. (2009) [10]	Japanese	200	160(80)

Some authors classified the LFs into midline and lateral types, and therefore, reported a higher incidence for the LLF [3,10,18,19]. However, we adopted the classification used by Sanomiya Ikuta et al, [3] and classified the LFs into MLFs and LLFs.

This discrepancy emphasizes the need for a standard definition for LLF to determine when we should consider an LF as an LLF.

The location of the LLF is more important than its number. In our study, the majority of LLFs were found in the second premolar region, which was in accordance with the findings of Sanomiya Ikuta et al [3]. Many studies also showed that LLF was mostly found in the premolar region [2,18,19]. However, a cadaveric study in India reported the canine region as the most common region for presence of LLF [20].

Regarding the foramen size, the majority of MLFs (81%) were smaller than 1mm. It should be mentioned that older patients with the diameter of foramen > 1mm are at higher risk of hemorrhage during surgical procedures in the anterior mandible [16]. The mean diameter of the MLF was larger in male patients based on our results. Some studies reported similar findings [17,19]. But Sheikhi et al, [9] and Von Arx et al. [21] did not find any significant correlation between the size of LF and gender/age. In the present study, the mean distance between the MLF and the inferior border of the mandible was 7.7mm. This value was slightly lower than that reported by Aoun et al, [12] and Babiuc et al, [8] who reported this distance to be 11.5 and 14mm, respectively. In their studies, the number of patients with two LFs was higher than that in our study; thus, they separately examined the superior and inferior LFs.

In fact, they reported the distance between the superior LF and the inferior border of the mandible. In our study, due to fewer number of cases with double MLFs, the mean distance was reported without classifying the foramina into the superior and inferior types. This is one possible reason for the difference in the results. Kawai et al, [22] also confirmed this statement as they reported that the distance between the inferior mandibular plane and the inferior LF was 4.42mm; while, the distance between the superior LF and the inferior mandibular plane was 11.4mm.

We found a mean distance of 8.6mm between the LLF and the inferior border of the mandible. This value was higher compared

with the value reported by Sanomiya Ikuta et al, [3] which was 5.8mm. This difference may be due to ethnic diversity. In the present study, the mean distance from the LF to the lower border of the mandible was not significantly different between males and females. but Sheikhi et al. [9] reported a greater distance between the LF and the inferior border of the mandible in males.

This study had some limitations. We investigated retrospective data and therefore, scanning parameters were not the same in all patients. This may affect the visualization of anatomical structures. In the present study, variations of the LF were evaluated. Further studies may focus on the location, course and direction of lingual canals.

CONCLUSION

There was a significant variability in the location and size of the mandibular LF in our study on the Iranian adults. The presence of LFs and canals in the mandible is frequently undervalued in clinical procedures. The anterior region of the mandible should not be considered as a safe zone for implant placement. Presurgical assessment of the LF and canal is imperative to prevent intra-operative and postoperative complications such as hemorrhage.

ACKNOWLEDGMENTS

We would like to thank our colleagues at the Oral and Maxillofacial Department of Shahid Beheshti University of Medical Sciences for their cooperation.

CONFLICT OF INTEREST STATEMENT

None declared.

REFERENCES

1. Gahleitner A, Hofschneider U, Tepper G, Pretterklieber M, Schick S, Zauza K, Watzek G. Lingual vascular canals of the mandible: evaluation with dental CT. *Radiology*. 2001 Jul;220(1):186-9
2. Katakami K, Mishima A, Kuribayashi A, Shimoda S, Hamada Y, Kobayashi K. Anatomical characteristics of the mandibular lingual foramina observed on limited cone-beam CT images. *Clin Oral Implants Res*. 2009 Apr;20(4):386-90.
3. Sanomiya Ikuta CR, Paes da Silva Ramos Fernandes LM, Poleti ML, Alvares Capelozza AL,

- Fischer Rubira-Bullen IR. Anatomical study of the posterior mandible: Lateral lingual foramina in cone beam computed tomography. *Implant Dent*. 2016 Apr;25(2):247-51.
4. Kalpidis CD, Konstantinidis AB. Critical hemorrhage in the floor of the mouth during implant placement in the first mandibular premolar position: a case report. *Implant Dent*. 2005 Jun;14(2):117-24.
 5. Krenkel C, Holzner K. Die linguale Knochenperforation als Kausalfaktor einer bedrohlichen Mundbodenblutung bei einem Einzelzahnimplantat der Eckzahnregion [Lingual bone perforation as causal factor in a threatening hemorrhage of the mouth floor due to a single tooth implant in the canine region]. *Quintessenz*. 1986 Jun;37(6):1003-8.
 6. Mardinger O, Manor Y, Mijiritsky E, Hirshberg A. Lingual perimandibular vessels associated with life-threatening bleeding: an anatomic study. *Int J Oral Maxillofac Implants*. 2007 Jan-Feb;22(1):127-31.
 7. de Oliveira-Santos C, Souza PH, de Azambuja Berti-Couto S, Stinkens L, Moyaert K, Rubira-Bullen IR, Jacobs R. Assessment of variations of the mandibular canal through cone beam computed tomography. *Clin Oral Investig*. 2012 Apr;16(2):387-93.
 8. Babiuc I, Tărlungeanu I, Păuna 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;52(3):827-9.
 9. 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. *Dent Res J (Isfahan)*. 2012 Dec;9(Suppl 1):S45-51.
 10. Tagaya A, Matsuda Y, Nakajima K, Seki K, Okano T. Assessment of the blood supply to the lingual surface of the mandible for reduction of bleeding during implant surgery. *Clin Oral Implants Res*. 2009 Apr;20(4):351-5.
 11. Tagaya A, Matsuda Y, Nakajima K, Seki K, Okano T. Assessment of the blood supply to the lingual surface of the mandible for reduction of bleeding during implant surgery. *Clin Oral Implants Res*. 2009 Apr;20(4):351-5.
 12. Aoun G, Nasseh I, Sokhn S, Rifai M. Lingual Foramina and Canals of the Mandible: Anatomic Variations in a Lebanese Population. *J Clin Imaging Sci*. 2017 Apr;7:16.
 13. Jacobs R, Mraiwa N, vanSteenberghe D, Gijbels F, Quirynen M. Appearance, location, course, and morphology of the mandibular incisive canal: an assessment on spiral CT scan. *Dentomaxillofac Radiol*. 2002 Sep;31(5):322-7.
 14. Kim DH, Kim MY, Kim CH. Distribution of the lingual foramina in mandibular cortical bone in Koreans. *J Korean Assoc Oral Maxillofac Surg*. 2013 Dec;39(6):263-8.
 15. Liang X, Jacobs R, Lambrechts I, Vandewalle G. Lingual foramina on the mandibular midline revisited: a macroanatomical study. *Clin Anat*. 2007 Apr;20(3):246-51.
 16. 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. *J Craniofac Surg*. 2013 Jul;24(4):1403-7.
 17. 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 Oct;66(5):272-9.
 18. Sahman H, Sekerci AE, Ertas ET. Lateral lingual vascular canals of the mandible: a CBCT study of 500 cases. *Surg Radiol Anat*. 2014 Nov;36(9):865-70.
 19. Xie L, Li T, Chen J, Yin D, Wang W, Xie Z. Cone-beam CT assessment of implant-related anatomy landmarks of the anterior mandible in a Chinese population. *Surg Radiol Anat*. 2019 Aug;41(8):927-34.
 20. Murlimanju BV, Prakash KG, Samiullah D, Prabhu LV, Pai MM, Vadgaonkar R, et al. Accessory neurovascular foramina on the lingual surface of mandible: incidence, topography, and clinical implications. *Indian J Dent Res*. 2012 May-Jun;23(3):433.
 21. von Arx T, Matter D, Buser D, Bornstein MM. Evaluation of location and dimensions of lingual foramina using limited cone-beam computed tomography. *J Oral Maxillofac Surg*. 2011 Nov;69(11):2777-85.
 22. Kawai T, Asaumi R, Sato I, Yoshida S, Yosue T. Classification of the lingual foramina and their bony canals in the median region of the mandible: cone beam computed tomography observations of dry Japanese mandibles. *Oral Radiol*. 2007 Dec;23(2):42-8.