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Lingual Foramina of the Mandible: Anatomic Variations in a Turkish Population

Lingual Foraminalar: Türk Popülasyonunda Anatomik Varyasyonlar

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ABSTRACT

Objective: Determination of the location, frequency, and number of a lingual foramen in the mandible in a Turkish population using cone beam computed tomography (CBCT).

Methods: From the CBCT images obtained from patients who applied to the Private Dentistomo Imaging Establishment for any reason between July 2020 and July 2021, 400 images that met the inclusion criteria were randomly selected. The medial lingual foramina (MLF), paramedian lingual foramina (PLF), and posterior lingual foramina (POLF) were analyzed using CS 3D Dental Imaging Software (NY Rochester, USA). Frequency, location, classification, distance to the alveolar crest, distance to the mandibula basis, and diameter values were analyzed.

Results: This study examined 400 subjects, 227 (56.75%) males and 173 (43.25%) females. A total of 1253 lingual foramen (544 MLF, 338 PLF, 371 POLF) were detected in the CBCT images of 400 patients. The minimum number of MLFs was 0, and the maximum number of MLFs was 5. MLFs were found in 84.5% of the analyzed images. In our study, PLFs were most common in the central incisors region with a rate of 45.9%, and POLFs were found in the second premolar region with a rate of 37.4%.

Conclusion: Together with this study, it has been shown that the prevalence of lingual foramina is high in the Turkish population. Therefore, caution should be exercised during implant treatment, especially in the mandibular interforaminal region.

Keywords: Lingual foramen, cone-beam computed tomography, implant, mandible

ÖZ

Amaç: Türk popülasyonunda konik ışınlı bilgisayarlı tomografi (KIBT) kullanılarak mandibuladaki lingual foramenin yeri, sıklığı ve sayısının belirlenmesi.

Yöntemler: Temmuz 2020 ile Temmuz 2021 tarihleri arasında herhangi bir nedenle Özel Dentistomo Görüntüleme Merkezi'ne başvuran hastalardan elde edilen KIBT görüntülerinden, dahil etme kriterlerini karşılayan 400 görüntü rastgele seçildi. Medial lingual foraminalar (MLF), paramedian lingual foraminalar (PLF) ve posterior lingual foraminalar (POLF), CS 3D Dental Görüntüleme Yazılımı (NY Rochester, ABD) kullanılarak analiz edildi. Frekans, yer, sınıflandırma, alveolar kret mesafesi, mandibula tabanı mesafesi ve çap değerleri analiz edildi.

Bulgular: Bu çalışmaya 227 (%56,75) erkek ve 173 (%43,25) kadın olmak üzere toplam 400 birey dahil edildi. 400 hastanın CBCT görüntülerinde toplam 1253 lingual foramen (544 MLF, 338 PLF, 371 POLF) tespit edildi. Minimum MLF sayısı 0, maksimum MLF sayısı ise 5 idi. İncelenen görüntülerin %84,5'inde MLF tespit edildi. Çalışmamızda PLF'ler %45,9 oranıyla en sık santral kesici dişler bölgesinde, POLF'ler ise %37,4 oranıyla ikinci premolar bölgesinde görüldü.

Sonuç: Bu çalışmayla birlikte, Türk toplumunda lingual foramen prevalansının yüksek olduğu gösterilmiştir. Bu nedenle, özellikle mandibular interforaminal bölgede implant tedavisi sırasında dikkatli olunmalıdır.

Anahtar Kelimeler: Lingual foramen, konik ışınlı bilgisayarlı tomografi, implant, mandibula

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INTRODUCTION

The interforaminal region of the mandible is a general elective area for different oral surgical procedures due to its sufficient anatomical conditions. Some of these procedures performed in this area include placement of dental implants, use as a donor site for bone grafts, genioplasty in orthognathic surgery, and insertion of screws during plating for the treatment of maxillofacial fractures. Unfortunately, nearly fatal cases of upper airway obstruction due to bleeding have been reported after implant placement in this region. Many of these have been dedicated to cutting the sublingual artery when the misguided drill punctures the lingual cortex and damages a blood vessel in the adjacent soft tissues.[1]

In a case report published by Niamtu in 2001, it was reported that he encountered heavy bleeding while applying the implant in the mandibular canine region, and although he delayed the implant application and took local hemostatic measures, a rare clinical picture leading to airway obstruction due to severe bleeding in the floor of the mouth within the following 2 minutes.[2] Kalpidis et al.[3] published a case report in 2005, it was reported that bleeding started in the submandibular region, and the floor of the mouth elevated within 5 minutes after the osteotomy was created with a pilot drill in an implant operation to be performed in the mandibular first premolar region.

Undoubtedly, bleeding is caused by damage to vessels. It is also established that the sublingual artery, a section of the lingual artery, is the major artery supplying the floor of the mouth. It has been presented that the submental artery also plays a significant role in the nutrition of the floor of the mouth. If the lingual cortex is punctured during implant placement, the sublingual artery may be lacerated and, although rare, may cause life-threatening hemorrhage. In addition to a laceration to the sublingual artery, rupture of the periosteum caused by removing the periosteal lambo can cause severe bleeding. Even if the mandibular lingual cortex is not punctured, the sublingual artery moving through the bone may be damaged, causing bleeding. It may spread to the tissues, which may elevate the tongue and cause obstruction of the upper airways. This may become a state of emergency necessitating endotracheal intubation or emergency tracheostomy. It has been reported that the probability of encountering suchlike bleeding is enhanced in patients who have been using anticoagulant medications for a long time.[4]

Numerous cadaver and tomography-based studies have been experimented on to understand the interforaminal region's anatomy and reach evidence-based results.

In many studies, foramina have been classified according to regions as follows:

• *Medial lingual foramina:* The foramina in the middle of the symphysis.

• *Paramedian lingual foramina:* The foramina among the central incisors' mesial and the canines' distals.

• *Posterior lingual foramina:* The foramina among the mesial of the first premolars and the distal of the third molars.[5]

Medial Lingual Foramina

It is the most common lingual foramina. There may be just one example, but it is more likely that there will be more. According to studies, the maximum number of lingual foramina in the midline is four. These foramina can be found above, below, or at the level of the genial tubercle. It is over the spina mentalis if there is just one medial lingual foramen.[5]

Paramedian Lingual Foramina

Especially in edentate individuals, this area has been and continues to be a popular choice for implant cavity preparation. Perforation of the lingual cortical bone in the canine region has been documented in several case reports as a cause of bleeding issues during implant cavity preparation.[5]

Posterior Lingual Foramina

Even though the molar region has the lowest radiographically foramina frequency, the lingual submandibular fossa should be avoided. Perforation of the lingual cortical bone has been recorded during implant cavity preparation in the posterior mandible, and 2-dimensional radiography (periapical or panoramic) does not allow an accurate assessment of the bony structure in this region.

Given this knowledge, clinical studies must consider potential dangers in the interforaminal region, which is frequently surgically treated without incident. However, CBCT is a very accessible and preferred option today to detect anatomical variations that may be encountered regardless of experience. However, it still needs to become the routine of office practice, especially in our country. This is why statistical results from the radiographic examination of a large population will be a valuable source of information for our colleagues.

This study aims to statistically examine the changes in the frequency, number, and width of lingual foramina in a whole mandibular bone between bilateral retromolar regions according to age and gender factors.

The study will be carried out on the Turkish population. It aims to have a preliminary idea about the procedures that oral, dental, and maxillofacial surgeons will do even when there is no chance of getting cone beam tomography.

METHODS

Ethical approval was obtained from the Ethics Committee of Gazi University (Date: September 21, 2021 – E-172288). Since our study is a retrospective observation study, consent was not obtained from the patients.

Study Design

Four hundred images selected from cone-beam computed tomography (CBCT) images taken from patients who had applied to a private imaging center for any reason were retrospectively examined by Dt. Bilgesu KURT, who was a resident in The Department of Oral and Maxillofacial Surgery with three years of experience under the supervision of a senior dentomaxillofacial radiology specialist.

HDX brand Dentri-Sα (Seul, South Korea) device was used in the CBCT scans to be examined. Irradiation parameters were determined as 80-90kVp and 7-10mA, and the imaging area was defined as 16x14.5-16x8 mm (Free FOV).

Images were analyzed on the computer screen in axial and cross-sectional planes with a section thickness of 0.2 mm, using CS 3D Dental Imaging Software (NY Rochester, USA).

Accordingly, the following inclusion and exclusion criteria have been determined. Among the randomly selected images, images taken from patients aged 18-75 years and in which the entire mandibular bone could be observed were included. Images of patients with pathology in any part of the mandibular bone, where the entire mandibular bone could not be observed, jaw fracture, images containing artifacts related to the patient or extraction technique, and patients with total edentulism were excluded from the study.

The region to be examined was determined as the area between the bilateral retromolar regions (if there is a wisdom tooth, the distal border of this tooth).

Parameters to be Examined

In the tomography images selected randomly following the criteria, the area between the bilateral retromolar regions (if there is a wisdom tooth, the distal border of this tooth) was examined. In the examination, the projectional distance of the apical border of the foramen to the base of the mandible, the distance of the coronal border of the foramen to the mandibular alveolar crest, the diameter at the widest part of the foramen, the number of canals and the adjacent tooth area parameters were evaluated.

Statistical Analyses

The data obtained in this study were analyzed with the licensed IBM SPSS 21 (IBM SPSS Corp., Armonk, NY, USA) package program. While investigating the normal distribution of the variables, Shapiro-Wilk's and Kolmogorov Smirnov Tests were used due to the number of units. The significance level was 0.05 while interpreting the results; In the case of $P<.05$, it was examined that the variables did not come from the normal distribution, and in the case of $P>.05$, the variables came from the normal distribution.

While examining the differences between the groups, the Mann-Whitney U test was used for two-group comparisons in case the variables did not come from a normal distribution. In addition, the Kruskal Wallis-H test was used for more than two groups. Finally, in case of significant differences in the Kruskal Wallis-H Test, the groups with differences were determined with the Post-Hoc Multiple Comparison Test.

Chi-Square analysis was applied when examining the relationships between groups of nominal variables

While interpreting the results, 0.05 was used as the significance level; it was stated that there was a significant difference in the case of $P<.05$, and there was no significant difference in the case of $P>.05$.

RESULTS

A total of 400 radiographs, 227 of which were taken from men and 173 of them taken from women, were included in the study. 56.75% of the radiographs in the study were taken from men, and 43.25% were taken from women.

The minimum age of 400 patients examined was 18, the maximum age was 75, and the mean age was 44.06. 40% of the participants were under 40 years old, 43.25% were between 41 and 60, and 16.75% were over 60(Table 1).

Table 1. Frequency Distribution Table of Demographic Information

		n	%
Gender	**Men**	227	56.75
	Women	173	43.25
	Total	400	100
Age	**40 years and under**	160	40
	41-60 years old	173	43.25
	Over 60 years	67	16.75
	Total	400	100

A total of 1253 lingual foramen were detected in 400 CBCT images examined. Of these, 43.42% are MLF, 26.98% are PLF, and 29.61% are POLF (Table 2).

Table 2. Frequency Table of Foramina Groups

	n	%
MLF	544	43.42
PLF	338	26.98
POLF	371	29.61
Total	1253	100

A statistically significant difference exists between the foramina groups regarding distance to the basis ($P<0.05$). The distance to the basis of the POLF groups is significantly lower than those with PLF and MLF. There is a statistically significant difference between the foramina groups regarding the distance to the alveolar crest ($P<0.05$). The distance to the alveolar crest of those with MLF compared to those with PLF and POLF; the distance to the alveolar crest of those with PLF is significantly lower than those with POLF. There is a statistically significant difference between the foramina groups regarding diameter values ($P<.05$). The diameter values of those with MLF and PLF are significantly lower than those with POLF (Table 3).

Statistically significant differences were found only in terms of distances to the base and distances to the crest between genders. In females, the values for distance to the base and distance to the crest are significantly lower compared to those in males ($P<.05$) (Table 4).

Table 3. Analysis Results Regarding the Difference Between Foramina Groups in Terms of Distance and Diameter Values

		Foramina group						Kruskal Wallis H Test		
		n	Mean	Median	Min	Max	Sd	Mean Rank	H	*P*
Distance To basis (Mm)	**MLF**	544	9.38	10.6	0.8	26.7	4.64	698,31	81,397	**.001**
	PLF	338	9.12	9.6	0.8	25.8	4.89	666,78		
	POLF	371	6.74	6	0	26.7	2.78	486,19		
	Total	1253	8.53	7.8	0	26.7	4.41	POLF-PLF POLF-MLF		
Distance to alveolar crest (Mm)	**MLF**	544	19.9	19.25	5.3	36.3	5.78	567,34	35,209	**.001**
	PLF	338	20.83	20.5	3.1	33.7	5.75	629,88		
	POLF	371	21.72	22.2	5.7	30.8	4.16	711,85		
	Total	1253	20.69	20.8	3,1	36.3	5.39	MLF-PLF MLF-POLF PLF-POLF		
Diameter	**MLF**	544	0.81	0.7	0,3	2.6	0.3	600,92	31,262	**.001**
	PLF	338	0.79	0.7	0,3	2	0.29	574,73		
	POLF	371	0.86	0.8	0,4	1.8	0.24	712,86		
	Total	1253	0.82	0.8	0,3	2.6	0.28	MLF-POLF PLF-POLF		

Table 4. Analysis Results Regarding the Difference Between Genders in Terms of Distance and Diameter Values Without Extraction Discrimination

			Gender						Mann Whitney U Test		
			n	Mean	Median	Min	Max	Sd	Mean Rank	z	*P*
Total	**Distance to basis (Mm)**	**Male**	711	8.79	8	0.8	26.7	4.6	648.31	2.387	**.017**
		Female	542	8.19	7.45	0	25.8	4.12	599.05		
		Total	1253	8.53	7.8	0	26.7	4.41			
	Distance to alveolar crest (Mm)	**Male**	711	21.51	21.7	5.3	36.3	5.59	680.45	5.988	**.001**
		Female	542	19.62	19.8	3.1	33.2	4.93	556.89		
		Total	1253	20.69	20.8	3.1	36.3	5.39			
	Diameter	**Male**	711	0.82	0.8	0.3	2.6	0.31	623.17	0.433	**.665**
		Female	542	0.81	0.8	0.3	1.7	0.25	632.03		
		Total	1253	0.82	0.8	0.3	2.6	0.28			

DISCUSSION

Damage to the mandibular lingual cortex is the most common condition associated with hemorrhagic accidents during dental implant placement. Accordingly, CBCT examinations play an essential role before surgical interventions in the mandibular interforaminal region, especially in the mandibular anterior region, considering its rich vascular structure will help minimize possible complications.[6] Damage to the mandibular lingual cortex is most commonly associated with hemorrhagic accidents during dental implant placement.[7]

CBCT is considered the gold standard for imaging the lingual foramen, with studies showing that CBCT is effective in visualizing the lingual foramen, ranging from 80% to 100%.[8-11]

Various cadaveric and tomography-based studies have been carried out in the literature, including many different parameters, to create knowledge about the frequency and location of the lingual foramen.[1,6,12-14]

In the study performed by Katakami et al.[15], in which CBCT images of 181 patients were examined, a total of 154 lingual foramen were found, in the study conducted by He et al.[16], in which CBCT images of 200 patients were examined, a total of 683 lingual foramen, in the survey conducted by Liang et al.[17], in which CT images of 555 patients were analyzed, a total of 132 MLF, in the study conducted by Sheikhi et al.[18],in which CBCT images of 102 patients were examined, a total of 205 MLF, Von Arx et al.[5] In the study, which examined the CBCT images of 179 patients, a total of 217 lingual foramen, 86 of which were MLF and 131 LLF, were discussed, in a study by Gahleitner et al.[19], in which CT images of 32 patients were examined, a total of 65 lingual foramen, Kilic et al.[20] A total of 395 lingual foramen, 236 MLF and 159 LLF, in the study in which CT images of 200 patients were examined, in a survey by Şekerci et al.[13] in which CBCT images of 500 patients were examined, 476 MLF, in a study by Şahman et al.[21] in which CBCT images of 500 patients were examined, 163 LLF, in the study of Trost et al.[12],in which CBCT images of 460 patients were analyzed, a total of 844 lingual foramen were detected, of which 613 were MLF and 231 LLF.

Our study examined CBCT images of 400 patients, and 1253 lingual foramen was detected, including 544 MLF; 709 LLF (338 PLF + 371 POLF).

In cadaver-based studies in the literature, 84%-99% of individuals have been reported to have MLF.[22] When we look at the tomography-based studies, Shekhi et al.[18] had at least 1 MLF in every patient they examined, Liang et al.[17] had at least 1 MLF in 80% of the images they examined, Wang et al.[23] had at least one MLF. In addition, at least 1 MLF was found in 97% of them, Tepper et al.[24] reported that they encountered MLF in all 70 CBCT images they examined, and Babiuc et al.[25] found MLF in all 36 CBCT images they examined.

In studies conducted in the literature, it has been reported that the maximum number of MLFs in an individual is 4.[17-21,23] In our study, the minimum MLF number was 0, and the maximum MLF number was 5, which is consistent with this information, and MLF was found in 84.5% of the images examined.

The distance of MLFs to the base of the mandible is one of the parameters measured in studies in the literature, as in our study. For example, Gahleitner et al.[19] examined 53 dental CT images and found 10.2±5.5 mm, Von Arx et al.[5] looked at CBCT images; this value was 9.99 mm, Vandewalle et al.[26] evaluated 380 dry mandibles as 10 mm, Wang et al.[23] 10.2±5.24 mm, Şekerci et al.[13] In their study in which they evaluated CBCT images, Katakami et al.[15] found a lower value of 9.34 mm compared to other studies in the literature and reported it as 7.06±1.15 mm.

In our study, the mean distance of MLFs to the base of the mandible was 9.38 mm, which supports the literature.

When the distances of the MLFs to the alveolar crest are examined, it is seen that it is 18.33±5.45 mm in the study by Yıldırım et al.[6], 20.64±5.32 mm in the study by He et al.[16], and 14.2 mm in the study by Babiuc et al.[25], Aoun et al.[27] found an average of 16.24 mm in a survey of a 90-person Lebanese population, and 15.5±6.42 mm in a study by Silvestri et al.[28] in which CBCT images of 100 edentulous patients were evaluated. 57), it was reported as 15.49 mm.

Our study's mean distance from the alveolar crest was 19.25 mm.

Considering the data on PLFs, in many studies, PLF and POLF were evaluated together and named lateral lingual foramen.[6,16,19,23] One of the researchers who evaluated PLFs separately, Şekerci et al.[13] mm, a mean of 24.01 mm for the distance to the crest; Von Arx et al.[5] reported a mean value of 11.54±8.19 mm for the distance to the base, and they did not measure the distance to the alveolar crest.

In our study, the mean distance of the PLF to the basis was 9.12 mm, and the mean distance to the alveolar crest was 20.83 mm.

One of the researchers who evaluated POLFs separately, Şekerci et al.[13], reported an average value of 6.83 mm for the distance to the base, 20.7 mm for the distance to the alveolar crest, and Von Arx et al.[5] reported an average value of 7.07 mm for the distance to the alveolar crest. However, they did not measure the distance to the alveolar crest.

In our study, the mean distance of POLFs to the base was 6.74 mm, and the mean distance to the alveolar crest was 21.72 mm. The values found support the literature.

Tooth adjacency of PLF and POLF is another parameter evaluated in the literature. In the study by Von Arx et al.[5], the highest rate was in the canine region, with a rate of 37.2% for PLFs. The survey conducted by Xie et al.[29] reported that they detected the most PLFs in the canines region with a rate of 38.3% and 43.9.

In our study, unlike the literature, PLFs were mainly found in the central incisor region, with a rate of 45.9%.

In the study by Von Arx et al.[5], POLFs were mainly in the first premolar region with a rate of 27.5%; in the survey by Katakami et al.[15], they were primarily in the second premolar region with a rate of 39.7% in POLFs, In the study by Ikuta et al.[30], POLFs were mainly in the second premolar region with a rate of 26.9%, and in the study by Şekerci et al.[13] POLFs were primarily in the first premolar region with a rate of 28.7%, In the survey conducted by Xie et al.[29], they reported that POLFs were detected mainly in the second premolar region with a rate of 31.9%, in the study by Wang et al.[23] they saw POLFs in the first and second premolar region with a rate of 41.6%.

In our study, POLFs were found in the second premolar region with a rate of 37.4% and in the first premolar region with a rate of 16.38%, and the results are consistent with the literature.

Their study by Lustig et al.[31] revealed that the mean diameter of the lingual foramen is also an important parameter. In their ultrasound/Doppler measurement-based study with 20 patients, they reported that the mean size of the artery was 1.41±0.34 mm and the blood flow was 2.92±3.19 mL/min; They concluded that the artery was large enough to cause bleeding in procedures involving implant placement and symphysis. Yıldırım et al.[6] mean 0.92±0.44 mm for MLFs, 0.84±0.34 mm for LLFs; Gültekin et al.[32] mean 0.8±0.2 mm for MLFs, 0.6±0.1 mm for LLFs, Kılıç et al.[20] mean 1.05 mm for MLFs, 0.92 mm for LLFs, Gahleitner et al.[19] reported a mean value of 0.7±0.3 mm for MLFs and 0.6±0.3 mm for LLFs.

Our study found mean diameter values of 0.81 mm for MLFs, 0.79 mm for PLFs, and 0.86 mm for POLFs. There is a statistically significant difference between age groups regarding diameter values (P<0.05). Diameter values of those aged 40 years and younger are significantly lower than those aged 41-60.

CONCLUSION

When the case reports of significant bleeding complications related to implant operations performed in the interforaminal region are evaluated in the literature, it is noted that life-threatening hematomas accompany ≥15 mm implant placement, but it is recommended to use <15 mm implants in the mandible, especially in the intercanine region.[33-35]

As seen in our study, the crest distances of the lingual foramen can be pretty varied. The importance of CBCT images in diagnosis and treatment planning has emerged again in surgical interventions, especially implant operations in the interforaminal region of the mandible.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Gazi University (Date: September 21, 2021, Number: E.172288).

Informed Consent: Since our study is a retrospective observation study, consent was not obtained from the patients.

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