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Examination of Mandibular Lingual Foramen Variations with Cone Beam Computed Tomography: A Pilot Study

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ABSTRACT

Aim: The aim of this study was to determine the number, location, dimensions, and distance from the lower edge of the mandible and the crest of the medial and lateral lingual foramen (MLF-LLF) in cone beam computed tomography (CBCT) images and to evaluate the relationships with age and gender.
Material and Methods: The locations of MLF and LLF were identified in cross CT sections and their numbers, the dimensions of the foramen, the distances were recorded, and relationships with age and gender were evaluated.
Results: The study included 93 patients (mean age 39.85±13.28 years), with 48 male and 45 female participants. One MLF was found in 48 patients, 2 in 33 patients, 3 in 5 patients, and no MLF in 7 patients. 1 LLF was detected in 32 patients, and 2 LLF in 5 patients. No foramen was found in 5 patients. The MLF dimensions and the distance of the MLF to the lower edge of the mandible in men were found to be significantly higher than women. It was determined that as age increases, the distance of MLFs from the lower edge of the mandible increases. MLFs were mostly located above the genial tubercle. A total of 16 LLFs were identified in the anterior region outside the midline, 20 LLFs in the premolar region, and 6 in the molar region.
Conclusion: This study revealed that LFs were predominantly located in the midline and in the inter-foraminal area. A detailed radiological examination of these areas must be performed before the operations.

Mandibular Lingual Foramen Varyasyonlarının Konik Işınlı Bilgisayarlı Tomografi ile İncelenmesi: Pilot Çalışma

Makale Bilgisi

Makale Geçmişi

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Anahtar Kelimeler:
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Lingual foramen,
Mandibula.

ÖZET

Amaç: Bu çalışmada, konik ışınlı bilgisayarlı tomografi (KIBT) görüntülerinden medial ve lateral lingual foramenlerin (MLF-LLF) sayısı, yerleşimi, boyutları, mandibula alt kenarı ve kret tepesine olan uzaklıklarının belirlenmesi ve bu verilerin yaş ve cinsiyetle olan ilişkilerinin değerlendirilmesi amaçlanmıştır
Gereç ve Yöntemler: Tomografi kesitlerinde MLF ve LLF lokasyonları belirlenmiş ve sayıları kaydedilmiştir. Foramenlerin boyutları, mandibula alt kenarı ve alveol kret tepesine olan mesafeleri ölçülmüş ve yaş ve cinsiyetle olan ilişkileri değerlendirilmiştir.
Bulgular: Çalışmaya dahil edilen 93 hastanın 48'i erkek, 45'i kadındır ve hastaların yaş ortalaması 39.85±13,28'dir. 48 hastada 1 tane MLF, 33 hastada 2 tane, 5 hastada ise 3 tane bulunurken sadece 7 hastada MLF bulunamamıştır. 32 hastada 1 tane LLF, 5 hastada ise 2 adet LLF tespit edilmiştir. 5 hastada ise foramen bulunamamıştır. Erkeklerin MLF boyutları ve MLF'lerinin mandibula alt kenarına uzaklıkları, kadınlara göre anlamlı düzeyde daha yüksek bulunmuştur. Yaş arttıkça MLF'lerin mandibula alt kenarı ile olan mesafesinin arttığı belirlenmiştir. MLF'lerin çoğunlukla genial tüberkül üstünde yer aldıkları belirlenmiştir. LLF'lerin 16 tanesinin orta hat harici anterior bölgede, 20 tanesinin premolarlar sahasında, 6 tanesinin de molar bölgede olduğu belirlenmiştir.
Sonuç: Bu çalışmanın sonucunda; LF'lerin çoğunlukla orta hatta ve mental foramenler arası sahada olduğu görülmüştür. Cerrahi operasyon öncesi bu sahaların radyolojik muayenesinin detaylı bir şekilde yapılması gerekmektedir.

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INTRODUCTION

Before surgical operations on the mandible, it is essential to precisely determine the location of the anterior extension of the inferior alveolar canal (IAC), the presence of lingual concavity, and the location of crucial anatomical structures such as the lingual canal, foramina and accessory mandibular canals.[1]

Many surgical procedures are performed in the mandible and inter-foraminal region, such as placing dental implants, orthognathic surgery, and obtaining autogenous grafts, and this area is considered as relatively 'safe and simple' area by surgeons. However, this region contains critical anatomical structures such as sublingual, submental, and incisive arteries and the anastomoses formed by these arteries. Perforation of the lingual cortex during the operation and bleeding that may occur due to damage to these structures may lead to life-threatening complications that may cause airway obstruction.[2,3]

Arterial branches arising from these anastomoses penetrate the mandible through the lingual foramen (LF) to provide nutrition to the mandible.[4] Lingual foramina associated with intrabony canals are divided into two: medial and lateral lingual foramina. Medial lingual foramen (MLF) is located in the midline and almost everyone has at least one.[2,4,5] The lateral lingual foramen (LLF) can be seen through the mandible, particularly between the midline and premolar teeth.[2,4]

When any surgical operation is planned in the mandibula anterior region, the anatomical locations of the lingual canal and foramen must be determined precisely and in detail.[2,3] Conventional periapical and panoramic radiographs are insufficient to determine this anatomical structure before the operation.[2-4] Cone beam computed tomography (CBCT) images enable a three-dimensional examination of the hard tissues in the operation area before surgery and the location of anatomical structures in detail. Bone canals on the lingual surface of the mandible are visible in cross-sections of CBCT images and these images are very useful to reduce the possibility of complications.[2,3]

In this study, it was aimed to determine the number, location, dimensions, and distances to the lower edge of the mandible and the crest of the medial and lateral lingual foramen on CBCT images of a specific population and to evaluate the relationships of the obtained data with age and gender.

MATERIAL AND METHOD

In this retrospective study, the images of 120 patients who had lower jaw CBCT scans performed for various reasons (such as the presence of impacted teeth, cysts or tumors, implant planning, pre-surgical planning, temporomandibular joint diseases, malocclusion) at Istanbul Okan University Faculty of Dentistry Hospital between 2022 and 2023 were examined. The research was approved by the Istanbul Okan University Ethics Committee decision numbered 168-19.

In the Power analysis performed with G*Power (Heinrich Heine University Düsseldorf) software, based on similar studies,[2-4] it was calculated that working with 90 samples is appropriate. The mandibular tomography images with no image artifacts due to patient position or movement, the absence of a foreign object, and standard exposure parameters (96 kV, 5.6 mA, 12 s, 200 mm voxel size, 13x9 mm or 13x5.5 mm imaging areas) were included in the study. Tomography images with diseases such as fibrous dysplasia, medication related osteonecrosis of the jaw (MRONJ), and multiple myeloma that cause changes in bone density, insufficient diagnostic quality, exposure parameters outside the specified standard values, missing teeth in the premolar area, and images of patients under 18 years of

age were excluded from the study. As a result of the preliminary investigation, 10 images were excluded because of edentulousness, 9 images were excluded because of pathology in the relevant region, 8 images were excluded because of artifacts, and images of 93 patients were included in the study.

Images were examined in Romexis dental imaging software (Planmeca, Helsinki, Finland) by two observers (an oral and maxillofacial surgeon, and a dentomaxillofacial radiologist both with over 10 years of experience) with different clinical and radiological experiences. Both observers completed the assessments separately; 20 tomography images were chosen at random to determine intra-observer agreement; and two weeks after the first measurements were finished, both observers repeated the assessments. Cross-sectional tomography images were used to identify the MLF and LLF locations, and their numbers were noted. The measurements include the foramen dimensions as well as their distances from the alveolar crest superior surface and the mandible inferior border (Figures 1, 2, and 3). MLFs were named MLF1, MLF2, and MLF3 according to the order of their detection starting from the crest, and LLFs were named LLF1, and LLF2 according to the order of their detection from the midline to the distal.

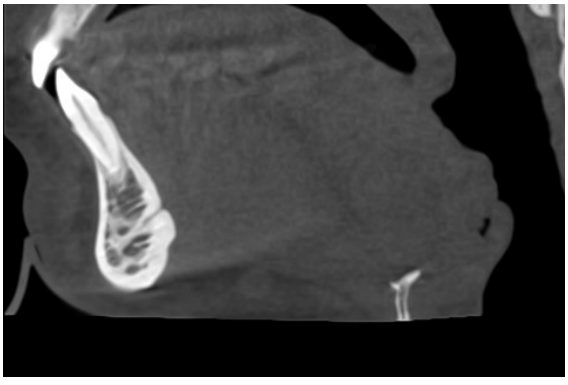

Figure 1: MLF is positioned on the genial tubercle in the midline of the lower jaw.

(MLF: Medial Lingual Foramen)

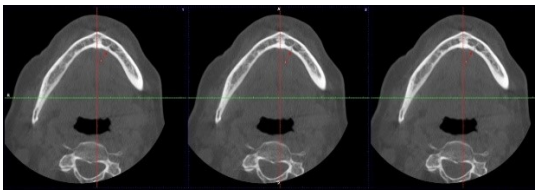

Figure 2: LLF observed in CBCT images is shown with a red arrow in consecutive axial sections.

(LLF: Lateral Lingual Foramen, CBCT: cone-beam computed tomography)

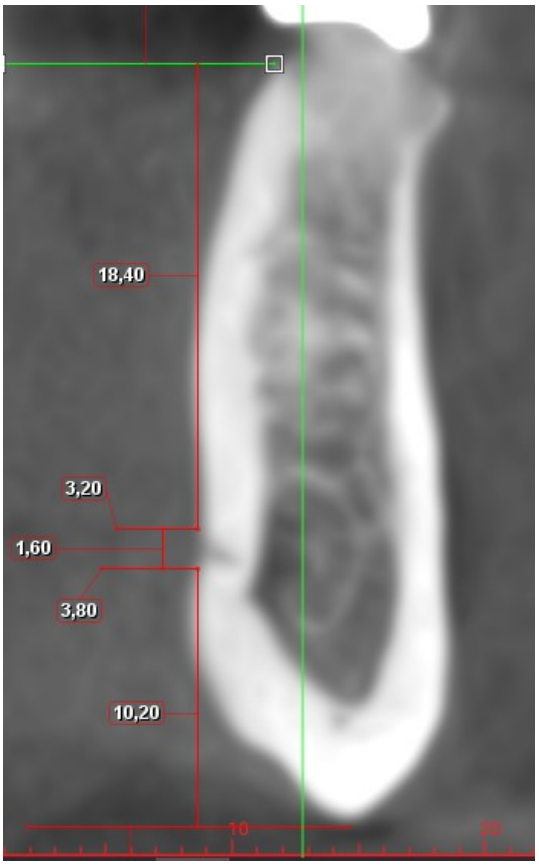

Figure 3: Measurement of the size and distance of the foramen from the top of the alveolar crest and the inferior cortex.

Statistical analysis:

Intra-observer and inter-observer agreements were measured by Cohen's Kappa coefficient. Categorical data are expressed with frequency and percentage rate; whereas numerical data are expressed as mean ± SD. The relationship between independent variables was analyzed with Spearman's rho correlation test and Mann Whitney U test. SPSS 21.0 (SPSS, Chicago, IL, USA) program was used in data analysis. Type I error level was accepted as 0.05.

RESULTS

The mean age of the 93 individuals who were included in the study was determined as 39.85±13.28, with 48 of them male and 45 female.

Detailed information about the number and location of the foramina is given in Table 1. One MLF was found in 48 patients, 2 in 33 patients, and 3 in 5 patients, only 7 patients had no foramen. One LLF was detected in 32 patients, and 2 LLFs were detected in 5 patients. In 5 patients, neither LLF nor MLF was found.

Table 1: Foramen frequencies and locations

	n	%
Medial Lingual Foramen		
One	48	51.61
Two	33	35.48
Three	5	5.37
None	7	7.52
Location		
Under the genial tubercle	54	41.86
Above the genial tubercle	75	58.13
Lateral Lingual Foramen		
One	32	34.4
Two	5	5.37
None	56	60.21
Location		
Anterior	16	38.09
Premolar	20	47.61
Molar	6	14.28

Table 2 shows the comparison of MLF and LLF numbers by gender, the MLF and LLF numbers did not differ significantly by gender ($p>0.05$). Additionally, it was determined that there was no significant relationship ($p>0.05$) between MLF and LLF numbers and age (Table 3).

Table 2: Comparison of MLF and LLF Frequencies by Gender

Parameter	Gender	Med (SS)	Z	p
MLF	Female Male	1.39 (0.66) 1.58 (0.66)	-1.17	0.240
LLF	Female Maler	1.28 (0.49) 1.00 (0.00)	-1.25	0,210

Test: Mann Whitney U, $p<0.05$
(MLF: Medial Lingual Foramen, LLF: Lateral Lingual Foramen)

Table 3: Relationship Between MLF and LLF and Age

	Age	
Parameter	**r**	**p**
MLF	-0.002	0.882
LLF	0.195	0.544

Test: Spearman's rho correlation test, $p<0.05$
(MLF: Medial Lingual Foramen, LLF: Lateral Lingual Foramen)

In the gender comparison of MLFs' size and the distances from the alveolar crest and the inferior border of mandible, it was determined that MLF1 dimensions and distances from the inferior border of the mandible were significantly different between genders. MLF1 dimensions and distances of MLF1 from the inferior border of the mandible in men are significantly higher than in women (Table 4).

Table 4: Comparison of MLF Parameters by Gender

Parameter	Gender	n	Med (SS)	Z	p
MLF1 Size	Female Male	42 45	1.53 (0.54) 1.82 (0.51)	-2.65	**0.008**
MLF1 Cret	Female Male	42 45	13.93 (3.57) 16.05 (5.93)	-1.61	0.108
MLF1 Inf	Female Male	42 45	12.22 (4.00) 13.21 (5.25)	-2.13	**0.033**
MLF2 B Size	Female Male	16 22	1.50 (0.45) 1.49 (0.56)	-0.36	0.720
MLF2 Cret	Female Male	16 22	23.56 (4.19) 24.12 (5.45)	-0.44	0.657
MLF2 Inf	Female Male	16 22	3.38 (2.50) 5.15 (3.19)	-1.88	0.060
MLF3 Size	Female Male	1 4	1.00 (.) 1.56 (0.40)	-1.41	0.157
MLF3 Cret	Female Male	1 4	26.00 (.) 20.90 (4.20)	-1.41	0.157
MLF3 Inf	Female Male	1 4	1.40 (.) 4.65 (4.65)	-1.45	0.147

Test: Mann Whitney U, $p<0.05$

Size: The distance at which the foramen is widest in the mesiodistal direction, Crest: The distance between top the alveolar crest and the foramen, Inf: The distance between the foramen and the inferior border of the mandible, MLF: Medial Lingual Foramen

Table 5 shows the results of the relationship between MLF parameters and age. Accordingly, it was determined that there was a positive and significant relationship between the distance of MLF1s from the inferior border of the mandible and age. It was revealed that as age increases, the distance of MLF1s to the lower edge of the mandible increases.

Table 5: Relationship Between MLF Parameters and Age

	Age	
Parameter	**r**	**p**
MLF1 Size	-0.118	0.170
MLF1 Cret	-0.030	0.784
MLF1 Inf	0.261	**0.015**
MLF2 Size	-0.132	0.428
MLF2 Cret	0.265	0.108
MLF2 Inf	-0.129	0.439
MLF3 Size	0.300	0.624
MLF3 Cret	0.200	0.747
MLF3 Inf	-0.718	0.172

Test: Spearman's rho correlation test, $p<0.05$

Size: The distance at which the foramen is widest in the mesiodistal direction, Crest: The distance between top of the alveolar crest and the foramen, Inf: The distance between the foramen and the inferior border of the mandible, MLF: Medial Lingual Foramen.

There was no statistically significant difference ($p>0.05$) when examining the association between gender and position of MLFs above or below the genial tubercle.

LLF was seen in a total of 37 patients. While 1 LLF was observed in 32 patients, 2 LLFs were detected in 5 patients. It was determined that 16 (38.1%) of the LLFs were in the anterior region outside the midline, 20 (47.6%) were in the premolar region, and 6 (14.2%) were in the molar region.

The relationship between LLF locations, age and gender were examined, and no statistically significant difference was found ($p>0.05$).

The dimensions of the LLFs and their distance from the alveolar crest and the inferior border of the mandible were examined according to age and gender, and no statistically significant difference was found ($p>0.05$).

DISCUSSION

Each location within the maxillofacial area has unique anatomical and dental characteristics. As a result, an extensive radiological examination of the relevant region needs to be performed prior to dental implant treatment or any surgical operations. The jaws have many unnamed accessory foramina. Lingual foramina are usually observed in the midline and the area between the premolars, where nerves and vessels exit, especially on the lingual side of the lower jaw.[6] The presence of LFs is crucial for bleeding because it increases the risk of lingual cortex perforation during implant placement, especially in ridges with thin bucco-lingual direction.[5] Perforation of the lingual cortex during surgery in the inter-foraminal area can cause excessive bleeding and life-threatening complications due to lingual artery damage. In the literature, there are some case reports [7-9] that present this complication. To control these complications, patients were urgently hospitalized, intubated, and operated to remove the hematoma. The objective of this study was to reduce the risk of clinicians experiencing this kind of complication by providing information about the positions and dimensions of LLFs and MLFs.

It is very difficult to identify LFs using conventional radiographic methods.[10] CBCT provides detailed three-dimensional imaging of the structures in the jaw at high resolution.[6] In this study, determining the number, location, and size of LFs, and evaluating the relationship of these data with age and gender to give clinicians an idea in pre-operative evaluations is aimed by examining CBCT images.

Classification of LFs varies according to studies. In some studies,[2,3,11-14] the LFs located in the midline were referred to as medial lingual foramen, those outside the midline as lateral lingual foramen, and in the other studies, [1,5,15,16] the foramina located in the entire mandible lingual were referred to as LF and examined. While in some studies, [11,15] only the LFs in the inter-foraminal area were examined, in others,[1-3,5,12-14,16] the LFs in the entire mandible were examined. In this study, the LFs located in the midline were referred to as MLF, while the LFs located outside the midline were referred to as LLF, and the entire mandible was examined. Complications may increase if the radiographic examination fails to evaluate the entire jaw, and the relatively "safe and simple"

inter-foraminal area is not examined precisely.

Absence of LF in the mandible is extremely rare.[13] Sekerci et al. [1], Demiralp et al. [17] and Taschieri et al. [13] stated that there were very few patients without LF in their study, and in this study, LF could not be detected in only 5 patients, supporting previous studies.

Studies indicated that approximately 3–3.8% of individuals showed absence of the lingual foramen in the midline. Kuzu et al. [18] examined MLF in 136 patients and found that each individual had at least one MLF.[3,14] In this study, MLF was not found in 7.52% (7 patients), and it was thought that this may be related to the population that included in the study. Studies [3,13,14,19] examining the number of MLFs reported that the highest rate was two foramina in the midline; however, in this study, one MLF was observed in 51.6% of cases, and a maximum of three foramina were detected in a patient. According to researches [1,6,13,19] analyzing whether MLFs are placed below or above the genial tubercle, MLFs are generally positioned above the genial tubercle, supporting this study. These findings point out that caution should be taken when lifting the flap in the midline, beginning at the top of the ridge.

When comparing MLF sizes and locations with age and gender, it was observed that MLF sizes and, the distance of MLFs to the inferior edge of the mandible were greater in men, and the MLF size increased with age. These findings are consistent with previous studies.[3,4,11] This demonstrates the need for caution when operating on the mandible of elderly and male patients.

In this study, LFs located outside the midline were named LLF, and the entire lower jaw was examined. The presence of LLF was mostly observed in the premolar region, followed by the anterior region, excluding the midline. The results of studies investigating LLFs[2-5,12,16] also support these findings. These findings indicate the need for extra care while operating in the inter-foraminal region. Also, it was determined that the prevalence of LLF was not influenced by gender or age.

Studies examining the dimensions of the LLFs and their distances from the crest and inferior edge of the mandible have shown that LLF dimensions are greater in males, while the distance between LLFs and the inferior edge and crest of the mandible is shorter in females.[2-4,20] In this study, no statistically significant difference was found in terms of these parameters, and it was thought that this may be due to the population included in the study.

The present study has certain limitations, and there is room for improvement in future research directions. The sample size comprised a specific number of patients from a single center sharing similar geographic characteristics within a specific timeframe. Future studies investigating the variations of LF in diverse and larger populations will enhance our comprehension of these variations and potentially mitigate associated complications.

CONCLUSION

As a result of this study, it was observed that the lingual foramen was mostly located in the midline and in the inter-foraminal area. In order to avoid serious complications in this area, which is considered as relatively 'safe area' for surgical operations, a detailed radiological examination must be performed before the operation.

Ethical Approval

The research was approved by the Istanbul Okan University Ethics Committee decision numbered 168-19.

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: MÇ, CB. Data collection or data entry: MÇ, CB. Analysis and interpretation: MÇ, CB. Literature search: MÇ. Writing: MÇ, CB.

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