ORIGINAL PAPER

ANATOMICAL VARIATIONS OF MANDIBULAR LINGUAL FORAMEN AND ITS BONY CANALS IN TURKISH CYPRIOT POPULATION: A CONE-BEAM COMPUTED TOMOGRAPHY STUDY

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ABSTRACT

Introduction: It is important to determine anatomical structures to prevent complications, which may occur in surgical interventions, e.g., implantation, in the midline region of the mandible, obtaining a graft from this region, genioplasty procedure, and post-traumatic fixation.

Objectives: The current study aimed to investigate mandibular lingual foramen (LF) anatomical variations and their associated vascular canals using cone-beam computed tomography (CBCT).

Material and methods: CBCT images from 329 patients (mean age, 43.31 years) were examined. These images, with a 512 × 512 matrix, were processed using InVivo version 5.1.2 software (Anatomage; San Jose, CA, USA). Anatomical classification was performed based on LF location and quantity, with a separate classification of LFs in the mandibular midline region.

Results: Among the analyzed images, 99.4% (n = 327) displayed LF. In majority, single LF was observed in 54.4% (n = 179), two LFs were seen in 29.5% (n = 97), three LFs in 13.1% (n = 43), and four LFs were noted in 2.1% (n = 7) of patients. The most common type was midline LF, present in 83% (n = 273) of cases. A combination of midline and paramedian types was noted in 15.2% (n = 50), while the paramedian type alone or combined with the posterior type was not found in any image.

Conclusions: The anatomy and location of LF differ considerably among the Turkish Cypriot population. Pre-operative CBCT imaging is recommended to determine the exact location of LF in order to prevent possible surgical complications in patients who are planning for oral implants in the anterior region of the mandible.

Key words: computed tomography, anatomical variations, lingual foramen, lingual vascular canal.

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INTRODUCTION

The placement of implants in the mandibular midline is commonly considered safe. However, it requires careful consideration of crucial anatomical structures, including the mental nerve, incisive canal, lingual foramen (LF), and lingual vascular canal. LF is mostly detected in the lingual surface of the mandibular midline,

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around genial tubercle region, but less commonly can be located laterally [1].

Recent studies on both anatomical mandibular dissection and radiographic evaluation with dental computed tomography generally used for pre-surgical three-dimensional evaluation of the oral and maxillofacial region, have also proven the existence of these foramens [2-6].

According to their location, foramina situated above the genial tubercle (GT) are commonly known in literature as the superior genial spinal foramen, typically housing branches of the lingual artery, vein, and nerve. Conversely, foramen below the GT is named the inferior genial spinal foramen. Occasionally, foramina may contain branches of the sublingual artery and vein, and in some instances, they may include submental vessels and branches of the mylohyoid nerve [7].

In addition to providing anatomical data, studies in the literature are also extremely important in preventing complications, such as bleeding, hematoma, cortical perforation, or periosteal rupture involving these vessels [8-10].

Lingual vascular canals house the sublingual artery, submental artery, mylohyoid artery, and their anastomoses, collectively supplying the floor of the mouth. Perforation of the lingual mandibular cortex during procedures, such as genioplasty or dental implant placement, can result in severe bleeding, posing a potential life-threatening condition for the patient [10, 11].

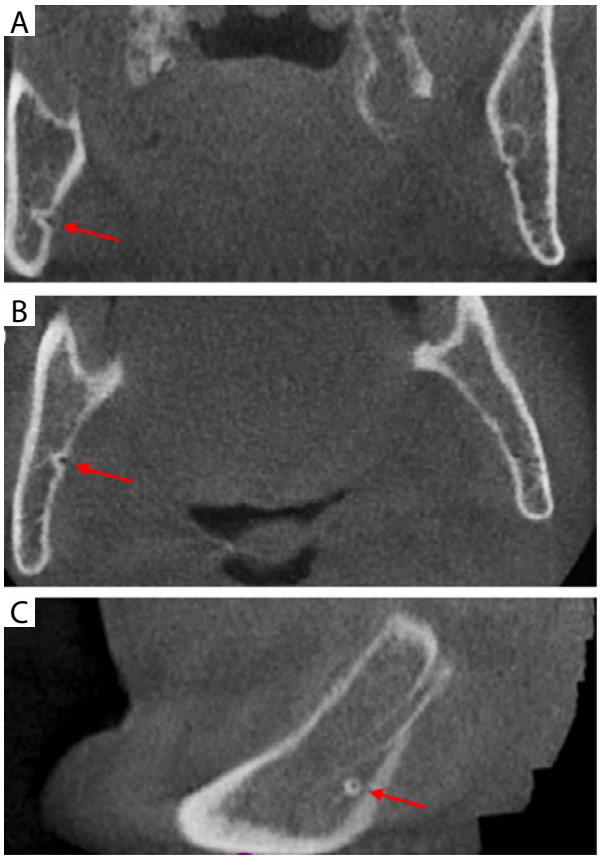

FIGURE 1. Posterior type of LF. (**A**) Coronal, (**B**) axial, and (**C**) sagittal scans of the same patient

Radiological imaging can help preventing complications, with detecting and evaluating the lingual vascular canals. Computed tomography (CT) and cone-beam computed tomography (CBCT) scans provide detailed and high resolution images, which are recommended modalities for observing the anterior mandibular lingual cortex before executing planned procedures in this area. Lower radiation dose and affordable price make CBCT preferable for the majority of researchers [12].

OBJECTIVES

This study aimed to investigate the anatomical variations of anterior mandibular LFs and their canals using CBCT.

MATERIAL AND METHODS

This investigation included 329 CBCT images acquired from adult patients with partially edentulous mandibles. During data selection, particular attention was given to cases with the presence of teeth in the anterior mandible. CT data were meticulously chosen for the study, ensuring that the areas of interest were within field of view (FOV) and without any artifacts. Exclusion criteria comprised individuals with a history of head and neck trauma, prior mandibular or surrounding structure surgeries, tumors, and systemic/genetic disorders.

All patient records from individuals aged 18-85 years who sought services at the Near East University Faculty of Dentistry Department of Radiology between 2011-2016, and who underwent lower jaw imaging, were precisely reviewed for lingual foramen (LF) presence. Assessment included the identification of LF, associated bony canals, and their respective locations. CBCT scans were conducted using NewTom 3G (Quantitative Radiology srl Co., Verona, Italy), with a 12-inch field of view to encompass the entire facial anatomy. Scans featured 0.3 mm thick axial slices and isotropic voxels. Exported in DICOM format with a 512 × 512 matrix, axial, coronal, and sagittal images were subsequently imported into InVivo version 5.1.2 (Anatomage, San Jose, CA, USA) three-dimensional imaging software. Classification process was carried out within the multiplanar tab to ensure comprehensive evaluation.

Every image underwent reconstruction on a 21.3 inch flat-panel color active matrix TFT medical display (Nio Color 3MP, Barco, France), with a resolution of 76 Hz, 0.2115 mm pitch, and a 10-bit depth. Examiners had the flexibility to employ enhancement and orientation tools, including magnification, brightness, and contrast adjustments, to augment the visualization of landmarks. Image evaluation and classification were performed on axial, coronal, and sagittal scans. In sagittal, axial, and

coronal sections, the canals starting from the lingual and progressing into the mandible were recorded as the posterior lingual canals. These canals can later merge with the mandibular canals in subsequent sections (Figure 1).

Anatomical classification was done according to the location of LF [13]. Sub-groups were classified as follows (Figure 2):

1) none;
2) midline type: foramina located in the center of symphysis;
3) paramedian type: foramina located between the mesial sides of central incisors and the distal sides of canines;
4) posterior type: foramina located between the mesial sides of the first premolars and the distal sides of the third molars;
5) midline-paramedian type: presence of LF in the same patient in the midline and paramedian regions;
6) midline-posterior type: presence of LF in the same patient in the midline and posterior regions;
7) paramedian-posterior type: presence of LF in the same patient in the paramedian and posterior regions;
8) all types: presence of LF in the same patient in the midline, paramedian, and posterior regions.

Additionally, another classification was performed for LFs located in the midline region (Figure 3), dividing them into 6 sub-groups according to their number and localization [14].

CBCT scans were evaluated independently by the maxillofacial radiologist (AK) and anatomist (BCO) to identify potential anatomical variations. Subsequently, a consensus session was conducted to finalize the identification of these variations. Prior to commencing radiographic examination for this study, the examiners underwent calibration to enhance their ability to recognize and identify anatomical variations. In order to achieve this, 30 additional CBCT scans, different from those used in the study, were utilized. During the radiographic examination procedure, the examiners exclusively assessed CBCTs, ensuring they were blinded to other patient data.

Prevalence of both the classifications was calculated. Frequency analyses were conducted to obtain descriptive distributions of the variables. Mean and standard deviation was evaluated for age, and ages were categorized into three groups: below 35, 35-55, and above 55 years. Associations between two categorical variables were verified by chi-square test of independence. For three main observed aspects, differences between proportions of a single category based on sex or age group were assessed with χ^2 goodness-of-fit test. All analyses were performed using IBM SPSS version 22.0 software package, and a p-value less than 0.05 was considered statistically significant.

RESULTS

In this study, CBCT scan images of 329 subjects were analyzed. 53.2% (n = 175) of the individuals were males, while 46.8% (n = 154) were females. Age of the subjects varied between 18 and 85 years, with a mean of 43.31 and a standard deviation of 17.47. 39.2% (n = 129) of the participants were below 35 years, 30.7% (n = 101) were between 35 and 55 years, and 30.1% (n = 99) were above 55 years. LF was detected in 99.4% (n = 327) of the scanned images. Only three subjects (0.9%) did not have a LF, and single LF was detected in more than half (54.4%, n = 179) of the individuals. Following the frequency of single LF, two LFs were observed in 29.5% (n = 97), three LFs were detected in 13.1% (n = 43), and

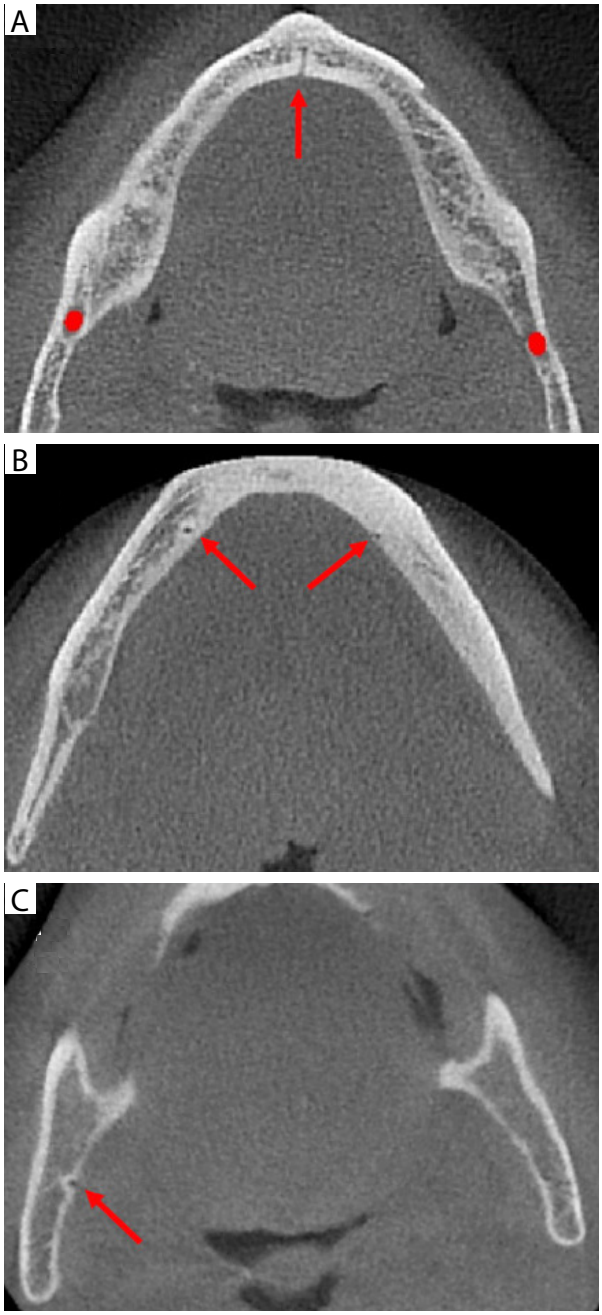

FIGURE 2. Anatomical classification according to the location of lingual foramen. (**A**) Midline type, (**B**) paramedian type, and (**C**) posterior type

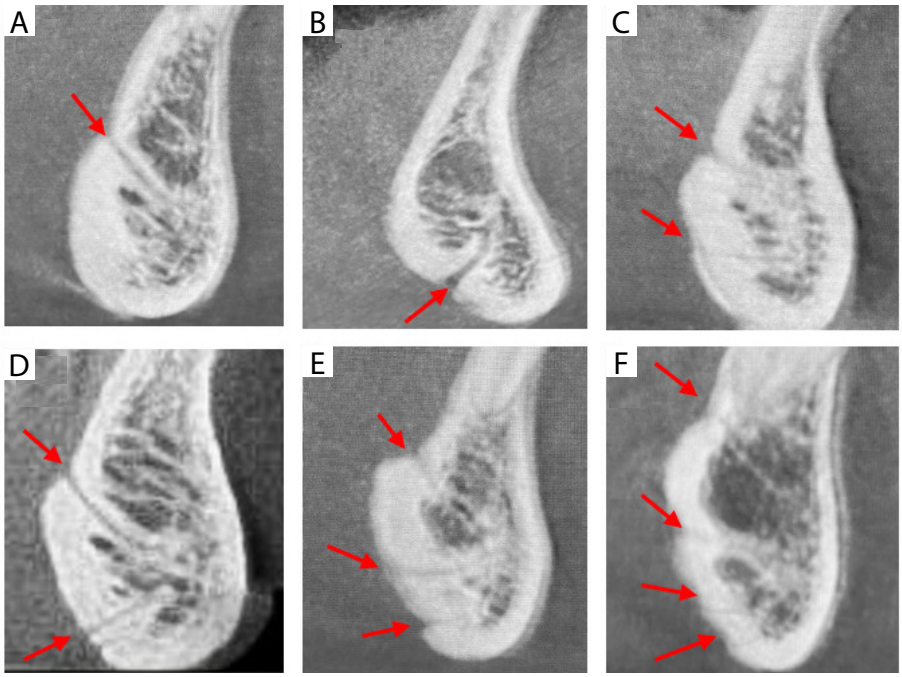

FIGURE 3. Six different classes of midline type LF and its bony canals located relative to GT. **A**) Class I – one lingual vascular canal above GT. **B**) Class II – one lingual vascular canal under GT. **C**) Class III – one above GT and second below GT. **D**) Class IV – two intersecting lingual vascular canals. **E**) Class V – one above GT and two below GT. **F**) Class VI – one above GT and three below GT

four LFs were noticed in 2.1% (n = 7), as can be seen in Table 1. The midline LF type was the most frequent anatomical class, with a ratio of 83% (n = 273), followed by the midline and paramedian types, with 15.2% (n = 50). In two subjects (0.6%), both the midline and posterior types were observed, and one subject (0.3%) presented the posterior type. The paramedian type alone or together with the posterior type was not detected in any image (Table 2). Six different classes were observed in the midline area (Table 3). The most frequently observed variation was class I (39.8%, n = 131), followed by class IV (30.7%, n = 101), and class II (14.3%, n = 47).

In comparative analysis, the number of detected LFs, anatomical LF type, and the midline area class were all compared based on the sex and age groups of the subjects. Associations could only be tested for the midline area classification versus the sex (p = 0.178) and age groups (p = 0.048) using χ^2 test of independence. Other associations could not be tested due to the low number of observations in their categories. However, univariate χ^2 goodness-of-fit tests were conducted for each category of the three main variables to determine if the proportions between the gender and age groups were significantly different or not. As a result, no significantly different proportions were detected between sexes for any category (Table 4), and in all age groups, single LF, midline location, and class I in midline classification were the most commonly observed (Table 5).

DISCUSSION

Dental implantation is scientifically accepted and widely used treatment method for partial or total replacement of missing teeth. It has been reported in the literature that among all surgical procedures, dental implants are the most common cause of hemorrhages in the anterior mandibular region [15]. Although periapical and panoramic radiographs are inexpensive and easily accessible imaging modalities, it has been reported that they are insufficient in monitoring the anterior mandibular region. It is recommended to evaluate the floor of the mouth with CT or CBCT before planning any procedures [16]. Although CT imaging is an effective modality when assessing this region, CBCT is the preferred method by both the researchers and surgeons due to its lower radiation dose and affordable price compared with CT [14].

The absence of LF in the mandible is as important as its presence. We identified three patients in our study without a LF. Although this is unusual situation, this finding is in line with the results of studies conducted by Taschieri *et al.* (0.7%) [6], Demiralp *et al.* (3.4%) [13], and Şekerci *et al.* (1.8%) [17].

Considering the classification of the number of lingual foramens and canals localized in the midline region of the mandible, similar to our study, Denny *et al.* [18] conducted their study using CBCT as the imaging modality, and LFs were found in all participating patients.

TABLE 1. Frequencies and percentages of the number of observed LFs

Number of LFs		*n*	%
None		3	0.9
One		179	54.4
Two		97	29.5
Three		43	13.1
Four		7	2.1

Single LF was observed in 69%, two LFs in 29.3%, and three LFs were seen in 1.7% of the cases. Additionally, 98.3% of the patients had LF located in the midline region. In another study evaluating 50 dry human mandibles, 98% of the study population had at least one LF; single LF was seen in 72%, two LFs in 22%, and three LFs were observed in 4% of the patients [19]. Alqutaibi *et al.* [2] investigated the occurrence of LFs using CBCT, and reported that single canal was seen in 30.9%, two canals in 54.7%, and three canals were observed in 14.7% of the cases. In their study, unlike in our and the above studies [18, 19], the occurrence of two canals was higher than the single canal.

TABLE 2. Frequencies and percentages of the observed anatomical classes

Anatomical class	*n*	%
1. None	3	0.9
2. Midline type	273	83.0
3. Paramedian type	0	0.0
4. Posterior type	1	0.3
5. Midline + paramedian type	50	15.2
6. Midline + posterior type	2	0.6
7. Paramedian + posterior type	0	0.0
8. All types	0	0.0

TABLE 3. Frequencies and percentages of the observed midline area classes

Midline classification	*n*	%
None	3	0.9
Class I	131	39.8
Class I	47	14.3
Class III	20	6.1
Class IV	101	30.7
Class V	27	8.2
Class VI	0	0.0

Sheikhi *et al.* [20] evaluated 102 CBCT images, and reported that 100% of their study group had at least one LF. This is in line with the current study, where 99.4% of the study population had at least one LF. The distribution of LF numbers in this study was the same as in the study of Alqutaibi *et al.* [2], in which 52.9% of the patients had two LFs, 24.5% had one LF, 19.6% had three LFs, and 2.9% had four LFs.

Considering the classification according to the localization of the lingual foramen in other parts of the mandible, the results of the current study are similar to Demiralp *et al.* [13] research. They scanned 58 ancient dry mandibles with CBCT, and found that the incidence of LF was 96.6%. Midline-located LF was the most common location (34.4%), followed by midline + paramedian location (32.8%). In our study, the most common location of LF was also the midline (83%), and the second most common location was the midline + paramedian (15.2%).

In another study in the literature, similar to the results of our study, it was reported that LFs were most commonly localized in the midline region, with an incidence of 55.8% [21].

Silvestri *et al.* [4] classified LFs into two categories according to their location in the mandible: the medial LF close to the midline, and the lateral LF located beyond the midline. Similar to the results of our study, they report-

TABLE 4. Comparative analysis of the number of the observed lingual foramen, anatomical class, and midline classification based on sex of the subjects

Variable /Category	Male	Female	*p*-value*	Total
Number of lingual foramens				
None	3	0	–	3
One	100	79	0.136	179
Two	42	55	0.187	97
Three	26	17	0.170	43
Four	5	2	–	7
Anatomical class				
1. None	3	0	–	3
2. Midline type	142	131	0.506	273
3. Paramedian type	0	0	–	0
4. Posterior type	0	1	–	1
5. Midline + paramedian type	28	22	0.396	50
6. Midline + posterior type	2	0	–	2
7. Paramedian + posterior type	0	0	–	0
8. All types	0	0	–	0
Midline classification				
None	2	1	–	3
Class I	68	63	0.662	131
Class II	30	17	0.058	47
Class III	7	13	0.180	20
Class IV	50	51	0.921	101
Class V	18	9	0.083	27
Class VI	0	0	–	0
Total	175	154		329

**p-values obtained from χ^2 goodness-of-fit tests*

TABLE 5. Comparative analysis of the number of the observed lingual foramen, anatomical class, and midline classification based on age of the subjects

Variable /Category	< 35 years	35-55 years	> 55 years	Total
Number of lingual foramens				
None	0	0	3	3
One	74	44	61	179
Two	35	37	25	97
Three	19	15	9	43
Four	1	5	1	7
Anatomical class				
1. None	0	1	2	3
2. Midline type	112	80	81	273
3. Paramedian type	0	0	0	0
4. Posterior type	0	0	1	1
5. Midline + paramedian type	15	20	15	50
6. Midline + posterior type	2	0	0	2
7. Paramedian + posterior type	0	0	0	0
8. All types	0	0	0	0
Midline classification				
None	0	0	3	3
Class I	51	37	43	131
Class II	21	8	18	47
Class III	5	9	6	20
Class IV	42	36	23	101
Class V	10	11	6	27
Class VI	0	0	0	0
Total	129	101	99	329

ed that the incidence of medial LFs (76.4%) was higher than that of lateral LF (23.6%). The same classification of LFs in Silvestri *et al.* [4] and Taschieri *et al.* [6] studies was applied, and the results were reported to be higher for LFs located in the midline compared withlaterally-located LFs.

CONCLUSIONS

The anatomy and location of the LF in the mandible differ considerably among the Turkish Cypriot population. Pre-operative CBCT imaging is recommended to determine the exact location of the LF, to prevent possible surgical complications in patients who are planning for implants in the anterior region of the mandible.

DISCLOSURES

1. Institutional review board statement: The study was approved by the Dental Research Ethical Committee of the Faculty of Medicine of Near East University, with approval number: 2021/95-1409.
2. Assistance with the article: None.
3. Financial support and sponsorship: None.
4. Conflicts of interest: The authors declare no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

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