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Morphometric Analysis of the Mandibular Lingual Foramina Using Cone-Beam Computed Tomography in Elderly Korean

Análisis Morfométrico de los Forámenes Linguales Mandibulares Mediante Tomografía Computarizada de Haz Cónico en Adultos Mayores Coreanos

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SUMMARY: The aim of this study was to determine the morphologic characteristics of the lingual foramen and lateral lingual foramen using cone-beam CT in elderly Korean. Cone-beam CT images were obtained from 80 Korean older than 50 years (mean age, 65.2 years). The prevalence of the lingual and lateral lingual foramina at the lingual aspect of the mandible was determined. The diameter and height to the upper margin of the foramina from the mandibular inferior margin, and the bone height to the alveolar crest from the mandibular inferior margin were measured. In addition, the location of the lateral lingual foramen, the direction of its canal, and the presence of communication with the mandibular canal were evaluated. All of elderly Korean possessed at least one lingual foramen, with two or three foramina occurring in 77.5 % of Korean. A lateral lingual foramen was observed in 91.3 % of Korean, with the prevalence being highest at the second premolar in dentulous cases (21.6 %; 33/153). The very high frequencies of these foramina were attributable to high frequencies of relatively small-diameter inferior lingual foramen and lateral lingual foramen in the incisor region. The prevalence of a large-diameter (≥1 mm) superior lingual foramen was high, at 31.0 %. A large-diameter lateral lingual foramen in the premolar region occurred at a frequency of 17.0 %; communication with the mandibular canal was observed in 70.0 % of these cases. These quantitative data on the lingual and lateral lingual foramina of the mandible provide valuable information that could help to avoid surgical complications during implant placement in elderly Korean.

KEY WORDS: Lingual foramen; Lateral lingual foramen; Elderly Korean; Cone-beam CT.

INTRODUCCIÓN

The mandible, which comprises hard cortical bone, receives its blood and nerve supply from the inferior alveolar neurovascular bundle through the mandibular foramen. At the first molar, these inferior alveolar neurovascular bundles consist of a large trunk of the inferior alveolar nerve, with an area of 4.02 mm2, and a relatively small portion of the inferior alveolar artery, with an area of 0.3 mm2 (Lee *et al*., 2015). The radius of the arterial lumen of the inferior alveolar artery decreases with advancing age, due to fibrous thickening of the intima and fibrosis of the media (Semba *et al*., 2001). Together with tooth loss, these arteriosclerotic changes result in a change in the blood supply of the mandible from centrifugal circulation in younger people to centripetal circulation in older people (Bradley, 1972). This altered circulation in the elderly requires external blood supply from the periosteum and musculature, as well as other soft tissues (Kalpidis & Setayesh, 2004).

External vascular sources in the lingual surface of the mandible include various accessory foramina such as the lingual, lateral lingual, interalveolar, and innominate nutrient foramina. Research conducted using magnetic resonance imaging and histologic techniques has demonstrated that the neurovascular bundle enters through

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these foramina into the mandible (Liang *et al*., 2005). Among the accessory foramina, the prevalence of a lingual foramen, which is located near the mental spine at the mandibular symphysis, is very high, at 76.8–100 % according to the results of analysis using different races and various research methods (Kim *et al*., 2015). Branches of the sublingual artery and the lingual nerve or the mylohyoid nerve enter the anterior mandible predominantly through this foramen (Mcdonnell *et al*., 1994; Kalpidis & Setayesh, 2004; Liang *et al*., 2005, 2007). The submental artery, a branch of the facial artery, often enters the anterior mandible by perforating the mylohyoid muscle (Liang *et al*., 2007; Rosano *et al*., 2009; Gakonyo *et al*., 2015). Bleeding can occur due to damage to this foramen during surgical procedures, and there may be confusion regarding which artery should be quickly ligated (Kalpidis & Setayesh, 2004; Rosano *et al*., 2009).

The lateral lingual foramen (LLF), which is located close to the inferior margin of the mandible on the opposite side of the mental foramen, primarily contains the submental artery and mylohyoid nerve, but also often contains a branch of the sublingual artery and the lingual nerve (Gahleitner *et al*., 2001; Kalpidis & Setayesh, 2004; Tagaya *et al*., 2009). The LLF is located in the sublingual space above the mylohyoid line, thus the possibility of damage increases during surgical procedures because of its relatively close location to the alveolar crest (Morikage *et al*., 2017). Damage to the LLF during implant placement can cause a life-threatening sublingual hematoma (Nakajima *et al*., 2014).

The frequency, location, diameter and distribution of these accessory foramina vary according to their type (Moro *et al*., 2018). According to the comparison of previous studies on the lingual foramen, even in the same race, there was a difference in the occurrence rate depending on the research subjects and methods (Kim *et al*., 2015). It has also been reported that their frequency and diameter are higher in males, and with advancing age, the presence of periodontal disease, and in edentulous patients (Bilge *et al*., 1992; He *et al*., 2016). As the elderly population increases with an increase in life expectancy, the frequency of tooth loss due to periodontitis and tooth decay is also increasing. According to one previous study confirming the restoration type of lost teeth using implant treatment in Koreans, an average of 2.8 implants were operated in one patient, and implant treatments in 50s and older were higher than its average. And in their 50s, the number of patients and implants were the highest (Hong *et al*., 2002). There is thus a need to clearly classify the accessory foramina as consistent anatomical structures that occur with high frequency and to investigate their morphologic characteristics in the elderly with frequent and large number of implant treatments, toward increasing clinician understanding.

Cone-beam computed tomography (CBCT) has a high resolution and is widely used for the precise evaluation of anatomical structures before surgical procedures (Makris *et al*., 2010; von Arx *et al*., 2011; Wang *et al*., 2015). Retrospective studies using CBCT images can enable analysis of various fine structures in the maxillofacial region without additional radiation to the patient, acquisition of a large number of images, and statistical analysis using basic biological information such as age and sex. Therefore, the aim of this study was to provide quantitative data on the lingual and lateral lingual foramina in elderly Korean older than 50 years by evaluating their prevalence and morphologic characteristics using CBCT.

MATERIAL AND METHOD

Study design. CBCT images from 180 adult Korean who visited Chosun University Dental Hospital in Korea between April and December 2016 were selected at random, and those for Korean aged ≥50 years were extracted (n=99). Exclusion criteria included the presence of syndromes, systemic diseases, craniofacial anomalies, fracture or surgical treatment, or pathologic conditions affecting the mandible, inadequate image quality due to movement artifacts, and the inferior margin of the mandible not visible. Application of the study exclusion criteria ultimately yielded data for 80 Korean that were amenable to analysis (39 males and 41 females). The average age of the Korean included in this study was 65.2 ±8.8 years (63.3 years in males and 67 years in females), and ranged from 50 to 81 years. This retrospective study was conducted with the approval of the Research Ethics Committee of Chosun University Dental Hospital (approval number CUDHIRB-1609-041) and followed medical protocol and ethics guidelines as outlined in the Declaration of Helsinki.

CBCT methodology. CBCT scanning was performed using Carestream model CS9300 (Carestream Health, Rochester, NY, USA) at the Department of Oral and Maxillofacial Radiology of the Chosun University Dental Hospital. The field of view of each scan was a cylinder with a diameter of 17.0 cm and a height of 13.5 cm, and the voxel size was 0.3 mm. The exposure parameters were 90 kVp and 5 mA. The images were saved in Digital Imaging and Communications in Medicine format and were analyzed retrospectively by two dentists with more than 10 years of experience using OnDemand3DTM of the three-dimensional imaging-analysis software (Cybermed, Seoul, Korea). Measurements were taken at the same magnification by setting the magnification of the image as constant.

Measurements. The lingual and lateral lingual foramina were defined and measured only when both observers confirmed their presence in a particular image. The lingual foramina are located above and below the mental spine located at the lingual surface of the mandibular symphysis. Therefore, the lingual foramen was defined within the boundary that exists in the mental spine, and then was classified based on its level relative to the mental spine into the superior lingual foramen, the foramen at the level of the mental spine, and the inferior lingual foramen. The presence of a LLF was confirmed when it was located below the root apex and located outside the posterior edge of the mental spine. The prevalence and number of lingual and lateral lingual foramina were determined, and then the following measurements were made: (1) the diameter of each foramen at the point where the canal starts within its orifice, (2) the height to the upper margin of each foramen from the inferior margin of the mandible, and (3) the bone height to the alveolar crest of the mandible from the inferior margin of the mandible. The LLF was evaluated based on its location relative to tooth position. In edentulous Korean, the LLF was divided according to three tooth regions based on the position of the canine eminence and the mental foramen: incisor, premolar, and molar regions. The lingual foramen was evaluated in the direction from the lingual surface to the labial surface based on the sagittal plane (upward, horizontal, and downward) and the LLF was investigated in the sagittal and transverse planes (forward, perpendicular, and backward) (Fig. 1). Then, the LLF in dentulous Korean were classified according to analogous dimensions and course characteristics, and categorized according to location in one of three mandibular tooth regions: incisor (from the posterior edge of the mental spine to the distal margin of the canine), premolar, and molar regions. The status of communication between the LLF and the mandibular canal or the incisive canal was also explored. The images were examined twice by two observers on separate days.

Statistical analysis. Statistical analyses were performed using SPSS software (version 12.0, SPSS, Chicago, IL, USA). Analysis of the interobserver reliability yielded high values for Cronbach's a, ranging from 0.705 to 0.887 depending on the measured parameter; subsequent analyses used the average of the measured values of the two observers. Two-independent samples t test was performed to determine the significance of any difference between sidedness (left vs. right mandible) for all measured parameters. These tests revealed no significant difference between the left and right mandibles for any of the measured parameters ($P>0.05$); data for the left and right mandibles were therefore pooled for each parameter. Differences in the lingual foramen according to level relative to the mental spine and in the LLF according to mandibular tooth region were examined for statistical significance using one-way analysis of variance and post-hoc comparison with the Scheffé test. In each categorized group of the lingual foramen and LLF, two-independent samples t test was performed to determine the significant difference according to sex (male vs. female) and tooth-loss status (dentulous vs. edentulous) in all measurement parameters. Further analysis included the foramina with a large diameter (i.e., ≥1 mm). Mean ±standard-deviation values were calculated for all morphologic measurements, and the criterion for statistical significance was set at $P<0.05$.

Fig. 1. Cone-beam computed tomography (CBCT) images of the lingual foramen and the lateral lingual foramen. A, Superior lingual foramen (arrowhead) located above the mental spine (dotted red line) in the sagittal plane. B and C, Lateral lingual foramen (arrowheads) in the sagittal and axial planes, respectively. The diameter of each foramen was measured at the point where the canal starts within the orifice of the foramen in the sagittal plane. The height to the upper margin of each foramen and the bone height to the alveolar crest of the mandible from the inferior margin of the mandible were also measured. The course of the lingual foramen was evaluated based on the sagittal plane. Each lateral lingual foramen was evaluated according to its location relative to the tooth position, its course was determined based on the sagittal and transverse planes, and the presence of communication (arrow) with the mandibular canal or the incisive canal was recorded.

RESULTS

Prevalence of the lingual foramen. As shown in Table I, in total, 231 lingual foramen were counted, with all elderly Korean having at least 1. There were 2 lingual foramina in 27 Korean (33.8 %) and 3 lingual foramina in 35 Korean (43.8 %). A superior lingual foramen above the mental spine was observed in 92.5 % of elderly Korean, which coursed downward toward the labial side in 92.3 % of cases. Inferior lingual foramina below the mental spine were found in large numbers (n=122), being observed in 92.5 % of elderly Korean, and coursing upward in 68.0 % of cases. Both the superior and inferior lingual foramina were more prevalent in males than in females. The foramen at the level of the mental spine was observed in small numbers (n=31) in 26 Korean (32.5 %) and generally presented in a horizontal direction in 90.3 % of cases (Table I).

Dimensions of the lingual foramen. The diameters of the superior lingual foramen, foramen at the level of the mental spine, and inferior lingual foramen were 0.81±0.25, 0.59±0.19, and 0.59±0.18 mm, respectively. The diameter of the superior lingual foramen was significantly larger than those of the foramen at the level of the mental spine and the inferior lingual foramen, and was significantly larger in males than females ($P<0.05$ for all). The heights of the superior lingual foramen, foramen at the level of the mental spine, and inferior lingual foramen from the inferior margin of the mandible were 15.19±1.47, 10.22±1.59, and 4.52±2.64 mm, respectively; differences between groups according to location relative to the mental spine were statistically significant (Table I). There was no statistical difference according to tooth-loss status for any of these parameters: they consisted in 68 dentulous Korean (33 males and 35 females) and in 12 edentulous Korean (6 males and 6 females) (Fig. 2). The bone height from the inferior margin of the mandible was 33.37±2.64 mm in dentulous Korean (33.32±2.97 mm in males and 31.96±3.93 mm in females) and 28.35±4.95 mm in edentulous Korean (29.89±3.93 mm in males and 26.82±5.72 mm in females). The difference in mean bone height between dentulous and edentulous Korean was statistically significant (P=0.039), while the difference in mean bone height between males and females was not irrespective of tooth-loss.

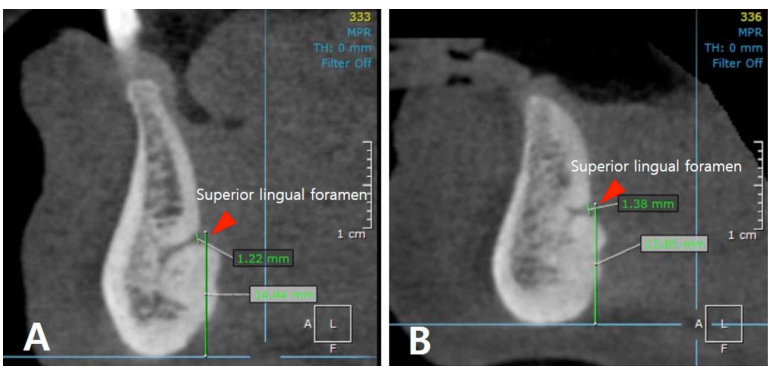

Fig. 2. CBCT images of the superior lingual foramina with a diameter of ≥1 mm (arrowheads) in elderly Korean. A, Dentulous patient. B, Edentulous patient.

Table I. Prevalence and morphologic characteristics of a lingual foramen according to location relative to the mental spine and sex in elderly Korean

	Person with this foramen % (*n/N*)	Overall occurrence of the foramen % (*n/N*)	Diameter of the foramen (mm)	Height of the foramen (mm)	Course % (*n/N*)		
					Downward	Horizontal	Upward
Superior lingual foramen	92.5 % (74/80)	33.8 % (78/231)	0.81±0.25^{ab}	15.19±1.47^{cd}	92.3 % (72/78)	7.7 % (6/78)	0
Male	94.9 % (37/39)	47.4 % (37/78)	0.85±0.20*	15.53±1.19†	91.9 % (34/37)	8.1 % (3/37)	
Female	90.2 % (37/41)	52.6 % (41/78)	0.78±0.29*	14.88±1.63†	92.7 % (38/41)	7.3 % (3/41)	
Foramen at the level of the mental spine	32.5 % (26/80)	13.4 % (31/231)	0.59±0.19^{a}	10.22±1.59^{ce}	0	90.3 % (28/31)	9.7 % (3/31)
Male	25.6 % (10/39)	32.3 % (10/31)	0.63±0.25	11.09±1.51		100 % (10/10)	0 % (0/10)
Female	39.0 % (16/41)	67.7 % (21/31)	0.58±0.16	9.81±1.48		85.7 % (18/21)	14.2 % (3/21)
Inferior lingual foramen	92.5 % (74/80)	52.8 % (122/231)	0.59±0.18^{b}	4.52±2.64^{de}	0	32.0 % (39/122)	68.0 % (83/122)
Male	94.9 % (37/39)	51.6 % (63/122)	0.62±0.19	4.34±2.88‡		28.5 % (18/63)	71.4 % (45/63)
Female	90.2 % (37/41)	48.4 % (59/122)	0.57±0.16	4.72±2.37‡		35.5 % (21/59)	64.4 % (38/59)

Data are mean±SD values except where indicated otherwise. The diameter of each foramen was measured at the point where the canal starts within its orifice. The height of the foramen was measured to its upper margin.
*, †, and ‡ indicate that the lingual foramen differs significantly between the sexes in same lingual foramen group for each measured parameter (two-independent samples t test; $P<0.05$). The same superscript letters indicate significant differences between the lingual foramen group according to location relative to the mental spine for each measured parameter (one-way ANOVA; $P<0.05$).

Among the lingual foramina, a diameter of ≥1 mm occurred most frequently for the subgroup of superior lingual foramina (31.0 %), with a diameter that was significantly larger for females than for males (1.14 mm vs. 1.09 mm; P<0.05). Both foramina at the level of the mental spine and inferior lingual foramina had predominantly small diameters, with only one patient (3.8 %) for the former and five Korean (6.8 %) for the latter, respectively, presenting with a diameter of ≥1 mm (Table II).

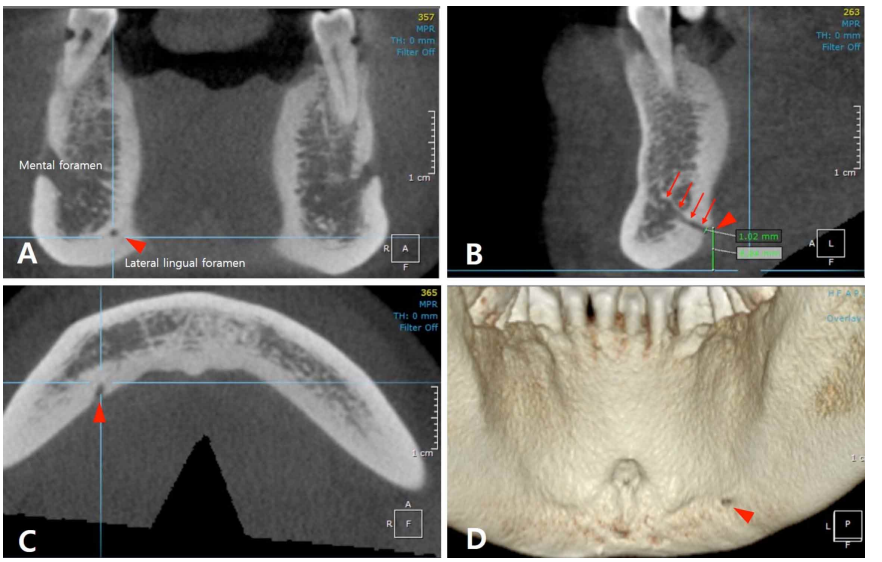

Fig. 3. CBCT images of lateral lingual foramina (arrowheads) with a diameter of ≥1 mm in the premolar region and connectivity to the mandibular canal in elderly Korean. The arrow indicates communication between a lateral lingual foramen and the mandibular canal or the incisive canal. A, Coronal image. B, Sagittal image. C, Axial image. D, Three-dimensional reconstruction of CBCT images.

Prevalence and dimensions of the LLF. As shown in Table III, a LLF in the lingual surface of the mandible was observed in 91.3 % of elderly Korean, with the highest frequency being observed at the second premolar of dentulous Korean (21.6 %). The most frequently occurring tooth region of a LLF was in the premolar region (72.6 %). These foramina had a significantly larger mean diameter (0.73 mm) than those in other tooth regions. They had a mean height of 7.91 mm and communicated with the mandibular canal or incisive canal in 59.4 % of cases. Their direction of travel was primarily upward (63.8 %) and forward (87.0 %) toward the buccal side (Fig. 3; Tables III and IV). In the incisor region, a LLF was observed in 61.6

Table II. Prevalence and morphologic characteristics of a lingual foramen with a larger diameter (≥1 mm) according to location relative to the mental spine and sex in elderly Korean

	Person with this foramen % (*n/N*)	Overall occurrence of the foramen % (*n/N*)	Diameter of the foramen (mm)	Height of the foramen (mm)
Superior lingual foramen	31.0 % (23/74)	29.4 % (23/78)	1.12±0.11	15.23±1.22
Male	28.2 % (11/39)	29.7 % (11/37)	1.09±0.06*	15.43±1.36
Female	29.3 % (12/41)	29.2 % (12/41)	1.14±0.14*	15.04±1.10
Foramen at the level of the mental spine	3.8 % (1/26)	3.2 % (1/31)	1.17	13.95
Male	2.6 % (1/39)	10.0 % (1/10)	1.17	13.95
Female	0 % (0/41)	0 % (0/21)	0	0
Inferior lingual foramen	6.8 % (5/74)	4.0 % (5/122)	1.08±0.03	7.28±3.58
Male	10.3 % (4/39)	6.3 % (4/63)	1.08±0.03	7.84±3.88
Female	2.4 % (1/41)	1.6 % (1/59)	1.06	5.06

Table III. Prevalence and morphologic characteristics of a lateral lingual foramen (LLF) categorized according to location in one of three mandibular tooth regions and sex in elderly Korean

	Sagittal plane % (*n/N*)			Transverse plane % (*n/N*)		
	Upward	Horizontal	Downward	Forward	Perpendicular	Backward
LLF in the incisor region	21.0 % (13/62)	51.6 % (32/62)	27.4 % (17/62)	30.6 % (19/62)	67.7 % (42/62)	1.6 % (1/62)
LLF in the premolar region	63.8 % (44/69)	33.3 % (23/69)	2.9 % (2/69)	87.0 % (60/69)	11.6 % (8/69)	1.4 % (1/69)
LLF in the molar region	66.7 % (28/42)	26.2 % (11/42)	7.1 % (3/42)	76.2 % (32/42)	19.0 % (8/42)	4.8 % (2/42)

The incisor region includes central incisor, lateral incisor, and canine. The communication means that the LLF communicates with the mandibular canal or the incisive canal. The height of the mandible is the bone height to the alveolar crest of the mandible from the inferior margin of the mandible.

Table IV. Course of the LLF categorized according to location in one of three mandibular tooth regions, based on the sagittal and transverse planes.

	Sagittal plane % (*n/N*)			Transverse plane % (*n/N*)		
	Upward	Horizontal	Downward	Forward	Perpendicular	Backward
LLF in the incisor region	21.0 % (13/62)	51.6 % (32/62)	27.4 % (17/62)	30.6 % (19/62)	67.7 % (42/62)	1.6 % (1/62)
LLF in the premolar region	63.8 % (44/69)	33.3 % (23/69)	2.9 % (2/69)	87.0 % (60/69)	11.6 % (8/69)	1.4 % (1/69)
LLF in the molar region	66.7 % (28/42)	26.2 % (11/42)	7.1 % (3/42)	76.2 % (32/42)	19.0 % (8/42)	4.8 % (2/42)

% of cases, and had a significantly smaller mean diameter (0.57 mm) but greater mean height from the inferior margin of the mandible (9.86 mm) than those observed in the other tooth regions. They were primarily directed horizontal (51.6 %) and perpendicular (67.7 %) toward the labial surface (Tables III and IV). In the molar region, a LLF was observed in 43.8 % of cases, with a mean diameter of 0.70 mm and a mean height of 8.34 mm; the frequency of communication with the mandibular canal was 38.1 %. These foramina coursed primarily upward (66.7 %) and forward (76.2 %) toward the buccal side (Tables III and IV). With the exception of mean bone height from the inferior margin of the mandible, there was no significant difference for any of these parameters according to sex or tooth-loss status: the incisor region was 57 dentulous cases and 5 edentulous cases, the premolar region was 59 dentulous cases and 10 edentulous cases, and the molar region was 37 dentulous cases and 5 edentulous cases.

There were no cases of large-diameter (≥1 mm) LLF in the incisor region. LLF in the premolar region had a large diameter in 17.0 % of elderly Korean, of which 70 % communicated with the mandibular canal or incisive canal. The mean height of these foramina from the inferior margin of the mandible was significantly greater for females than for males (8.38 mm vs. 7.39 mm; Table V).

Table V. Prevalence and morphologic characteristics of LLFs with a larger diameter (≥1 mm) according to location in one of three mandibular tooth regions and sex in elderly Korean.

	Person with this foramen % (*n/N*)	Overall occurrence of the foramen % (*n/N*)	Diameter of the foramen (mm)	Height of the foramen (mm)	Height of the mandible (mm)	Presence of a communication % (*n/N*)
LLF in the incisor	0 % (0/45)	0 % (0/62)	0	0	0	0 %
Male	0 % (0/20)	0 % (0/29)	0	0	0	0 %
Female	0 % (0/25)	0 % (0/33)	0	0	0	0 %
LLF in the premolar	17.0 % (9/53)	14.5 % (10/69)	1.07±0.06	7.89±1.72	31.04±5.50	7/10 (70.0 %)
Male	16 % (4/25)	11.4 % (4/35)	1.10±0.07	7.39±0.22*	29.42±8.56	4/4 (100 %)
Female	17.9 % (5/28)	17.6 % (6/34)	1.06±0.05	8.38±2.19*	32.12±2.62	3/6 (50.0 %)
LLF in the molar region	9.4 % (3/32)	7.1 % (3/42)	1.12±0.09	8.36±1.90	33.10±2.64	2/3 (66.7 %)
Male	7.7 % (1/13)	5.6 % (1/18)	1.09	7.46	35.62	1/1 (100 %)
Female	10.5 % (2/19)	8.3 % (2/24)	1.14±0.11	8.81±2.46	31.84±2.09	1/2 (50.0 %)

DISCUSSION

The surgical procedures in the edentulous mandible such as placement of dental implants, extraction, flap surgery, torus removal, and osteotomy can cause unexpected complications such as a hemorrhage in the floor of the mouth, temporary nerve disturbance, or long-lasting neuropathy (Wang *et al*., 2015; Moro *et al*., 2018). In particular, these complications can occur as a result of damage to the external vascular supply passing through the accessory foramen caused by excessive reflection of the lingual mucoperiosteal flaps, or perforation of the lingual cortical plate by instrumentation (Kalpidis & Setayesh, 2004; von Arx *et al*., 2011). The clinical impact of this bleeding may be exacerbated if the patient has a hypertension or abnormal hemostasis, or takes an anticoagulant drug (Kim *et al*., 2013). In elderly people with high morbidity for these chronic diseases, attention to these accessory foramina is particularly important during surgical procedures. Therefore, the present study explored the morphologic characteristics of the lingual foramen and the LLF using CBCT in elderly Korean.

All elderly Korean in this study possessed at least one lingual foramen, consistent with the high prevalence (96.2–100 %) found in previous studies using CBCT or microcomputed tomography (von Arx *et al*., 2011; Choi *et*

al., 2013; Wang *et al*., 2015; He *et al*., 2016; Moro *et al*., 2018). On the other hand, the direction and diameter of these lingual foramina differ depending on where they appear above or below base on the mental spine (Makris *et al*., 2010; Choi *et al*., 2013; Kim *et al*., 2015). In other words, their risk of damage during surgical procedures differs markedly because of the distance from the alveolar crest. In particular, in edentulous patients the superior lingual foramina are located very close to the alveolar crest due to resorption of the alveolar bone, and so careful consideration is needed when placing an implant longer than 13 mm in the anterior mandible in these patients (Rosano *et al*., 2009). In the present study it was considered necessary to analyze the lingual foramen categorizing it according to its position relative to the mental spine.

The findings of this study demonstrated that when there were two or more lingual foramina, there existed one superior lingual foramen and several inferior lingual foramina that had a smaller diameter and were located near the inferior margin of the mandible. The superior lingual foramen had a mean diameter of 0.81 mm and a mean height from the inferior margin of the mandible of 15.19 mm, and were significantly greater than those of foramina located at other levels. Most traveled downward from the orifice of the foramen. In previous research, the reported ranges of mean diameter and mean height of the superior lingual foramen are 0.71–1.05 mm and 9.32–15.09 mm, respectively. The superior lingual foramen generally had a greater diameter and height than the inferior lingual foramen, and most coursed downward (Makris *et al*., 2010; von Arx *et al*., 2011; Choi *et al*., 2013; Wang *et al*., 2015; He *et al*., 2016; Moro *et al*., 2018). The overall morphologic characteristics and general rates of occurrence are similar to those reported previously; however, the mean values of foramen diameter and height from the inferior margin of the mandible were slightly larger than the average examined by the large spectrum of ages in previous reports. In addition, in this study, although tooth-loss status did not significantly impact any of the measured parameters, they did differ according to sex, with males having a larger mandible and possessing foramina with significantly higher frequencies, larger diameters, and greater heights. Previous studies that compared the difference with age group based on 50 or 55 years reported that there was no significantly difference in dimensional characteristics of these lingual foramina according to age group, except for the distance from the alveolar crest to the lingual foramen due to atrophic changes of the alveolar process because of periodontal disease or tooth loss (Sheikhi *et al*., 2012; He *et al*., 2016). Thus, it may be more appropriate to evaluate the lingual foramina according to individual patient characteristics other than age.

An accessory foramen diameter of ≥1 mm has great implications for clinicians since a larger amount of blood flows through it, thus increasing the possibility of complications such as hemorrhage or nerve disorder if it is injure (Gahleitner *et al*., 2001). The frequency of superior lingual foramina with a diameter larger than 1 mm in two previous studies was 11.9 % and 21.23 %, and the frequency in males was higher than in females (Wang *et al*., 2015; He *et al*., 2016). The overall frequency was higher in the present study of elderly Korean, at 31.0 %, and contrary to those previous reports, the frequency and diameter were significantly larger in females than males. This finding may have implications with respect to postmenopausal female patients with osteoporosis, in whom more care may be needed during surgery to the mandible.

A large number of accessory foramina exist on the lateral side of the mandibular symphysis. However, the LLF must be distinguished with the interalveolar foramina, which run perpendicularly downward located close to the alveolar crest in the incisor region (Kalpidis & Setayesh, 2004; Moro *et al*., 2018). In the present study, LLF were highly prevalent being observed at a frequency of 91.3 %, with 72.6 % of cases occurring in the premolar region. These LLF in the premolar region were large, with a mean diameter and height of 0.73 and 7.91 mm, respectively, and were located closer to the inferior margin of the mandible. They communicated with the mandibular canal or the incisive canal in 59.4 % of cases and traveled upward and forward.

Previous research using CBCT have also demonstrated a high frequency of LLF in the premolar region, and particularly in the second premolar (Gahleitner *et al*., 2001; Tagaya *et al*., 2009; von Arx *et al*., 2011; Kim *et al*., 2013; Wang *et al*., 2015; He *et al*., 2016; Moro *et al*., 2018). The reported range of values for mean diameter and mean height was 0.6–0.9 and 6.78–9.50 mm, respectively, with communication with the mandibular canal or incisive canal by running forward in 68.5 % of cases. The statistical significance of differences between males and females, and between different patient ages for mean diameter and height in previous studies vary (Kim *et al*., 2013; Wang *et al*., 2015). In the present study, although there was no significant difference in any of the measured parameters according to sex and tooth-loss status, the mean diameter and height of the LLF observed in the premolar region differed significantly compared with the other tooth regions, it is thus necessary to pay particular attention to those in the premolar region.

LLF in the premolar region are difficult to observe in panoramic radiography and perpendicular x-rays because their canal runs into the mandible with its thin cortification

and mesial course, and overlaps with the opposite mandible and cervical vertebrae (Gahleitner *et al*., 2001; Moro *et al*., 2018). Therefore, inexperienced surgeons need to pay more attention to these anatomical structures during implant placement (Kalpidis & Setayesh, 2004). In this study of elderly Korean, a LLF with a large diameter of ≥1 mm in the premolar region was observed more frequently than in previous research (at 17.0 % vs. 10.9 %) (Wang *et al*., 2015), and in 70 % of these cases there was evidence the LLF communicated with the mandibular canal or incisive canal. These high values in elderly Korean suggest that the LLF in the premolar region has a greater lingual vascular and neural supply to the mandible, and is consequently more prone to damage and subsequent surgical complications such as bleeding or nerve disorders.

A major finding of this study is that the very high frequencies of lingual and lateral lingual foramina in elderly Korean (100 % and 91.3 %, respectively) were attributable to high frequencies of relatively small-diameter inferior lingual foramen and lateral lingual foramen in the incisor region. On the other hand, clinicians should be very careful when encountering an accessory foramen with a diameter larger than 1mm during surgical procedures. In elderly Korean over 50 years of age, large-diameter superior lingual foramina occurred at a high frequency (31.0 %), and 70.0 % of the LLF in the premolar region (frequency, 17.0 %) showed communication with the mandibular canal. Therefore, these quantitative findings on the lingual foramen and the LLF provide valuable information that could help to avoid surgical complications during implant placement in elderly Korean.

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YU, S. K.; LIM, J.; BAE, C. J.; SEO, Y. S. & KIM, H. J. Análisis morfométrico de los forámenes linguales mandibulares mediante tomografía computarizada de haz cónico en adultos mayores coreanos. *Int. J. Morphol., 40(3)*:688-696, 2022.

RESUMEN: El objetivo de este estudio fue determinar las características morfológicas del foramen lingual y del foramen lingual lateral mediante TC de haz cónico en adultos mayores coreanos. Se obtuvieron imágenes de TC de haz cónico de 80 coreanos mayores de 50 años (edad media, 65,2 años). Se determinó la prevalencia de los forámenes linguales y linguales laterales en la cara lingual de la mandíbula. Se midió el diámetro y la altura hasta el margen superior de los forámenes desde el margen inferior mandibular, y la altura ósea hasta la cresta alveolar desde el margen inferior mandibular. Además, se evaluó la ubicación del foramen lingual lateral, la dirección de su canal y la presencia de comunicación con el canal mandibular. Todos los adultos mayores coreanos tenían al menos un foramen lingual, con dos o tres forámenes en el 77,5 %. Se observó un foramen lingual lateral en el 91,3 %, siendo la prevalencia más alta en el segundo premolar en casos dentados (21,6 %; 33/153). Las mayores frecuencias de estos forámenes se atribuyeron a altas frecuencias de foramen lingual inferior y foramen lingual lateral de diámetro relativamente pequeño en la región de los incisivos. La prevalencia de un foramen lingual superior de gran diámetro (≥1 mm) fue alta, del 31,0 %. Un foramen lingual lateral de gran diámetro en la región premolar ocurrió con una frecuencia del 17,0 %; se observó comunicación con el canal mandibular en el 70,0 % de estos casos. Estos datos cuantitativos sobre los forámenes linguales y linguales laterales de la mandíbula proporcionan información valiosa que podría ayudar a evitar complicaciones quirúrgicas durante la colocación de implantes en adultos mayores coreanos.

PALABRAS CLAVE: Foramen lingual; Foramen lingual lateral; Adultos mayores coreanos; TC de haz cónico.

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