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Radiologic evaluation of the lingual foramen and the lateral lingual foramen in the elderly person

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그림목차

ABSTRACT in KOREAN

고령자에서 혀구멍과 가쪽혀구멍의 방사선학적 평가

임 진 웅

조선대학교 대학원 치의학과

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고령자에서 위축된 아래턱의 재건을 위해 임플란트 식립은 안전하고 최소 침습적인 보철 치료로 주로 고려된다. 그러나 무치악 환자에서 임플란트 식립 후 출혈이나 신경 손상과 같은 예상치 못한 합병증이 꾸준히 보고되고 있다. 게다가 연령 증가에 따라 치아 상실과 아래이틀동맥의 동맥경화성 변화로 인해 아래턱의 혈액 공급은 원심 순환에서 구심 순환으로 변화한다. 아래턱 혀쪽면에 위치하는 덧구멍은 턱뼈 밖의 혈관 공급원으로, 점막골막 피판의 과도한 거상이나 기구에 의한 혀쪽 겉질뼈의 천공으로 인해 덧구멍을 통과하는 혈관이 손상되면 외과적 합병증이 발생할 수 있다. 따라서 본 연구에서는 콘빔전산화단층촬영 영상을 이용하여 고령자의 성별과 유무치악에 따른 혀구멍과 가쪽혀구멍의 형태학적 특징을 분석하고자 하였다.

본 연구에서는 조선대학교 치과병원 영상치의학과에서 촬영한 평균 연령 65.2세(연령대 50-81세)로 50세 이상의 총 80명의 콘빔전산화단층촬영

영상을 이용하였다. 혀구멍과 가쪽혀구멍의 발현, 직경, 구멍의 높이 및 구멍 위치에서의 아래턱뼈 높이를 조사 하였다. 혀구멍의 시상면을 기준으로 주행 방향을 평가하였다. 그리고 가쪽혀구멍의 치아 기준 위치, 시상면과 횡단면을 기준으로 한 주행 방향 및 턱뼈관 또는 앞니관과의 연결 여부를 조사하였다. 모든 측정 항목에서 좌우, 성별 및 유무치악에 따른 통계적 차이를 분석하였다.

고령자에서 혀구멍과 가쪽혀구멍에 관하여 다음과 같은 결과를 얻었다.

1. 모든 고령자에게 있어 혀구멍이 한 개 이상 관찰되었고, 77.5%는 2개 또는 3개의 구멍이 관찰되었다.
2. 가쪽혀구멍은 91.3%에서 관찰되었으며, 특히 치아가 있는 환자는 둘째 작은어금니에서 21.6%로 가장 높은 빈도를 보였다.
3. 이와 같은 높은 빈도는 상대적으로 작은 직경을 가지는 아래혀구멍과 앞니부위 가쪽혀구멍의 빈도의 증가에서 기인하였다.
4. 위혀구멍은 유무치악과 관련없이 아래턱뼈가 큰 남성에서 평균 직경 0.8 mm, 평균 구멍 높이 15.53 mm 로 유의적으로 큰 직경과 높은 위치를 가졌다.
5. 가쪽혀구멍은 성별과 유무치악에 따라 유의적 차이가 없었으며, 작은어금니부위에서 72.6%의 상당히 높은 빈도와 0.7 mm의 큰 직경을 가졌다.
6. 고령자의 경우 1 mm 이상의 큰 직경을 가지는 위혀구멍은 31.0%로 높은 빈도를 보였고, 작은어금니부위의 가쪽혀구멍 역시 17.0%의 높은 빈도를 보였으며 턱뼈관과 70.0%에서 연결이 관찰되었다.
7. 고령자의 여성은 특히 1 mm 이상의 큰 직경을 가지는 위혀구멍과 작은어금니부위의 가쪽혀구멍이 더 높은 빈도와 큰 직경을 보였다.

이러한 연구 결과는 고령자에게 있어 임플란트 식립, 점막골막 피판의 형성, 골절단술 및 골융기 제거와 같은 외과적 수술 시 합병증을 피하기 위하여 혀구멍과 가쪽혀구멍에 관한 정량적 자료를 제시할 수 있다.

중심어: 혀구멍, 가쪽혀구멍, 고령자, 수술 합병증, 콘빔전산화단층촬영

Ⅰ. Introduction

The mandible consisted of hard cortical bone gets a supply of blood and nerve from the inferior alveolar neurovascular bundle through the mandibular foreman, a major foramen located on the medial surface of the mandibular ramus on both sides. These inferior alveolar neurovascular bundle consists of a larger trunk of the inferior alveolar nerve with an area of 4.02 mm^2 and a relatively small portion of the inferior alveolar artery with an area of 0.3 mm^2 at the first molar (Lee et al., 2015). In particular, the radius of the arterial lumen in inferior alveolar artery decreases due to fibrous intimal thickening and fibrosis of the media with age (Semba, Funakoshi, & Kitano, 2001). As a result, due to tooth loss and arteriosclerotic changes of the inferior alveolar artery, the blood supply of the mandible changes from centrifugal in younger people to centripetal circulation in older people (Bradley, 1972). This new circulation in the elderly person requires an external blood supply from periosteal, muscular, andother soft tissues (Kalpidis & Setayesh, 2004).

As external vascular sources in the lingual surface of the mandible, there are various accessory foramen such as lingual foramen, lateral lingual foramen, interalveolar foramen, and innominate nutrient foramen, and the neurovascular bundle enters through these foramen into the mandible according to previous researches using magnetic resonance

imaging and histology (Liang et al., 2005). Among these accessory foramen, the lingual foramen, which locates near by the mental spine at the mandibular symphysis, is very high 81-100% in frequency (Kim et al., 2015). A branch of the sublingual artery and the lingual nerve or the mylohyoid nerve mainly enters through this foramen into the anterior mandible (Kalpidis, & Setayesh, 2004; Liang et al., 2005; McDonnell, Reza Nouri, & Todd, 1994; Liang et al., 2007). Often, the submental artery, a branch of the facial artery, enters by perforating the mylohyoid muscle (Rosano et al., 2009; Liang et al., 2007; Gakonyo et al., 2015). As a result, when bleeding occurs due to damage of this foramen during surgical operation, clinician may arise a confusion in deciding which artery should be quickly ligation (Kalpidis, & Setayesh, 2004; Rosano et al., 2009). And it is called as various nomenclatures such as medial lingual foramen, genial foramina, genial spinal foramina, and midline lingual foramen according to the literature (Kim et al., 2015).

The lateral lingual foramen, which locates close to the inferior border of the mandible in the opposite side of the mental foramen, is the cause of life threatening sublingual hematoma due to the damage of the foramen after implant placement (Yu et al., 2016; Uchida et al., 2015; Nakajima et al., 2014). This mainly passes through the submental artery and mylohyoid nerve, and often supplies by a branch of the sublingual artery and the lingual nerve (Kalpidis, & Setayesh 2004;

Tagaya et al., 2009; Gahleitner et al., 2001). This is also variously named as posterior lingual foramen, paramedian lingual foramen, and nutrient foramen (Yu et al.,2016).

In addition, these accessory foramen vary the frequency, location, diameter and distribution according to the their type (Moro et al., 2018; Przystańska, & Bruska, 2012; Kim et al., 1993). There are also reports that its frequency and diameter increase in male, age, morbidity of periodontal disease, and edentulous patient (He et al., 2016; Bilge, Harorli, & Yilmaz, 1992). Therefore, it is necessary to clearly classify the accessory foramen as a constant anatomical structure that appears at a particularly high frequency and investigate its morphologic characteristics including status of tooth loss and sex in the elderly person for understanding of the clinician (Moro et al.,2018; Przystańska, & Bruska, 2012; Yu et al., 2016).

The cone-beam computed tomography (CBCT) has a high resolution and is widely used for precise evaluation of anatomical structures before surgical procedures (Wang et al., 2015; von Arx T et al., 2011; Makris et al., 2010). In particular, a retrospective study using CBCT images enables analysis of various fine structures in the maxillofacial region without additional radiation to the patient, acquisition 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 evaluate the morphologic characteristics of the lingual foramen and

the lateral lingual foramen in the elderly person using cone beam computed tomography.

Ⅱ. Materials and methods

This study was randomly selected images of 180 adult patients who visited Chosun University Dental Hospital and took CBCT from April to December 2016. And then, 99 patients over 50 years of age were extracted, and excluded again according to exclusion criteria except status of tooth loss. Syndromes, systemic diseases, craniofacial anomalies, fracture or surgical treatment, pathologic conditions affecting the mandible, inadequate image quality due to shaking, and inferior border of the mandible not visible were excluded. A total of 80 subjects consisted of 39 males and 41 females were selected for the final study and their mean age was 65.2±8.8 years old with age range of 50~81 years old. 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 as outlined in the Declaration of Helsinki.

The CBCT scanning was performed using 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 scanning was a cylindrical with a diameter of 17 cm and a height of 13.5 cm, with 0.3 mm voxel. The exposure parameters were 90 kVp and 5 mA. The images were saved in Digital Imaging and Communications in Medicine format. The obtained CBCT images were

retrospectively analyzed by two dentists with more than 10 years of experience using 3D imaging analysis software (OnDemand3D™, Cybermed, Seoul, Korea). Measurements were performed at the same magnification by setting the magnification of the image constant.

The lingual and lateral lingual foramina were defined and measured only when both 2 observers observed them. The lingual foramen classified into the superior lingual foramen, the foramen at level of mental spine, and the lingual foramen according to the based on level of the mental spine. And the lateral lingual foramen was defined when it locates below the root apex. First, the prevalence and number of the lingual foramen and the lateral lingual foramen were investigated. The diameter of each foramen was measured at the point where the canal starts within the orifice of the foramen. The height to upper margin of each foramen and the bone height to alveolar crest of the mandible from the inferior border of the mandible were also measured. The lateral lingual foramen evaluated the location based on the tooth position, and then classified into the incisor (including the canine), the premolar, and the molar regions. At this time, edentulous patients were divided into 3 tooth regions based on the canine eminence and the mental foramen. The lingual foramen was evaluated the direction from the lingual surface to the labial surface based on the sagittal plane (upward, horizontal, and downward) and the lateral lingual foramen was also investigated its direction based on the sagittal plane and

transverse plane (forward, perpendicular, and backward) (Fig. 1). And the lateral lingual foramen was investigated the status of the communication with the mandibular canal or the incisive canal. It was examined two times by 2 observers on another day.

Statistical analysis of all obtained measurement data was performed using SPSS 12.0 (Chicago, IL, USA). First, as a result of analyzing the reliability between observers, Cronbach α appeared to be high from 0.705 to a maximum of 0.887 depending on the measurement item, and subsequent analyzes used the average of the measured values of the two observers. Two-independent samples t test was performed to confirm the difference according to left and right, sex, and status of tooth loss in all measurement items. At this time, there was no significant difference between the left and right in all items ($P>0.05$), thus the left and right were evaluated as the same group of each variable. The lingual foramen according to the level based on the mental spine and the lateral lingual foramen according to the mandibular tooth region were examined for significant differences using one-way ANOVA, and a post-hoc comparison with the Scheeffe test was then performed. The foramen with a diameter larger than 1 mm was further analyzed. The mean and standard deviation values were calculated for all measured values, and the significance level was 0.05.

Ⅲ. Results

All the elderly person had at least one the lingual foramen, and had 2 or 3 foramen in 77.5% (Table 1). The superior lingual foramen above the mental spine was observed in 92.5% of the patient and coursed downward toward the labial side in 92.3%. The inferior lingual foramen below the mental spine was observed in 122 large numbers in 92.5% of the patient and coursed upward in 68.0% (Fig. 2). In one case, a median perforating foramen (It reported as a case report by Iwanaga et al. (Iwanaga et al., 2016) and named.), which connected to the labial surface, was observed (Fig. 3). Both the superior and the inferior lingual foramina showed higher prevalence in male compared to female. The foramen at level of mental spine was observed in 31 small numbers in 26 patients and coursed a horizontal direction in 90.3% (Table 2).

The mean diameters of the superior lingual foramen, foramen at level of mental spine, and inferior lingual foramen were 0.81±0.25, 0.59±0.19, and 0.59±0.18 mm, respectively. In particular, the superior lingual foramen had a significantly larger diameter, and the male had a significantly larger diameter than the female. The mean height of the superior lingual foramen, foramen at level of mental spine, and inferior lingual foramen from the inferior border of the mandible were 15.19, 10.22, 4.52 mm, respectively, and there were significant differences

according to level based on the mental spine (Table 2). There was no statistical difference whether the tooth loss in all measurement items. And the mean bone height from the inferior border of the mandible is 33.37±2.64 mm in dentulous patients (33.32±2.97 mm in male, 31.96±3.93 mm in female) and 28.35±4.95 mm in edentulous patients (29.89±3.93 mm in male, 26.82±5.72 mm in female). Although the mean bone height did not differ according to sex, there was a significant difference in dentulous patients compared to edentulous patients (P=0.039).

The lateral lingual foramen in the lingual surface of the mandible was observed 91.3%, especially, dentulous patients showed the highest frequency of 21.6% at the second premolar (Table 3). In the incisor region, the lateral lingual foramen was observed in 61.6%, and the mean diameter was 0.57 mm and the mean height from the inferior border of the mandible was 9.86 mm, which was significantly smaller and higher than that of other tooth regions. They were driven horizontally (51.6%) and perpendicular (67.7%) toward the labial surface. In the premolar region, the lateral lingual foramen showed the highest frequency at 72.6%, the mean diameter was significantly larger as 0.73 mm, the mean height was 7.91 mm, and communicated with the mandibular canal or incisive canal in 59.4%. They traveled upward (63.8%) and forward (87.0%) direction toward the buccal side (Fig. 4). In the molar region, the lateral lingual foramen was observed at

43.8%, the mean diameter was 0.70 mm, the mean height was 8.34 mm, and communicated with the mandibular canal in 38.1%. They coursed upward (66.7%) and forward (76.2%) toward the buccal side (Table 4 & 5). Except for the mean bone height from the inferior border of the mandible, there was no significant difference according to sex and status of tooth loss in all measurement items.

The lingual foramen with a larger diameter than 1 mm was highly found 31.0% in the superior lingual foramen and its mean diameter of the female was 1.14 mm that was significantly larger than the male 1.09 mm. The lateral lingual foramen with a larger diameter than 1mm was frequently observed at 17.0% in the premolar region and communicated with the mandibular canal or incisive canal in 70%. In particular, the mean height from the inferior border of the mandible in the female was 8.38 mm, which was significantly higher compared to the male 7.39 mm (Table 6).

Ⅳ. Discussion

For reconstruction of atrophic mandibles after tooth loss due to causes such as periodontal disease, dental caries, wear, and tooth fracture, placement of dental implants is largely considered as safe and minimally invasive prosthetic treatment including implant-supported prostheses and implant-retained overdentures (Kalpidis, & Setayesh, 2004; Wang et al., 2015). However, it has been reported steadily unexpected complications such as life threatening hematoma, temporary nerve disturbance, or long lasting neuropathy after implant placement in the edentulous mandible (Kusum et al., 2015; Peñarrocha-Diago et al., 2019; Limongelli et al., 2015). In addition, other surgical procedures such as extraction, flap operation, torus removal, and osteotomy can also cause a hemorrhage in the floor of the mouth (Wang et al., 2015; Moro et al., 2018).

These surgical complications can occur as a result of damage to the external vascular supply passing through the accessory foramen because of excessive reflection of the lingual mucoperiosteal flaps for implant-bed preparation or perforation of the lingual cortical plate by instrumentation (Kalpidis, & Setayesh, 2004; von Arx T et al., 2011). Besides, if the patient has a hypertension or abnormal hemostasis or takes an anticoagulant drug, bleeding may be more dangerous (Kim, Kim, & Kim, 2013). In the elderly person with high morbidity for

these chronic diseases, attention to these accessory foramen is more required during surgical procedures such as implant placement, genioplasty, and bone grafting. Therefore, this study investigated the morphologic characteristics of the lingual foramen and the lateral lingual foramen according to sex and status of tooth loss in the elderly person.

In this study, there was at least one lingual foramen in all subjects, and this result was consistent with the high expression of 96.2-100% in previous studies using CBCT or micro-CT (Wang et al. 2015; Moro et al., 2018; von Arx et al., 2011; He et al. 2016;Choi et al., 2013). At this time, the mental spine located at the lingual surface of the mandibular symphysis is two pairs of protruding parts and is attached different muscles to each pair, and its shape and positional relationship are diverse (Kim et al., 1993). And the lingual foramen are located above and below these mental spine. The direction and diameter of the lingual foramen are different depending on the level, as a result, their possibility of damage is markedly different because of the distance from the alveolar crest during surgical procedures (Makris et al., 2010; Kim et al. 2015; Kim et al., 1993; Choi et al. 2013). In particular, in edentulous patients, since the superior lingual foramen are located very close to the alveolar crest due to the resorption of the alveolar bone, it should be required very high attention to place an implant longer than 13mm in the anterior mandible (Rosano et al., 2009). Therefore, it is

necessary to analyze the lingual foramen by subdividing it based on the mental spine.

As a result of this study, when there were two or more the lingual foramen, there consisted one superior lingual foramen and a number of the inferior lingual foramen that had a small diameter and located near the inferior border of the mandible. The superior lingual foramen had a mean diameter of 0.81 mm and a mean height from the inferior border of the mandible of 15.19 mm, which was significantly larger than that of other levels of foramen. And most of them were traveled inclined downward from the orifice of the foramen. In previous researches, the mean diameter of the superior lingual foramen ranged from 0.71 to 1.05 mm and the mean height was 9.32 to 15.09 mm showing a larger diameter and height than the inferior lingual foramen, and most of them were coursed downward (Wang et al., 2015; moro et al., 2018; von Arx et al., 2011; Makris et al., 2010; He et al., 2016; Choi et al., 2013). Like this, the overall morphological characteristics and the tendency of the frequency were similar to those of previous studies, but the mean values of diameter and height were slightly different. In addition, in this study, there was no significant difference in all measurement items according to the status of tooth loss, but males with relatively large mandible showed significantly higher frequency, larger diameter, and higher height. Thus, it could consider that it is more appropriate to evaluate this by individual differences than by age.

In forensic dentistry, the lingual foramen also has a unique identifying feature like fingerprint, thus they suggest its possibility of a potential role for identification (Mowafey et al., 2015).

When the diameter of the accessory foramen is larger than 1 mm, it has great implications for clinicians because a greater amount of blood flows through it and the possibility of complications such as hemorrhage or nerve disorder due to its injury increases (Gahleitner et al., 2001; Lustig et al., 2003). Previous studies reported that the frequency of superior lingual foramen with a larger diameter than 1 mm was 11.9% or 21.23% and that of males was higher (Wang et al., 2015; He et al., 2016). On the other hand, this study on the elderly person showed a high frequency of 31.0%, and in particular, females were 1.14mm, which was significantly larger in diameter and frequency than males. This could imply that female patients with a osteoporosis after a menopause need more attention.

A large number of the accessory foramen exist on the lateral side of the mandibular symphysis. However, since the lateral lingual foramen located close to the inferior border of the mandible in the premolar region and the interalveolar foramen running perpendicularly downward located close to the alveolar crest in the incisor region have different morphological features, it needs to distinguish them based on the root apex (Kalpidis, & Setayesh, 2004; Moro et al., 2018, Yu et al., 2016). In this study, we focused on the lateral lingual foramen, which has a

high probability of sublingual hematoma due to its injury. As a result, it was observed with a very high frequency of 91.3%, especially 72.6% in the premolar region. These lateral lingual foramen in the premolar region was large with a mean diameter of 0.73 mm, the mean height was 7.91 mm, which was located closer to the inferior border of the mandible. It communicated with the mandibular canal or the incisive canal in 59.4% and travelled upward and forward. Previous researches using CBCT also showed high frequency in the premolar region, especially in the second premolar and reported the mean diameter in the range of 0.6 to 0.9 mm, the mean height in the range of 6.78 to 9.50 mm, and communication with the mandibular canal or incisive canal by running forward at 68.5% (Wang et al. 2015; Moro et al., 2018; von Arx et al., 2011; He et al. 2016; Tagaya et al., 2009; Gahleitner et al., 2001; Kim, Kim, & Kim, 2013). And there are different results for the statistical difference between sex and age with respect to its mean diameter and height (Wang et al., 2015; Kim, Kim, & Kim, 2013). But in this study, although they did not show any significant difference in measurement items according to sex and status of tooth loss, the lateral lingual foramen in the premolar region had significant differences in mean diameter and mean height compared to other tooth regions.

The lateral lingual foramen in the premolar region is difficult to observe in panoramic radiography and perpendicular x-ray beams

because its canal running into the mandible is thin cortification, mesial course, and overlapping with the opposite mandible and cervical vertebrae (Moro et al., 2018; Gahleitner et al., 2001). Therefore, inexperienced surgeons should pay more attention to these anatomical structures during implant placement (Kalpidis, &Setayesh, 2004). In this study on the elderly person, the lateral lingual foramen with a diameter larger than 1 mm in the premolar region was observed more frequently at 17.0% than 10.9% of the previous research (Wang et al., 2015), and especially 70% of them communicated with the mandibular canal or incisive canal. This high figures in the elderly person suggests that the lateral lingual foramen in the premolar region has more lingual vascular and neural supply to the mandible, consequently it can easily occur surgical complications such as bleeding or nerve disorder due to the damage of the foramen. In addition, its communication with the mandibular canal or the incisive canal can explain a potential portal for tumor spread (Trikeriotis et al., 2008).

As a result of this study, although the lingual foramen and the lateral lingual foramen in the elderly person were observed at very high frequencies, 100% and 91.3%, respectively, it was caused by an increase in the frequency of the inferior lingual foramen and the lateral lingual foramen in the incisor region with relatively small diameter. In other words, since the lingual foramen showed a significantly larger diameter and higher height in males without any difference in status of

tooth loss, it is considered more the difference between individuals. Also, the lateral lingual foramen was no difference according to sex and status of tooth loss, thus it is necessary to consider them in the premolar region with a significantly higher frequency and large diameter.

In particular, clinicians should be very careful about accessory foramen with a larger diameter than 1mm in surgical procedures. In the elderly person, the superior lingual foramen with a large diameter is a high frequency of 31.0% and the lateral lingual foramen in the premolar region, which has a high frequency of 17.0%, showed 70.0% high communication with mandibular canal. In particular, women with large osteoporotic changes after a menopause showed significantly higher frequency and large diameter. In conclusion, because the blood supply of the mandible changes from centrifugal to centripetal circulation due to tooth loss and arteriosclerotic changes of the inferior alveolar artery, increased diameter of the lingual foramen and lateral lingual foramen with age can also increase blood supply through this foramen from external circulation. These findings could provide quantitative data on the lingual foramen and the lateral lingual foramen to avoid surgical complications in the elderly person.

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FIGURES

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 (arrowhead) 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 upper margin of each foramen and the bone height to alveolar crest of the mandible from the inferior border of the mandible were also measured. The lingual foramen was evaluated the direction based on the sagittal plane. And the lateral lingual foramen was evaluated the location related to the tooth position, the direction based on the sagittal and transverse planes, and whether the communication with the mandibular canal or the incisive canal.

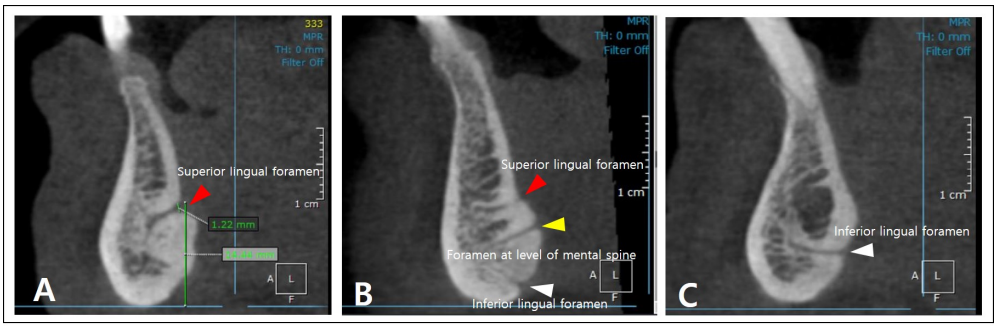

Fig. 2. CBCT images of the lingual foramen according to the based on level of the mental spine in the elderly person.

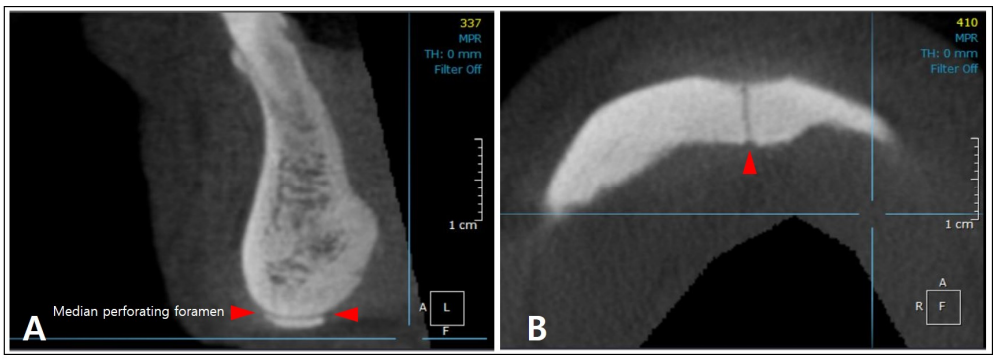

Fig. 3. CBCT images of the median perforating foramen in the elderly person. A, sagittal image; B, axial image.

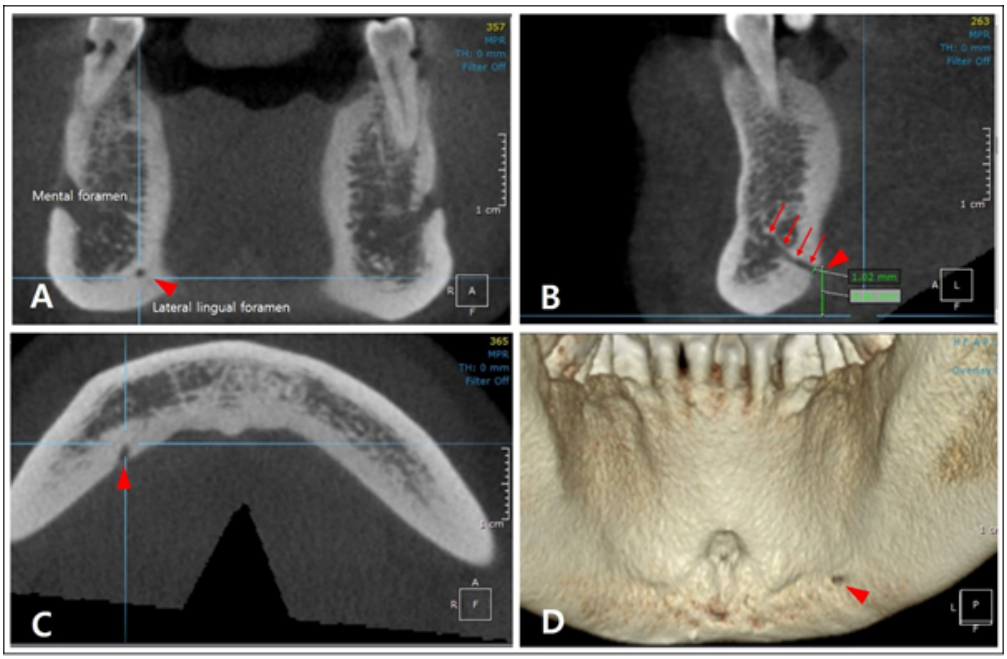

Fig. 4. CBCT images of the lateral lingual foramen in the premolar region with a greater diameter than 1 mm in the elderly person. A, coronal image; B, sagittal image; C, axial image; and D, 3D reconstructions of CBCT images. The arrows indicate that the lateral lingual foramen communicated with the mandibular canal or the incisive canal.

Table 1. Frequency of subjects according to the number of the lingual foramen observed

No. of Foramen	0	1	2	3	4	5	6	Overall
No. of subjects observed (%)	0	3 (3.75%)	27 (33.75%)	35 (43.75%)	9 (11.25%)	3 (3.75%)	3 (3.75%)	80 (100%)

Table 2. Morphologic characteristics of the lingual foramen according to the sex in the elderly person

	No. of subjects observed (%)	No. of occurrence (%)	Diameter of Foramen (mm)	Vertical distance of Foramen (mm)	Direction		
					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 level of 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. *, **, and *** indicate that the lingual foramen differs significantly on the sex in each measurement item using two independent samples t test (P <0.05). The superscript indicates that there are a significant difference between the same letters in each measurement item using one-way ANOVA (P <0.05).

Table 3. Presence of the lateral lingual foramen related to the tooth position in the dentulous elderly person

	CI	LI	C	P1	P2	M1	M2	Overall value
No. of presence	7	27	23	26	33	30	7	153
Incidence	4.6%	17.6%	15.0%	17.0%	21.6%	19.6%	4.6%	100%

CI, central incisor; LI, lateral incisor; C, canine; P1, first premolar; P2, second premolar; M1, first molar; M2, second molar.

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Table 4. Morphologic characteristics of the lateral lingual foramen (LLF) categorized into 3 mandibular teeth region according to the sex in the elderly person

	No. of subjects observed (%)	No. of occurrence (%)	Diameter of Foramen (mm)	Vertical distance of Foramen (mm)	Height of Mandible (mm)	No. of communication (%)
LLF in incisor region	61.6% (45/73)	35.8% (62/173)	0.57±0.15^{ab}	9.86±4.13^{c}	31.36±4.13	12.9% (8/62)
Male	57.1% (20/35)	46.8% (29/62)	0.58±0.16	10.43±4.30	32.70±1.92*	17.2% (5/29)
Female	65.8% (25/38)	53.2% (33/62)	0.57±0.14	9.03±3.84	30.20±5.12*	9.1% (3/33)
LLF in premolar region	72.6% (53/73)	39.9% (69/173)	0.73±0.20^{a}	7.91±1.85^{c}	31.45±4.61	59.4% (41/69)
Male	71.4% (25/35)	50.7% (35/69)	0.74±0.19	7.92±1.51	32.21±5.07	74.2% (26/35)
Female	73.7% (28/38)	49.3% (34/69)	0.72±0.21	7.91±2.18	30.66±4.00	44.1% (15/34)
LLF in molar region	43.8% (32/73)	24.3% (42/173)	0.70±0.18^{b}	8.34±1.91	32.68±3.13	38.1% (16/42)
Male	37.1% (13/35)	42.9% (18/42)	0.73±0.16	8.45±2.05	34.00±3.42**	55.5% (10/18)
Female	50.0% (19/38)	57.1% (24/42)	0.68±0.20	8.26±1.84	31.71±2.55**	25.0% (6/24)

The incisor region includes central incisor, lateral incisor, and canine. The communication means that the lateral lingual foramen communicates with the mandibular canal or the incisive canal.

Table 5. Direction of the lateral lingual foramen based on the sagittal and transverse planes

	Sagittal plane			Transverse plane		
	Upward	Horizontal	Downward	Forward	Perpendicular	Backward
LLF in 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 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 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)

Table 6. Morphologic characteristics of the superior lingual foramen and the lateral lingual foramen in premolar region with a larger diameter, ≥1 mm according to the sex in the elderly person

	Frequency (%)	Occurrence rate (%)	Diameter of Foramen (mm)	Vertical distance of 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
LLF in premolar region	17.0% (9/53)	14.5% (10/69)	1.07±0.06	7.89±1.72
Male	16% (4/25)	11.4% (4/35)	1.10±0.07	7.39±0.22*
Female	17.9% (5/28)	17.6% (6/34)	1.06±0.05	8.38±2.19*