Distribution of the lingual foramina in mandibular cortical bone in Koreans

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Objectives: The interforminal region, between the mandibular foramen, is known as a relatively safe area that is free of anatomic structures, such as inferior alveolar nerve, submandibular fossa, and lingual side of the mandible is occasionally neglected for its low clinical importance. Even in the case of a severely constricted alveolus, perforation of the lingual cortical bone had been intended. However, anterior extension of the inferior alveolar canal, important anatomic structure, such as concavity of lingual bone, lingual foramina, and lingual canal, has recently been reported through various studies, and untypical bleeding by perforation of the lingual plate on implantation has also been reported. Therefore, in this study, we performed radiographic and statistical analysis on distribution and appearance frequencies of the lingual foramina that causes perforation of the mandibular lingual cortical bone to prevent complications, such as untypical bleeding, during surgical procedure.

Materials and Methods: We measured the horizontal length from a midline of the mandible to the lingual foramina, as well as the horizontal length from the alveolar crest to the lingual foramina and from the lingual foramina to the mandibular border by multi-detector computed tomography of 187 patients, who visited Dankook University Dental Hospital for various reasons from January 1, 2008 to August 31, 2012.

Results: From a total of 187 human mandibles, 110 (58.8%) mandibles had lingual foramina; 39 (20.9%) had bilateral lingual foramen; 34 (18.2%) had the only left lingual foramen; and 37 (19.8%) had the only right lingual foramen.

Conclusion: When there is consistent bleeding during a surgical procedure, clinicians must consider damages on the branches of the sublingual artery, which penetrate the lingual foramina. Also, when there is a lingual foramina larger than 1 mm in diameter on a pre-implantation computed tomography, clinicians must beware of vessel damage. In order to prevent these complications and progress with a safe surgical procedure, a thorough radiographic examination before the surgery is indispensable. Further, clinicians should retract lingual flap definitely to confirm the shape of the lingual bone and existence of the lingual foramina.

Key words: Mandible, Dental implant, Computed tomography, Hemorrhage, Trigeminal nerve injuries

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safe areas, the lingual aspect of the mandible has been viewed as less clinically significant. Even in cases of alveolar bone atrophy, penetration of lingual cortical bone is recommended for denture implants. Recent studies, however, have demonstrated the existence of structures that could in fact cause complications: the anterior dilatation of inferior alveolar neural tubes, concavity of lingual bones, lingual foramina, and lingual tubes. Moreover, many cases of atypical hemorrhage have been caused by lingual plate perforation.

The sublingual and submental arteries run under the lingual aspect of the mandible, sending branches to the mylohyoid muscle, peripheral muscles, mucous membrane, and gingiva. These mucosal branches settle along the lingual aspect of the mandible and may require special care prior to surgery since they are known to deposit lingual cortical bone into the mandible. This study performed radiological and statistical analyses on the appearance frequency and distribution of lingual foramina in mandibular cortical bone in Koreans, with the aim of preventing clinical complications during surgical procedures.

II. Materials and Methods

1. Subjects

We examined 187 patients who had undergone CT scans at Dankook University Dental Hospital (Cheonan, Korea) between January 1, 2008 and August 31, 2012. Mandibles with intraosseous lesions or fractures in the target area were excluded.

Three observers measured the locations of the lingual foramina three times a week, using discriminable images of the axial, sagittal, and coronal views from MDCT (WCT-345-130, Somatom Emotion 6; Siemens AG, Munich, Germany). Of 187 patients, 121 were male and 66 were female. The average age (±standard deviation [SD]) was 33.13±15.40 years.

This study was conducted after obtaining approval from the Institutional Review Board.

2. Methods

The sagittal and axial CT images were used for measurements. In the sagittal view, three horizontal base lines and one vertical base line were established. The first horizontal base line (line A) was tangent to the mandibular margin in the buccolingual direction; the vertical base line (line V) was perpendicular to line A. The second horizontal line (line B) was perpendicular to line V, passing through the lingual foramina. The third horizontal line (line C) was tangential to the top of the alveolar bone crest, perpendicular to line V. According to these standards, vertical distance 1 (VD1) and vertical distance 2 (VD2) were measured in order, as shown in Fig. 1.

Next, one horizontal base line (line M) and one vertical base line (line H) were set. Line M was a straight line that precisely divided the mandible into two in the axial view. Line H was perpendicular to line M, passing through the fenestra of the lingual foramina. The horizontal distance (HD) was measured using images acquired based on these standards, as shown in Fig. 2.

3. Statistical methods

Statistical analyses at 95% confidence level were carried out using PASW Statistics version 18.0 (IBM Co., Armonk, NY, USA).

III. Results

1. Proportion of lingual foramina in mandibular cortical bone

Lingual foramina existed in 110 (58.8%) of 187 man-
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2. Horizontal distance

HD refers to the distance from the lingual foramina to the central base line that divides the mandible into two sections. For the left-sided foramina, the mean HD value (±SD) was 1.57±0.41 mm, the minimum value was 0.84 mm, and the maximum value was 3.68 mm. For right-sided foramina, the mean HD value (±SD) was 1.61±0.33 mm, the minimum value was 0.84 mm, and the maximum value was 2.62 mm.

3. Vertical distance 1

VD1, the vertical distance from the lingual foramina to the top of the alveolar bone crest, had a mean value (±SD) of 2.40±0.31 mm, minimum value of 0.90 mm, and the maximum value of 2.90 mm on the left side and a mean value (±SD) of 2.40±0.34 mm, minimum value of 0.70 mm, and maximum value of 3.10 mm on the right side.

4. Vertical distance 2

VD2, the distance from the lingual foramina to the inferior margin of the mandible, had a mean value (±SD) of 0.68±0.25 mm, minimum value of 0.34 mm, and maximum value of 2.29 mm on the left side and a mean value (±SD) of 0.68±0.28 mm, minimum value of 0.31 mm, and maximum value of 2.61 mm on the right side.

5. Tooth number and lingual foramina

Since lingual foramina can be located relative to tooth numbers, teeth are important reference points in implant surgery. A tooth number was recorded when the baseline of VDI met the alveolar ridge line. The second mandibular premolar was the most frequently recorded tooth on both sides, followed by the first mandibular premolar. No lingual foramina were noted in association with the lower lateral incisor on the right side. (Table 2)

6. Correlations with age and gender

In this study, lingual foramina were observed in 58.8% of the patients. There were no significant correlations between lingual foramina and age, gender, left or right side of the mandible, HD, VDI, or VD2.

IV. Discussion

Small foramina are often observed on the anterior surface of the mandible and near the premolars of the lingual man-

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**Table 1.** The appearance ratios of lingual foramina

| Appearance site | Left lingual foramina, n (%) | Right lingual foramina, n (%) |
|-----------------|------------------------------|------------------------------|
| Left only       | 34 (18.2)                    | -                            |
| Right only      | 37 (19.8)                    | 9                            |
| Bilateral       | 39 (20.9)                    | 18                           |
| None            | 77 (41.1)                    | 38                           |
| Total           | 187 (100.0)                  | 76                           |

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**Table 2.** Lingual foramina positions

| Tooth number   | Left lingual foramina | Right lingual foramina |
|----------------|-----------------------|------------------------|
| Lateral incisor| 3                     | -                      |
| Canine         | 5                     | 9                      |
| First premolar | 23                    | 18                     |
| Second premolar| 33                    | 38                     |
| First molar    | 6                     | 9                      |
| Second molar   | 7                     | 2                      |
| Total          | 77                    | 76                     |

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Fig. 2. Reference lines used in measurement on the axial views of multi detector computed tomography. (M: midline of mandible, H: vertical base line, HD: horizontal distance from midline to lingual foramina)
In 1986, there have been numerous case reports of severe hemorrhage during surgical procedures on the area between the lingual mandible and mental foramen (dental extraction, removal of lingual torus, biopsy, mandibulectomy, and denture implantation)\(^{21-27}\). According to these studies, most complications are caused by perforations to the lingual cortical bone during implant placement in the canine region\(^{28}\); this region contains the sublingual branches of the lingual and facial arteries, which anastomose before entering the lingual foramina, forming branches of the inferior alveolar artery\(^{8}\).

According to these cases, immediate bleeding and severe edema during implant surgery are due mostly to direct damage of the sublingual arteries, as a consequence of lingual cortical bone perforation. In cases of delayed bleeding, the possibility of damage by perforating sublingual artery branches must be considered. Moreover, bleeding risk must be assessed if the patient has hypertension or hemostatic disorder or takes anticoagulant drugs. Pre-surgical risk should also be assessed if the diameter of the foramen is greater than 1 mm on CT scan. Elderly patients who need alveoloplasty for denture procedures and patients who have severe alveolar bone atrophy are at increased risk, as their lingual foramina are close to the alveolar ridge; the appearance frequency of lingual foramina in these patients is also high.

Edema must be recognized as a key indicator of surgical bleeding. Damage to the perforating artery as it passes through the lingual foramen can cause edema, in which case, pressure should be applied to the lingual face of the mandible, and antihemorrhagics emergently administered\(^{29}\). When the bleeding ceases, antibiotics and steroids should be considered\(^{30}\).

**Fig. 3.** Vertical distance from mandible border to lingual foramina (vertical distance 2, VD2) according to the distance from the midline.

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Mandibular lingual foramina are difficult to identify on a panoramic X-ray because the cervical vertebrae overlap with the beam’s trajectory\(^1\). However, high-resolution CT is able to visualize the complex neurovasculature of the inter-foraminal space without distortion. CT scans are thus indispensable to pre-surgical evaluation, particularly for procedures such as dental implants, mandibular augmentation, and genioplasty. Pre-surgical scans should be used to evaluate volume, width, and shape of the mandible, as well as other anatomical structures.

V. Conclusion

This study aimed to investigate atypical hemorrhage and edema resulting from implant placement between the mental foramen, an area known to be ‘safe’ due to its lack of anatomically vulnerable structures. Our research on the lingual foramina, which are yet unclassified structures, investigated 187 patients presenting to Dankook University Dental Hospital via MDCT. We drew the following conclusions:

1. Lingual foramina existed in 110 (58.8%) of 187 mandibles. With regard to the distribution of the foramina, 39 (20.9%) were bilateral, 34 (18.2%) were left-sided, and 37 (19.8%) were right-sided.

2. The location of the lingual foramina varied from the lower lateral incisor to the second molar tooth, appearing most frequently in the second premolar tooth. Fig. 3 shows the vertical distance of the lingual foramina according to the distance from the center line.

3. VD2, the distance from the lingual foramina to the inferior margin of the mandible, had a mean value (±SD) of 0.68 ±0.25 mm, a minimum value of 0.34 mm, and a maximum value of 2.29 mm on the left side and a mean value (±SD) of 0.68±0.28 mm, a minimum value of 0.34 mm, and a maximum value of 2.61 mm on the right side.

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