Observation of buccal foramen in mandibular body using cone-beam computed tomography

By

Munetaka NAITOH¹, Kino NAKAHARA¹, Yuichiro HIRAIWA¹, Hidetoshi AIMIYA¹, Kenichi GOTOH² and Eiichiro ARIJI¹

¹Department of Oral and Maxillofacial Radiology, School of Dentistry
²Division of Radiology, Dental Hospital, Aichi-Gakuin University, Nagoya, Japan

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Summary: The location and course of the mandibular canal and multiple mental foramina are important in dental implant insertion and any surgical procedures involving the mandible. The purpose of the present investigation was to assess buccal foramen presence in the mandible using cone-beam computed tomography (CBCT) images.

A total of 84 patients were enrolled in this investigation. Buccal foramen presence in the mandibular body, which was defined as a buccal bone defect of the bony canal penetrating through the buccal cortical bone, was assessed using two- and three-dimensional CBCT images.

Buccal foramen presence, located from the median to molar regions, was observed in 44% of patients. There was no significant difference among gender and age. Also, a buccal foramen showing continuity with the mandibular canal was observed in 7.1% of patients.

Buccal foramen presence in the mandibular body could be assessed in detail using CBCT images.

Introduction

The location and course of the mandibular canal, and the location and number of mental foramina are important in dental implant insertion and any surgical procedures involving the mandible.

Recently, the course of the mandibular canal, such as the bifurcation and anterior loop, multiple mental foramina, mandibular incisive canal, and lingual foramen have been assessed using helical computed tomography (CT) and cone-beam computed tomography (CBCT) images¹–⁸. Jacobs et al. (2002)⁷ reported that the lingual foramen could be detected in 82% of cases using spiral CT scan images for the preoperative planning of implant placement. Also, on macroscopic observation, Liang et al. (2007)⁹ reported that the content was found to be derived from the lingual artery and lingual nerve for the superior genial spinal canal, and Kawai et al. (2006)¹⁰ reported that the branches of the inferior alveolar artery ran through the bony lingual canal to the lingual foramen between the canine and premolar regions of the mandible.

Although we have often experienced foramen presence on the buccal side of the mandible in addition to the mental foramen using CBCT images, in which the resolution is reportedly higher than that with helical CT images¹¹, its location and occurrence have not been assessed. Also, some foramina, which are continuous with the mandibular and incisive canals, of the buccal side foramina might be important in dental implant insertion.

The purpose of the present investigation was to clarify the location and rate of occurrence of buccal foramina, as well as continuity between the buccal foramen and mandibular or incisive canals using CBCT images.

Materials and Methods

Subjects

A total of 84 patients (27 males and 57 females) that had undergone preoperative imaging of dental implant treatment using CBCT were enrolled in this investigation. The overall mean age was 52.1 years (range: 19–77 years, s.d.: 14.3 years), being 54.4 years (s.d.: 14.4 years) in males and 50.8 years (s.d.: 14.1 years) in females.
CBCT images
A CBCT unit, Alphard VEGA (Asahi Roentgen Ind., Co., Kyoto, Japan) with a flat panel detector was used. The exposure volume was set at 102 mm in diameter and 102 mm in height (I-mode), and the voxel size was 0.2 mm × 0.2 mm × 0.2 mm. The scan was set at 80 kV and 5 mA, as recommended by the manufacturer.

The DICOM files of the axial images were saved to a portable hard disk (HD).

Observation of the buccal foramen
One oral and maxillofacial radiologist (M.N.) reconstructed and observed images as follows. Two-dimensional (2-D) images of various planes and three-dimensional (3-D) images in the mandibular body region were reconstructed on a computer (Macintosh G4, Apple Computer Inc., USA) using 3D visualization and measurement software (OsiriX Imaging Software, the OsiriX Foundation, Geneva, Switzerland, URL: http://www.osirix-viewer.com). Subsequently, buccal foramen presence was observed in the mandibular body from the anterior to posterior regions. The buccal foramen was defined as a canal penetrating the buccal cortical bone from the buccal bone surface was observed, and the mental foramen was excluded (Fig. 1).

The location and occurrence of buccal foramen presence
At first, the occurrence of the buccal foramen presence by sex and age was assessed. Then, the mesio-distal and superior-inferior location of the buccal foramen, and the continuity between the buccal foramen and mandibular canal, and between the buccal foramen and incisive canal, were recorded. The mesio-distal location was classified into two regions: the anterior and posterior regions of the mental foramen, and, moreover, the anterior region was classified into three regions: the median, incisor, and premolar regions. The superior-inferior location was classified into two regions: the superior and inferior regions of the root apex of the neighboring tooth. When continuity between the buccal foramen and mandibular canal was observed, the distance between the buccal foramen and point of bifurcation from the mandibular canal was measured.

Statistical analysis
The differences between males and females and between age groups were evaluated using Chi-square statistics. Differences were considered significant at P < .01.

Results
Buccal foramen presence was observed in 37 of 84 patients (44%), comprising 24 of 57 females (42%) and 13 of 27 males (48%). There was no significant difference between males and females. For age, patients were classified into 3 groups: less than 30 years old, between 30 and 60 years old, and more than 60 years old. Buccal foramen presence was observed in 5 of 9 patients (56%) less than 30 years old, in 21 of 46 (46%) between 30 and 60 years old, and in 11 of 29 (38%) more than 60 years old. There was no significant difference among 3 groups for age.

Buccal foramen presence was observed in 2 median, 29 left and 19 right sides. One medial buccal foramen was observed in two patients, and one buccal foramen was observed in 29 sides, two foramina in 13 sides, three in 5 sides, and five in 1 side. The locations of buccal foramina are shown in Table 1 and Fig. 2. Thirty-six foramina were in the incisor region, 26 were in the

<table>
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<tr>
<th>Table 1. Locations of buccal foramina.</th>
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<th>Anterior to the mental foramen</th>
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<th>Posterior to the mental foramen</th>
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<tr>
<td></td>
<td></td>
<td>Superior to the root apex</td>
<td>0</td>
<td>2</td>
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<tr>
<td></td>
<td></td>
<td>Inferior to the root apex</td>
<td>1</td>
<td>35</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>3</td>
<td>23</td>
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Total: 77
Buccal foramen in mandibular body using CBCT

premolar region anterior to the mental foramen, and 13 were in the molar region posterior to the mental foramen (Fig. 3). Seven buccal foramina showed continuity with the mandibular canal, consisting of 1 foramen anterior to and 6 posterior to the mental foramen (Fig. 4). Also, one buccal foramen in the incisive region was suggested to show continuity with the incisive canal (Fig. 5). The mean distance between the buccal foramen and point of bifurcation from the mandibular canal was 7.5 mm (range: 2.1−13.6 mm, s.d.: 3.7 mm).

Discussion

Recently, the CBCT unit has been developed, and technological improvements involving a flat panel detector and enlargement of the image field have been introduced. In previous studies, bifurcation of the mandibular canal and genial spinal bony canal were assessed using CBCT images\(^3\)\(^–\)\(^8\). However, foramen presence on the buccal side of the mandibular body was not assessed. Buccal foramina in the study included the so-called nutrient foramen and accessory foramen of the mental foramen. It was reported that if the beam of the radiograph is directed parallel to a canal and through its foramen in the cortical bone, the canal appears as a small, round radiolucency\(^13\). However, we have considered that detection of the buccal foramen was very difficult, since intra-oral and panoramic radiographs projected 3-D anatomic structures onto 2-D film, and the buccal foramen overlapped the trabecular and lingual cortical bones, and, moreover, the opposite mandible and cervical vertebrae in the panoramic radiograph.

Buccal foramen presence, distributing from the median to molar regions, was observed in 44% of patients. Since clinical images were used in the study, a golden standard of buccal foramen presence was not obtained. Further studies using dry mandibles and cadavers are needed to evaluate the accuracy of CBCT images using a receiver operating characteristic curve for buccal foramen presence.

The occurrence of buccal foramen presence was higher in less than 30 years old than in more than 60 years old, however there were no significant differences among 3 groups for age. The occurrence of buccal foramen pres-
ence decreased with increasing age. It was reported that in all regions of both jaws, nutrient canals become much more marked on intra-oral radiographs when the teeth are missing\(^1\). We considered that the detection of buccal foramen presence became difficult since the bone density of cortical bone decreased with aging. In this study, there were only two fully edentulous mandible. So, a statistical analysis was not possible between fully and partially edentulous mandibles. Further studies are needed to evaluate buccal foramen presence between dentate and edentulous mandibles.

Ichikawa (1961)\(^1\) reported that a nutrient foramen was formed in a prenatal stage, and the submental, lower lip and buccal arteries and direct branches of the facial artery distributed from the buccal foramen into mandibular cancellous bone. Also, Hirata (2000)\(^1\) described that the anthropological definition of an accessory mental foramen was a foramen of accessory bony canal originating from the mandibular canal. Toh et al. (1992)\(^1\) reported that one nerve issued from the accessory mental foramen, and then it supplied the skin at the corner of the mouth or mucous membrane of the middle area of the lower lip. We consider that observation of the buccal foramen, especially when continuous with the mandibular canal, is important in preoperative imaging for dental implant treatment. The occurrence rate of multiple mental foramina in Japanese was reported to be from 6.7% to 12.5% in previous macroscopic studies\(^1\),\(^8\). A buccal foramen showing continuity with one main mandibular canal was observed in 7.1% of patients, and 9.1% of buccal foramina. The rate of occurrence of buccal foramina continu-
ous with the mandibular canal was similar to that of the accessory mental foramen in the previous study. Also, one buccal foramen in the incisive region was suggested to show continuity with the incisive canal.

The mean distance between the buccal foramen and point of bifurcation from the mandibular canal was 7.5 mm. Toh et al. (1992)\textsuperscript{16} reported that the distance between the mental foramen and accessory mental foramen ranged from 0.67 to 5.74 mm; however, the distance of the bony canal between the buccal foramen and point of bifurcation was not previously measured.

Further studies using cadavers are needed to identify nerve and/or vascular structures passing into the narrow canal penetrating the buccal cortical plate, and evaluate their distribution.

**Conclusion**

Buccal foramen presence in the mandibular body was observed in 44% of 84 patients using CBCT images. Advancing CBCT images showed the bony canal coursing to the buccal foramen.

**Acknowledgement**

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**References**