RESEARCH

A false presence of bifid mandibular canals in panoramic radiographs

M-S Kim[†], S-J Yoon[†], H-W Park, J-H Kang, S-Y Yang, Y-H Moon, N-R Jung, H-I Yoo, W-M Oh and S-H Kim*

Dental Science Research Institute, 2nd Stage Brain Korea, School of Dentistry, Chonnam National University, Gwangju, South Korea, 500-757

Objectives: This study was performed in order to verify bifid mandibular canals revealed from panoramic radiographic results.

Methods: 1000 panoramic radiographs from dental patients and the panorama, cone beam CT (CBCT) and micro-CT from 40 dry mandibles were examined for bifid mandibular canals. The results were confirmed by a stereoscopic and histological examination of the cross-sectioned mandibles.

Results: The prevalence of bifid canals detected from the panoramic radiographs was 0.038. The panoramic radiographs from one dry mandible showed two separate radiolucent mandibular canal-like structures delineated by radio-opaque lines. However, a stereoscopic and histological examination of a cross-section of the mandible showed that only one canal was a true canal containing neurovascular bundles; the other was false, reflecting merely a bony trabecular pattern.

Conclusions: The presence of bifid mandibular canals determined by panoramic radiography should be judged with great caution in relation to dental surgery.

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Keywords: bifid canals; panorama; micro-CT; cone beam computed tomography; inferior alveolar nerve

Introduction

The mandibular canal, which transmits the inferior alveolar nerve and vessels supplying the mandibular teeth and adjacent structures, is a hollow space surrounded by bony tissue extending from the mandibular foramen posteriorly toward the mental foramen anteriorly. Knowing the accurate position and course of the mandibular canal within the mandible and identifying the anatomical variations, such as the bifid mandibular canal or additional foramen, is very important for preventing potential complications during surgical dental procedures, such as tooth extraction, implant installation and peri-apical surgery involving the mandible.

The existence of a bifid or double mandibular canal has been reported in various anatomical and radiographic studies. Its occurrence was found to be extremely rare, ranging from 0.08% to 0.95%.^{1–6} The existence of bifid mandibular canals can be identified relatively easily

by a retrospective study using panoramic radiography. However, there is some doubt regarding the actual existence of multiple mandibular canals owing to the observation limitations using panoramic radiographs.^{6–8} Recently, some case reports used three-dimensional (3D) CT to overcome the limitations in identifying the anatomical structures using two-dimensional (2D) radiographs.^{6,8–10} Even if CT is a reliable method, the most precise method for detecting the accurate location and course of the mandibular canal is direct observation by the dissection of cadavers or dry mandibles.

This study examined panoramic radiographs obtained from patients to determine the incidence of bifid mandibular canals. A bifid canal demonstrated from the panoramic radiographs among dry mandibles was tested for its real presence by CT, micro-CT, and stereoscopic and histological observations.

Materials and methods

The presence of bifid mandibular canals was examined using 1000 panoramic radiographs obtained from

*Correspondence to: Sun-hun Kim, Professor, PhD, DDS, Dental Science Research Institute, School of Dentistry, Chonnam National University, Yongbongdong, Gwangju, South Korea, 500-757; E-mail: ksh@chonnam.ac.kr

[†] These authors contributed equally to this study.

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dental patients in the dental clinic of Chonnam National University Hospital, Gwangju, South Korea, between 2004 and 2008. All radiographic cases were taken using a Scanora® (Soredex, Tuusula, Finland). To qualify the findings, bifid canals were determined by the consensus of three independent researchers.

40 human dry mandibles from the School of Dentistry, Chonnam National University were used for the next study. Panoramic radiographs were taken using Scanora® (Soredex). Among the panoramic radiographs, one mandible suggesting a bifid mandibular canal was selected. To confirm this finding, the cone beam CT (CBCT) images were acquired from the bifid canal region using CBMercuryRay (Hitachi, Tokyo, Japan). For a further examination, the mandible was divided into two parts: the second molar region (R1), and the mental foramen region (R2) (Figure 1). After taking radiographic images, this dry mandible was cross-sectioned surgically at 5-mm intervals using an EXAKT 300 band cutting system (Exakt Technologies Inc, Oklahoma City, OK). Micro-CT was performed using a SkyScan1172 high-resolution micro-CT (Micro Photonics Inc., Allentown, PA). To make histological observations, the sectioned specimens were immersion-fixed in a 4% paraformaldehyde solution, followed by decalcification in a 20% ethylene diamine tetra-acetic acid solution (pH 7.4) for several months. The specimens were then dehydrated in a graded series of ethyl alcohol and embedded in paraffin. 5-µm thick sagittal sections were made and stained with haematoxylin-eosin. The sections were then visualized and photographed using an optical microscope (Carl Zeiss, Oberkochen, Germany).

Results

The panoramic radiographs from 1000 dental patients at Chonnam National University Hospital and 40 dry mandibles were examined for the presence of bifid mandibular canals. In four cases, the panoramic radiographs indicated double mandibular canals, suggesting that the prevalence of bifid canals in Koreans was 0.038.

Among the panoramic radiographs obtained from the dry mandibles, only one case appeared to have a bifid mandibular canal (Figure 1). Each canal in this bifid canal was delineated at the molar region by radio-opaque compact bone. A CBCT scan was performed at R1 and R2 as seen in Figure 1, to determine if these canals were real bifid canals. The bifid mandibular canal was presented in R1 by the CBCT images. Two canals were detected by radio-opaque lines; one upper canal was circular in outline, whereas the other lower canal was elliptical (Figure 2a). However, only one canal was detected in R2 (Figure 2b). To make a direct observation, R1 containing the bifid canals was further cross-sectioned surgically at 5 mm thick intervals, and micro-CT and a histological examination was performed. The micro-CT images at R1 revealed two canals surrounded by radiopaque cortical bone. As observed in the CBCT images in Figure 2a, the upper canal was circular and complete, whereas the lower canal was elliptical and incomplete in outline. In addition, the cortical wall even appeared to be thicker in the lower canal (Figure 3). A stereoscopic observation clearly demonstrated that the upper canal contained vascular and nervous structures,

Figure 1 A panoramic radiograph of a dry mandible. The mandible appears to have bifid mandibular canals (arrows) on the right side and both canals are delineated at the molar region by radio-opaque lines. The R1 and R2 planes indicate the second molar and mental foramen regions, respectively

Figure 2 Cone beam CT images at the second molar and mental foramen regions (R1 and R2, respectively) in Figure 1. (a) Two canals are observed at R1; the upper canal (upper arrow) is circular in outline, whereas the lower canal (lower arrow) is elliptical. (b) Only one canal (arrow) is observed at R2

whereas the lower canal contained only marrow fatty tissue (Figure 4). This stereoscopic examination was also confirmed from the histological sections, which

showed definite neurovascular bundles in the upper true canal only (Figure 5a). The lower canal was made of thick lamellar bone (Figure 5b).

Figure 3 Micro-CT image of the second molar region in Figure 1. Two mandibular canals are surrounded by compact bone. The upper canal (upper arrow) is round in shape, whereas the lower one (lower arrow) is elliptical and incomplete. In addition, the lower canal appears to have thicker radio-opaque walls

Discussion

Regarding the origin of bifid mandibular canals, Chavez-Lomeli *et al*¹¹ suggested that during embryological development, three divisions of the inferior alveolar nerves innervating the mandibular teeth fuse together and one mandibular canal is formed as a result of rapid pre-natal growth and intramembranous ossification during remodelling in the mandibular ramus area. This theory would explain the existence of bifid or trifid mandibular canals resulting from the incomplete fusion of these three nerves. In the present study, the

Figure 4 Stereoscopic image of the second molar region in Figure 1. A true canal (upper short arrow) contains neurovascular bundles, whereas a false canal (lower short arrow) that is irregular in outline contains marrow tissue

Figure 5 Histological section at the second molars region. (a) The section shows also a true canal and a false canal which contain only marrow tissues. (b) The false canal was formed by thick lamellar bone

prevalence of bifid mandibular canals detected by panoramic radiography in Koreans was 0.038, which is relatively low compared with that in other ethnicities.^{1–6} Even though false-positive cases could also exist in these studies with panoramic radiographs, this difference might reflect racial differences.

In this study, the panoramic radiograph of a dry mandible revealed two separate radiolucent mandibular canal-like structures surrounded by radio-opaque cortical bone in the posterior region. However, a stereoscopic and histological examination of the cross-sectioned mandible showed that only one canal was a true canal containing neurovascular bundles. The other false canal was produced from trabecular patterns and did not contain any nerves and vessels. The CBCT and micro-CT images demonstrated that the false canal was elliptical in shape and incomplete in cortical outline. To explain the cause of false double canals, previous studies have suggested the existence of the mylohyoid groove,^{12–14} an impression of the mylohyoid nerve on the medial surface of the mandible,⁶ radiographic osteocondensation images produced by the insertion of the mylohyoid muscle into the mylohyoid line¹⁵ and confusion with the lingual vascular canal.¹⁶ The present study showed that trabecular structures could be observed as canal-like structure in the panoramic

radiographs. This suggests that dense trabecular structures can be another cause of false double canals.

All these explanations for double canals originated from 2D images, such as panoramic radiographs, which have a limitation in displaying intrabony structures. 3D images with great reproducibility were introduced to overcome the limitations of panoramic radiographs and evaluate more accurately the anatomical variations clinically.^{6,8–10} Indeed, when the panoramic radiographic results for the incidence of bifid/trifid mandibular canals were re-evaluated using CT, some of the results were found to be false canals.^{6,8,9} Nevertheless, CT has inevitable difficulties in identifying intracanal structures such as the nerves or vessels. Hence, the true incidence of mandibular canals might be lower than reported. Therefore, in the present study, direct stereoscopic and histological observations were performed to confirm the definite canal structures.

Failure in identifying the anatomical variations of the mandibular canal-like bifid canals can lead to some surgical complications. Most frequently, a patient can experience dyesthesia under mandibular anaesthesia.^{3,17,18} Traumatic neuroma or excessive bleeding can be caused by mandibular surgical procedures, such as the mandibular third molar surgery or mandibular osteotomy,^{19,20} and damage from an unknown canal is also possible in dental

implant placement.²¹ In addition, alveolar bone resorption in older patients can cause changes in the trabecular pattern, placing pressure on the neurovascular bundle near the mental foramen as a result of mandibular prostheses.²⁰ To prevent possible pain and discomfort experienced by patients during dental treatment, it is very important to

recognize the accurate intrabony course of the mandibular canal and identify its anatomical variations.

In conclusion, this study suggests that the presence of bifid mandibular canals shown in the 2D panoramic radiographs should be evaluated more carefully in relation to dental treatment.

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