Comparison between cone-beam and multislice computed tomography depicting mandibular neurovascular canal structures

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Objective. The most common diagnostic imaging modalities for cross-sectional imaging in dental implant planning are currently cone-beam computed tomography (CBCT) and multislice CT (MSCT). However, clinical differences between CBCT and MSCT in this task have not been fully clarified. In this investigation, the detection of fine anatomical structures in the mandible was assessed and compared between CBCT and MSCT images.

Study design. The sample consisted of 28 patients who had undergone CBCT and MSCT. The bifid mandibular canal in the mandibular ramus, accessory mental and buccal foramina, and median and lateral lingual bony canals were observed in 2-D images, and the findings were compared between CBCT and MSCT.

Results. Four of 19 canals observed in CBCT were not observed in MSCT images. Three accessory mental foramina in 2 patients and 28 lateral lingual bony canals in 18 patients were observed consistently using the two methods.

Conclusion. Depiction of fine anatomic features in the mandible associated with neurovascular structures is consistent between CBCT and MSCT images. **(Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;109:e25-e31)**

The most common diagnostic imaging modalities for cross-sectional imaging in dental implant planning are currently cone-beam computed tomography (CBCT) and multislice CT (MSCT).[1-6] The normal anatomic structures in the oral and maxillofacial region and cervical soft tissue have been compared using CBCT and MSCT images.[7-10] Hashimoto et al.[7] reported that the image quality of CBCT images using the 3DX unit (J. MORITA Mfg. Corp., Kyoto, Japan) was better than that of MSCT images for all of the following: cortical bone, cancellous bone, enamel, dentin, the pulp cavity, lamina dura, and periodontal ligament space. Mischkowski et al.[9] and Dreiseidler et al.[10] reported that the mandibular foramen, mandibular canal, mental foramen, and incisive foramen could be observed and the diagnostic quality was the same between CBCT and MSCT.

The location and course of various neurovascular bony canals, such as the bifid mandibular canal, accessory mental and buccal foramina, and median and lateral lingual bony canals in the mandible, are important for dental implant fixture insertion and implant-related bone grafting.[11-17] However, the relative detection of these anatomic structures has not been fully clarified.

Therefore, the purpose of this study was to compare the detection of fine mandibular structures, such as the bifid mandibular canal, accessory mental and buccal foramina, and median and lateral lingual bony canals, was assessed and compared between CBCT and MSCT images.

MATERIALS AND METHODS

Subjects

Since April 2007 CBCT has been performed for diagnostic imaging in dental implant planning, instead of MSCT, in our hospital. Twenty-eight (6 males and 22 females) of 342 patients undergoing CBCT imaging up until March 2009 were previously imaged using MSCT imaging. All patients were sufficiently informed regarding MSCT and CBCT, and gave their informed consent to participate. The reason for CBCT imaging was to assess bone grafting in 5 patients, for additional implant fixture insertion in 11 patients, and for the follow-up observation of inserted fixtures in 12 pa-

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Table I. Comparison of the depiction of mandibular anatomical structures between CBCT and MSCT images

	CBCT>MSCT	*CBCT=MSCT*	*CBCT<MSCT*
Bifid mandibular canal (n = 19)	4 (21%)	13 (68%)	2 (11%)
Accessory mental foramen (n = 3)	0 (0%)	3 (100%)	0 (0%)
Buccal foramen (n = 28)	1 (4%)	26 (93%)	1 (4%)
Median lingual bony canal (n = 55)	1 (2%)	54 (98%)	0 (0%)
Lateral lingual bony canal (n = 28)	0 (0%)	28 (100%)	0 (0%)

CBCT>MSCT, depiction in CBCT was superior to that in MSCT images; CBCT=MSCT, depiction in CBCT was equal to that in MSCT images; CBCT<MSCT, depiction in MSCT was superior to that in CBCT images.

tients. The mean age was 54.5 years (range: 21-74, SD ±10.9) at the time of CBCT imaging. The mean time between MSCT and CBCT imaging was 30.1 months (range: 6.7-58.8, SD ±15.0).

Imaging

The Alphard VEGA (Asahi Roentgen, Kyoto, Japan) CBCT unit 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 × 0.2 × 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).

MSCT imaging was performed using a HiSpeed NX/i Pro (GE Yokogawa Medical Systems, Tokyo, Japan) unit. The helical scan was set at 120 kV, 200 mA, with 0.5-mm-thick slices, and a 1.5 table pitch. The axial images were reconstructed using 0.5-mm-thick slices with 0.25-mm intervals, and the field of view (FOV) in axial images was set at 160 mm in diameter. The pixel size of axial images was 0.31 × 0.31 mm. A series of axial images in DICOM files were saved on a portable HD.

Observation of mandibular anatomical structures

Two oral and maxillofacial radiologists (M.N. and K.N.) reconstructed and interpreted CBCT and MSCT images simultaneously. The presence of bifid mandibular canal in the mandibular ramus, accessory mental and buccal foramina, and middle and lateral lingual bony canals was recored in axially, cross-, and longitudinally sectioned 2-dimensional (2-D) images using a computer (Macintosh G4, Apple Computer, Cupertino, CA) and 3-D visualization software (OsiriX Imaging Software, the OsiriX Foundation, Geneva, Switzerland),[18] and the findings were compared between CBCT and MSCT images.

The course and bifurcation of the mandibular canal were assessed, and the length of the bifurcated canal was measured. The presence of a bifid mandibular canal was recorded when the length was 5 mm or greater. When a secondary bifurcation of the bifid canal was observed, both secondary canals were measured. Bifid mandibular canals were classified into 4 types: retromolar, dental, forward, and bucco-lingual canals.[11] Because 16 sides that underwent bone block harvests from the retromolar region and 2 sides that underwent sagittal split ramus osteotomy were excluded from bifid mandibular canal assessment, a total of 38 sides were analyzed.

An accessory mental foramen was defined as a buccal foramen showing continuity with the mandibular canal, excluding the mental foramen.[12] A buccal foramen was defined as a canal penetrating the buccal cortical bone from the buccal bone surface not showing continuity with the mandibular canal, the so-called nutrient foramen.[13] The 56 sides of the 28 patients were analyzed for their presence.

The superior and inferior genial spinal bony canals,[14,15] other canals in the median mandible, and the lateral lingual bony canal in the premolar region[16,17] were observed in cross-sectional images, and they were analyzed in all 28 patients.

Statistical analysis

The differences between CBCT and MSCT in the depiction of the bifid mandibular canal, accessory mental foramen, buccal foramen, median lingual bony canal, and lateral lingual bony canal in the premolar region were evaluated using chi-square statistics. Differences were considered significant at P less than .01.

RESULTS

A comparison of the visualization of mandibular anatomical structures between CBCT and MSCT images is presented in Table I.

Bifid mandibular canal

In CBCT images, a bifid mandibular canal was observed on 18 of 38 sides. A secondary bifurcation was noted on one side, and a total of 19 bifid mandibular canals were observed. A retromolar canal was presented in 3 canals, and a forward canal in 16 canals. In MSCT images, 15 bifid canals including 1 secondary canal were observed on 14 sides. The retromolar canal

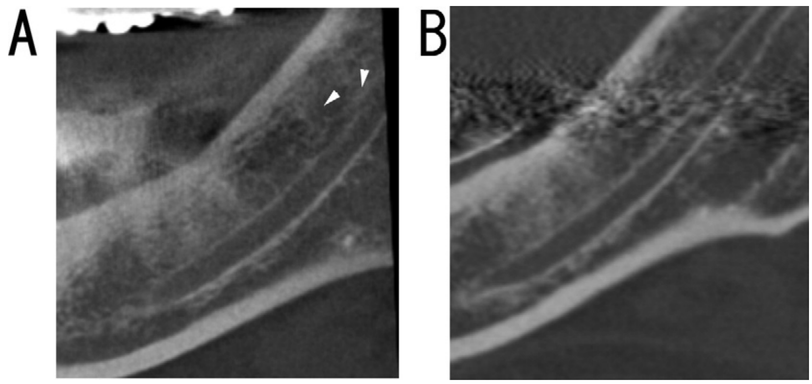

Fig. 1. Bifid mandibular canal on the left side of a 47-year-old man. A bifid mandibular canal was observed in the CBCT image (**A**). It courses forward at first and superiorly after the crook. It was not observed in the MSCT image (**B**), and a metal artifact was superimposed on the retromolar region.

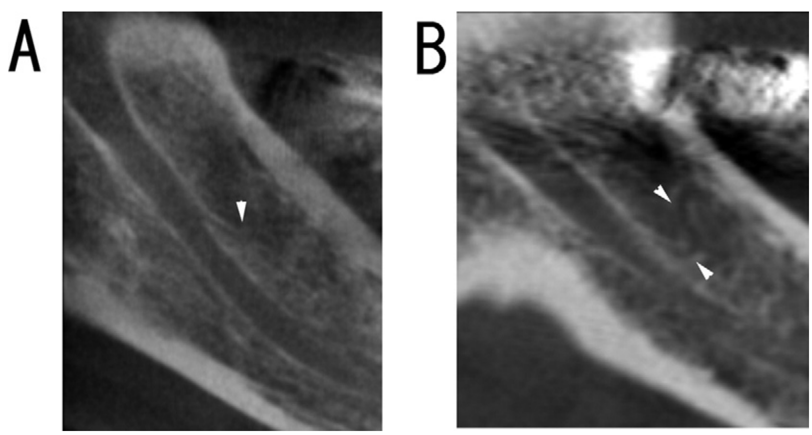

Fig. 2. Bifid mandibular canal on the left side of a 49-year-old woman. The bifid mandibular canal (*white arrowhead*) observed in the MSCT image (**B**) was longer than that in the CBCT (**A**) image.

was presented in 3 canals, and a forward canal in 12 canals. Thirteen bifid mandibular canals with 3 retromolar and 10 forward canals were clearly noted in both CBCT and MSCT images. Four forward canals observed in CBCT images were not identified in MSCT images (Fig. 1). Moreover, 2 forward bifid canals in an MSCT image were observed to be longer than in a CBCT image (Fig. 2).

Accessory mental foramen

Three accessory mental foramina were clearly observed in both CBCT and MSCT images (Fig. 3).

Buccal foramen

Twenty-seven buccal foramina in 1 median region and on 22 sides were observed in CBCT images, and 27 buccal foramina in 1 median region and on 21 sides were noted in MSCT images (Fig. 4). Two buccal foramina were observed in either of the 2 CT images.

Median lingual bony canal

In total, 53 median lingual bony canals in 28 patients were clearly identified in both CBCT and MSCT images (Fig. 5), and only 1 superior genial spinal bony canal was observed in CBCT images. Using CBCT images, a superior genial spinal bony canal was noted in 5 patients; inferior canal in 2 patients; superior and inferior canals in 14 patients; superior and mandibular inferior border canals in 1 patient; and superior, inferior, and mandibular inferior border canals in 6 patients.

Lateral lingual bony canal in the premolar region

A lateral lingual bony canal on 28 sides was observed in both CBCT and MSCT images (Fig. 6).

There were no significant differences between CBCT and MSCT regarding the depiction of the bifid mandibular canal, accessory mental foramen, buccal fora-

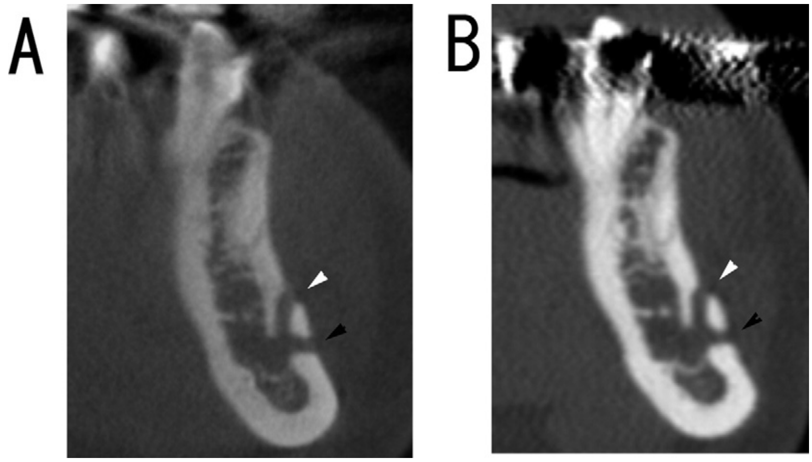

Fig. 3. Accessory mental foramen on the left side of a 46-year-old woman. An accessory mental foramen was clearly observed in both CBCT (**A**) and MSCT (**B**) images. White arrowhead, accessory mental foramen; black arrowhead, mental foramen.

Fig. 4. Buccal foramen on the left side of a 62-year-old man. A buccal foramen (*white arrowhead*) was clearly observed in both CBCT (**A**) and MSCT images (**B**).

men, median lingual bony canal, and lateral lingual bony canal in the premolar region.

DISCUSSION

Presently, CBCT and MSCT have been recommended as appropriate cross-sectional diagnostic imaging modalities for dental implant assessment[1-6]; however, their use has not been described in the Japanese guidelines for such diagnostic imaging.[19] The accuracy of CBCT and MSCT images is reportedly high in linear measurement.[1,2,4,5] Also, Mischkowski et al.[9] and Dreiseidler et al.[10] reported that various mandibular anatomical structures could be observed, and the diagnostic quality was the same between CBCT and MSCT images. Our study confirms the results of these previous authors in that both modalities are equally capable of detecting the presence of fine mandibular structures, such as the bifid mandibular canal, accessory mental and buccal foramina, and median and lateral lingual bony canals. Although the mean time between CBCT and MSCT imaging was approximately 30.1 months, we considered that the mandibular structures did not markedly change during this period.

Within the retromolar canal, which is one type of bifid mandibular canal, the artery branched from the inferior alveolar artery, and nerves derived from the inferior alveolar nerve trunk were observed.[20] Also, the retromolar nerves branched off to the buccal mu-

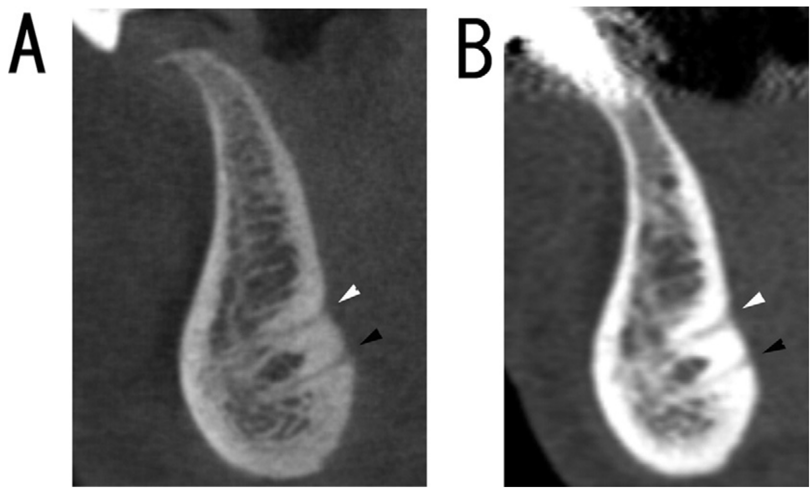

Fig. 5. Superior and inferior genial spinal bony canals in the median region of a 62-year-old man. Superior (*white arrowhead*) and inferior (*black arrowhead*) genial spinal bony canals were clearly observed in both CBCT (**A**) and MSCT images (**B**).

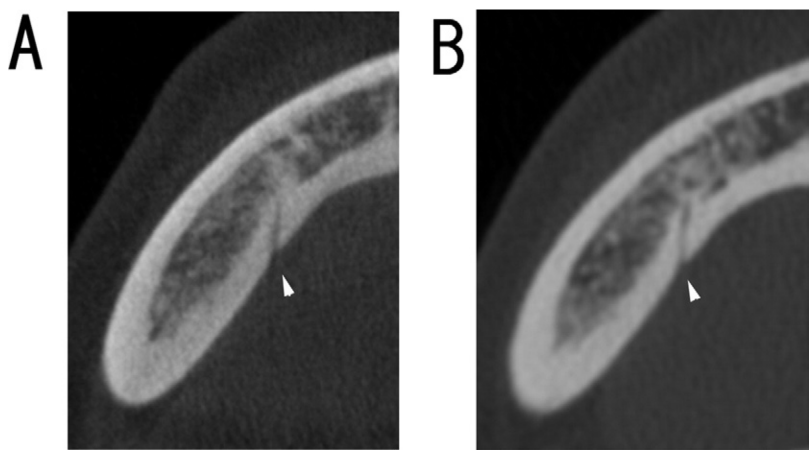

Fig. 6. Lateral lingual bony canal in the premolar region of a 49-year-old woman. A lateral lingual bony canal (*white arrowhead*) was observed in both CBCT (**A**) and MSCT images (**B**).

cosa and the buccal gingiva of the mandibular premolar and molar regions in one Japanese cadaver.[20] Toh et al.[21] observed the accessory mental nerve extending to the mucous membrane and the skin of the corner of the mouth, as well as the mucous membrane of the median labial region. Also, the accessory mental nerve communicated with branches of the facial and buccal nerves. The buccal foramina is considered to be the so-called nutrient foramen.[13] Ichikawa[22] 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. Jacobs et al.[14] reported that the superior genial spinal foramen contained a branch of the lingual artery and vein and lingual nerve. Also, a branch of the mylohyoid nerve together with branches or anastomoses of the sublingual and/or submental artery and vein were identified upon entering the inferior genial spinal foramen. Yoshida et al.[17] observed a branch of the inferior alveolar artery in the lateral lingual foramen of the mandibular premolar region. Moreover, it was indicated that potential risks might also be related to the presence of the lingual foramen and anatomic variations, such as an anterior looping of the mental nerve.[23]

We have previously reported that the presence of the bifid mandibular canal in the mandibular ramus region is more often observed on CBCT images (65%), compared with panoramic images (Range: 0.08 to 0.95%).[11] Four of 19 bifid canals observed in CBCT images were unclear in MSCT images. The internal diameter of the retromolar foramen was reported to range from 0.2 to more than 1.0 mm.[20] The pixel size and thickness in MSCT images were slightly large compared with the narrow foramen. Also, the retromolar region was consistent with the level of the occlusal plane, and MSCT images in the retromolar region were influenced by metal artifacts from metal restorations and/or cast crowns.

Depiction of the accessory mental and buccal foramina and middle and lateral lingual bony canals was almost identical for CBCT and MSCT images. The long axis of the accessory mental foramen was reported to range from 1.1 to 2.9 mm in CBCT images.[12] The mean long axis of the accessory mental foramina in CBCT images was 2.7 mm in the study, and it was comparatively large in the accessory mental foramina. The buccal foramen, reported in 44% of patients by Naitoh et al.,[13] was observed in 57% of patients using both CBCT and MSCT images. A superior and/or inferior genial spinal bony canal was observed in 100% of patients. Kawai et al.[15] reported that a superior or inferior genial spinal bony canal was presented in 97.1% of dry mandibles.

A lateral lingual bony canal was observed on 28 sides (50.0%) in 18 patients (64.3%) using CBCT. In a previous study, it was observed on 43.7% of sides of dry skulls and on 14.8% of sides of cadavers.[17] These results using CBCT and MSCT were similar to those using dry skulls.

CBCT presents with some major advantages compared with MSCT. First, the radiation exposure dose of the patients is relatively low.[24,25] Second, the CBCT machine can be used effectively in a dental clinic, but MSCT machine availability is usually limited to hospitals. Third, the level of resolution in CBCT images was reportedly higher than that in MSCT images.[2] In the present investigation, no large differences between CBCT and MSCT images were observed regarding the depiction of fine anatomical structures in the mandible, which included the accessory mental and buccal foramina and median and lateral lingual bony canals. However, the additional effectiveness of CBCT images might be shown by observing the bifid mandibular canal in the mandibular ramus region.

The quality of CBCT images may be influenced by the type of x-ray detector (image intensifier versus flat panel), and the diameter of the exposure field. Also, the quality of MSCT images may be influenced by the multidetector, slice thickness, and pixel size. Further studies involving anatomical structures are necessary to compare CBCT and MSCT images in multiple facilities with various CT machines.

CONCLUSION

There is no difference in the depiction of various fine anatomical structures in the mandible, such as the bifid mandibular canal, accessory mental and buccal foramina, and median and lateral lingual bony canals, between images obtained using CBCT with an FP detector and an MSCT scanner.

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