Mandibular Incisive Canal: Cone Beam Computed Tomography

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ABSTRACT

Purpose: Panoramic radiography is often used to analyze the anatomical structure of the teeth, jaws, and temporomandibular joints. Cone beam computed tomography (CBCT) imaging allows multiple axial slices of the image to be obtained through these anatomical structures. The aim of this study was to assess CBCT compared with panoramic radiography to verify the presence, location, and dimensions of the mandibular incisive canal.

Materials and Methods: CBCT scan images and panoramic radiographs of 89 subjects were compared for the presence of the mandibular incisive canal, its location, size, and anterior-posterior length. The distance between the incisive canal and the buccal and lingual plate of the alveolar bone, and the distance from the canal to the inferior border of the mandible and the tooth apex were also measured. A paired *t*-test was used to calculate any significant difference between the two imaging techniques.

Results: Eighty-three percent of the CBCT scans showed the presence of the incisive canal, as did 11% of the panoramic radiographs. The range of the incisive canal diameter, as seen in the CBCT scans, was from 0.4×0.4 mm to 4.6×3.2 mm. The mean length of the canal was 7 ± 3.8 mm. The distance from the inferior border of the mandible to the canal was 10.2 ± 2.4 mm, and the mean distance to the buccal plate was 2.4 mm. The apex–canal distance (in dentate subjects) was 5.3 mm.

Conclusion: The presence, location, and dimensions of the mandibular incisive canal are better determined by CBCT imaging than by panoramic radiography.

KEY WORDS: cone beam computed tomography, mandibular incisive canal, panoramic radiography

INTRODUCTION

Panoramic radiography is often used in dental practices because it provides analysis of anatomical structures in the maxillofacial region. However, a panoramic radiograph is a two-dimensional image, lacking information in the buccolingual direction.[1] Accurate measurements also are difficult to obtain because panoramic views produce a variable inherent magnification distortion, typically 20 to 30%. In addition, longitudinal assessment is not possible because of the difficulty in reproducing the exact patient position within the panoramic device.[2,3] The advantages of panoramic imaging include visualization of many anatomical features, low cost, and high availability.

Several attempts are made to overcome some limitations of panoramic radiography, such as the use of radiographic guides containing metal markers of known dimensions. Although this may mitigate some of the magnification errors inherent in panoramic radiography, it does not overcome all limitations, including the lack of cross-sectional information.[4,5]

In cone beam computed tomography (CBCT) imaging, multiple thin axial slices are obtained through

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the jaws, and then the data are reformatted with special software packages to produce cross-sectional and panoramic views. Computer software also is available to analyze the CBCT scans and to help in planning implant placement with electronically simulated fixtures.[6,7]

The advantages of CBCT-based systems include uniform magnification, a high-contrast image with a well-defined image layer free of blurring, easier identification of bone grafts or hydroxyapatite materials used to augment maxillary bone in the sinus region, multiplanar views, three-dimensional reconstruction, simultaneous study of multiple implant sites, and the availability of software for image analysis.[7] The disadvantages of CBCT include limited availability, expense, higher doses of radiation compared with conventional radiographic techniques, and possible metallic streak artefacts (scatter).[7,8] Several authors have reported that measurements and dimensional accuracy are more precise when using CBCT scans over any other radiographic techniques.[8–12]

When comparing CBCT scans and panoramic radiographs for dental implant planning and prediction of appropriate implant size, Ekestubbe[13] and Schropp and colleagues[14] found that, in approximately 70% of cases, the implant size changed when cross-sectional imaging was added to the preoperative evaluation. In other words, only 30% of the implants that were preselected using only panoramic radiographs were actually used after employing a CBCT scan or conventional tomography. Sonick and colleagues[15] found that, on average, there is about a 30% magnification in panoramic radiographs and less than 1% for CBCT scan images.

The ability to detect the presence of the mandibular incisive canal from conventional radiographs is limited.[16–19] Such images often fail to show an incisive canal or an anterior loop of the inferior alveolar canal.[20–22] Recent advances in imaging technology have increased the availability of cross-sectional imaging for preoperative assessment of potential implant sites and donor sites for block bone grafts. Although cross-sectional imaging might offer more detailed information concerning the mental foramen and anterior loop of the mandibular canal, only a few studies have shown this.[20,22,23]

To avoid nerve injury during surgery of the anterior mandible, use of radiographic techniques to establish the existence of an anterior loop of the mandibular canal and the existence of the mandibular incisive canal is necessary to determine a zone of safety.[24] The mandibular incisive canal is described as a prolongation of the mandibular canal anterior to the mental foramen that contains a neurovascular bundle.[20,25] Using CBCT scan analysis, Jacobs and colleagues[20] identified the mental foramen in the majority of their subjects (97%), with an anterior looping of the mandibular canal visualized in 7% of the cases. The incisive canal in the interforaminal region could be identified in 93% of the cases. The incisive canal appeared on the CBCT scans as a round radiolucent area within the mandibular trabecular bone, surrounded by a radiopaque rim.[20]

A study by Uchida and colleagues[26] on 38 Japanese hemimandibles found an anterior loop present in 62.7% and a 100% existence of an incisive nerve, with a variation in nerve diameter from 0.5 to 6.6 mm. The same result was found in the study by De Andrade and colleagues[25]: 100% of incisive canal existence. The visibility of the mandibular incisive canal is poorly documented in panoramic images.[27,28]

The aim of this study was to report the enhanced visibility of the mandibular incisive canal by CBCT radiography compared with panoramic radiography. The location, length, diameter, and tooth apex distance to the mandibular incisive canal were also measured in males, females, dentate, and edentulous subjects.

MATERIALS AND METHODS

This was a retrospective analytical study. The images employed were from the database of a pool of CT images (kVp: 120, mAs: 23.87) scanned for implant placement or bone grafting procedures at a private practice located in Northeast Ohio. The patients of this study were not identifiable in any way. CBCT images were evaluated by examining the incisive canal location, size, and anterior-posterior length. The canal having anatomical variations did not end at the same point and was measured as such. The distance between the incisive canal and the buccal and lingual plate of the alveolar bone was measured. The distance from the canal to the inferior border of the mandible and the tooth apex was also measured. The apices of the teeth that were used as an anatomical reference were teeth with apices most inferior relative to the line drawn.

The i-CAT Imaging System Software (i-CAT, Imaging Sciences International, Inc., Hatfield, PA, USA) was used in the study. This software allowed the recording of linear measurements of images (pixel size: 0.4 mm). The personal computer utilized was a

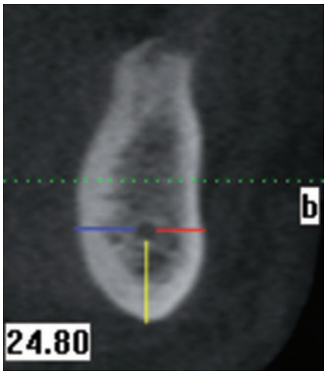

Figure 1 The distance analyzed: red: buccal to canal; blue: lingual to canal; yellow: inferior border; green: frankfurt horizontal plane.

desktop Intel-based processor (Hewlett-Packard Pavilion Elite m9200t series, Hewlett-Packard Development Company, Palo Alto, CA, USA). The measurements were completed on cross sections perpendicular to a line that was parallel to the inferior border of the mandible. The two reference points included the incisive canal and the inferior mandibular border. This plane passed through the inferior margin of the orbit and the upper margin of each ear canal (Figures 1–4).

The prevalence in percentages was calculated for the mandibular incisive canal in both CBCT scans and panoramic radiographs.

The mean values and SDs of each measurement (length, size, diameter of incisive canal, and location) were calculated. Comparison between the mean values was performed with the *t*-test for paired values (assuming equal and unequal variances). A value of significance was set as $p \leq .05$. The software utilized was SPSS for Windows (SPSS Inc., v16.0, Chicago, IL, USA).

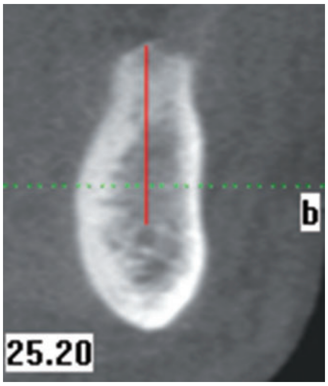

Figure 2 The distance between the incisive canal and the alveolar crest (*red line*). The Frankfurt horizontal plane is represented by the green line.

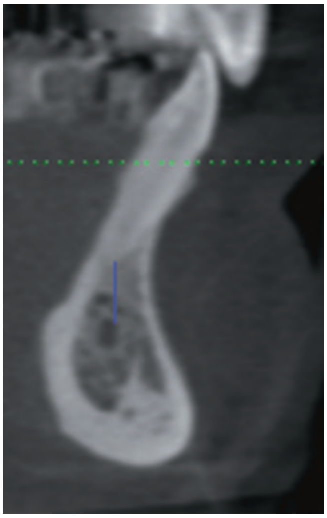

Figure 3 The distance between the incisive canal and the tooth apex.

RESULTS

A total of 89 CBCT scan images were studied. The population consisted of 51 females and 38 males. The mean age was 59 ± 14.9 years. In 83.1% of these images, it was possible to identify the incisive canal (in 64%, it was present bilaterally, and in 19.1%, unilaterally); it was not discernible in 16.9%. The interexaminer and intraexaminer repeatability was tested and resulted in no significant statistical differences ($p > .05$), indicating reliability. It was possible to visualize the mandibular incisive canal in only 10 subjects (out of 89) when panoramic radiography was used, showing a presence of 11.2%. These 10 subjects included 5 dentate males, 4

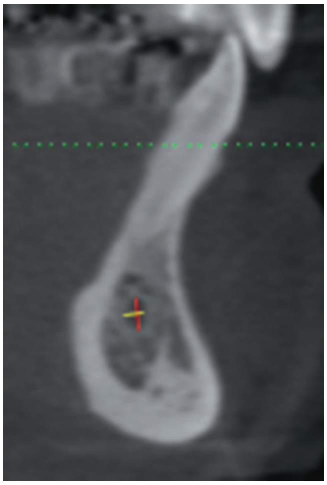

Figure 4 The diameter of the incisive canal. Red: height; yellow: width.

TABLE 1 Comparison of Mandible Border between Origin and Terminal Portion of the Incisive Canal in All Computed Tomography Scan Images

Mandible border	Origin (mm) Mean ± SD	Terminal Portion (mm) Mean ± SD	*p* Value
All	10.4 ± 2.3	10.1 ± 2.5	.081
Female	9.7 ± 1.9	9.5 ± 2.4	.513
Male	11.7 ± 2.4	11.1 ± 2.4	.071

dentate females, and only 1 edentulous female. No statistical differences could be determined in the existence of the incisive canal with regard to gender and dentate status in the panoramic radiographs.

For all CBCT images examined, the mean length of the incisive canal for the right side was 7.1 ± 4 mm, and for the left side was 6.6 ± 3.7 mm. Despite the apparent difference between sides, it was not statistically significant ($p > .05$). When the data were analyzed with regard to gender and dentate status, there was no significant difference between the left and the right side. Therefore, the data were analyzed as one unit ($p > .05$).

The incisive canal showed a constant distance from the mandible border, from its origin to its termination on both sides. The mean values for the origin and terminal measurement were 10.4 ± 2.3 mm and 10.1 ± 2.5 mm, respectively (Table 1).

Another finding for the mandibular incisive canal was that it is in close proximity to the buccal plate, independently of its origin or terminal location. At its origin, the mean distance from the canal to the lingual and buccal plate was 4.7 ± 2.1 mm and 2.2 ± 1.1 mm, respectively. At its terminal portion, the mean distance from the canal to the lingual and buccal plate was 5.2 ± 2 mm and 3.3 ± 1.7 mm, respectively (Table 2; Figure 5). While the nerve may have continued to extend, because of the i-CAT parameters and settings, we only were able to follow the length of the nerve until it dispersed within the canal's diameter and could no longer be seen.

Of the 89 CBCT scan images, 24 were images from edentulous patients (13 females and 11 males). Two groups were analyzed together (dentate and edentulous groups) in regard to mandible border distance. There was no statistical significance between the two groups ($p > .05$).

When the CBCT images were compared based on gender, the only statistical difference between those images (51 females and 38 males) was the distance between the mandibular incisive canal and the inferior border of the mandible ($p \le .05$). The data indicate that this distance is shorter in females. The mean values for

TABLE 2 Comparison of the Buccal and Lingual Proximity of the Incisive Canal between Origin and Terminal Portion in All Computed Tomography Scan Images

	Buccal (mm) Mean ± SD	Lingual (mm) Mean ± SD	*p* Value
All			
Origin	2.2 ± 1.1	4.7 ± 2.1	<.001
Terminal portion	3.3 ± 1.7	5.2 ± 2.0	<.001
Female			
Origin	2.2 ± 1.1	4.4 ± 1.9	<.001
Terminal portion	3.1 ± 1.6	5.1 ± 2.1	.001
Male			
Origin	2.4 ± 1.0	5.3 ± 2.2	<.001
Terminal portion	3.8 ± 1.8	5.3 ± 1.9	.009

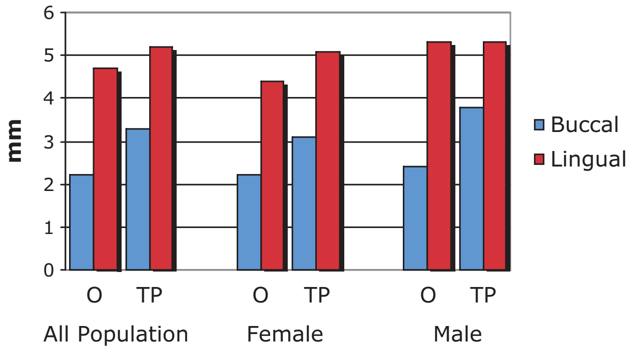

Figure 5 Comparison of the buccal and lingual proximity of the incisive canal between origin and terminal portion in all computed tomography scan images. O = origin; TP = terminal portion.

females and males relative to the distance from the border of the mandible to the origin was 9.7 ± 1.9 mm and 11.7 ± 2.4 mm, respectively, and to the terminal portion was 9.5 ± 2.4 mm and 11.1 ± 2.4 mm, respectively.

The data also were analyzed regarding the distance between the mandibular incisive canal and the apex of the teeth (Table 3). There was no significant difference between the right and left sides ($p > .05$). The mean distance from the apex of the teeth immediately superior to the origin was 4.6 ± 2.2 mm, and for the terminal portion of the canal was 6.1 ± 3.1 mm ($p \leq .05$). In females, the distance was 4.4 ± 2.4 mm (origin) and 5.9 ± 3.2 mm (terminal portion) ($p \leq .05$); for males, the distance was 4.8 ± 1.8 mm (origin) and 6.3 ± 2.8 mm (terminal portion) ($p \leq .05$) (see Table 3).

DISCUSSION

In the present study, it was possible to identify the incisive canal in the CBCT scans' reformatted cross-sectional images as a round radiolucent area within the mandibular trabecular bone, surrounded by a radiopaque rim representing the canal walls. The incisive canal was identified in 83% of the cases: 88% in females and 76% in males. Jacobs and colleagues[20] reported that the incisive canal was identified in 93% of the cases. It is interesting to point out that Jacobs and colleagues examined only female subjects, and their results are similar to those in the present study (88% for females). A reasonable question is why in cadaver dissection studies, it is possible to find 100% of existence of this incisive canal/nerve, and in the CBCT scans, this structure is visualized only in 83%. The incisive nerve becomes smaller while progressing from the distal to the most anterior part of the mandible to midline.[20,25,26,29] The reason that the incisive canal could not be identified in 17% of the cases was because the canal is too small to be visualized on the CBCT scan. Future studies using 3 Tesla magnetic resonance imaging scanners that scan at a much higher resolution may show results of the mandibular incisive canal that are similar to results from cadaver dissection studies.

In the present study, 11.2% of the panoramic radiographs showed the incisive canal. Jacobs and colleagues[30] also found that the incisive canal was visible in 15% of the cases examined. It has to be emphasized that the use of CBCT scan is helpful when the need for precise measurements arises during the surgical procedure. Because of variations in anatomical structure, especially in the anterior mandible, conventional radiographic techniques are of limited value because of the superimposition of anatomical structures, for example, cervical vertebra.[31–35] Also, panoramic images have a vertical and horizontal magnification of 24 to 37% and 1 to 63%, respectively.[34] The present study indicates that panoramic images for the identification of the incisive canal for preoperative planning in the interforaminal region are not suitable. It might be advisable to choose cross-sectional imaging such as CBCT scans.

Because of decreased bone-implant contact, incisive canals with large diameters may play a negative role in the osseointegration of implants. Furthermore, a large incisive canal might be involved in postoperative

TABLE 3 Comparison of the Apex Distance to the Incisive Canal between Origin and Terminal Portion in Computed Tomography Scan Images

	Origin (mm) Mean ± SD	Terminal Portion (mm) Mean ± SD	*p* Value
Apex–canal (all)	4.6 ± 2.2	6.1 ± 3.1	<.001
Apex–canal (female)	4.4 ± 2.4	5.9 ± 3.2	.003
Apex–canal (male)	4.8 ± 1.8	6.3 ± 2.8	.007

sensory disturbances. A dental implant penetrating the mandibular incisive canal could result in a possible stretching of the mental nerve.

In summary, the presence, location, and dimensions of the mandibular incisive canal are better determined by CBCT imaging than by panoramic radiography. The clinical significance of this study can be realized through mapping of the incisive canal and its proximity relative to anatomical considerations during osseous grafting procedures, specifically when using the chin graft protocol for harvesting donor bone.

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