Accuracy of Assessing the Mandibular Canal on Cone-Beam Computed Tomography: A Validation Study

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Purpose: To establish the accuracy of cone-beam computed tomographic (CBCT) views in determining the position and diameter of the mandibular canal.

Materials and Methods: Two freshly frozen cadaver heads, 1 dentate and 1 edentate, were used to acquire CBCT scans. Measurements on cross-sectional CBCT images were compared with measurements on digitized histologic sections of the same regions in the mandibles. The Student *t* test was used for statistical analysis.

Results: Comparing CBCT with histologic measurements showed that the position of the mandibular canal differed up to 0.47 mm (standard deviation, 0.29 mm). Mandibular canal diameters were up to 22.8% smaller in the CBCT planes. For the dentate jaw, these differences were statistically significant.

Conclusion: To be safe, when assessing the mandibular canal position on CBCT views, a 0.76-mm deviation should be taken into account. Because the diameter of the mandibular canal is displayed smaller, an enlargement by 0.74 mm is recommended.

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In oral rehabilitation, for esthetic and functional reasons, dental implants are an acceptable treatment solution with high predictability.[1-3] Reconstructions of alveolar defects with intraoral bone grafts has become a validated treatment allowing implant placement. However, one of the risk factors of such treatment is unintentional impairment of the inferior alveolar nerve (IAN). Cutting, tearing, or laceration of the IAN can occur during bone harvesting. Penetrating the mandibular canal, bone compression and hematomas during drilling, and subsequent implant placement also can damage the IAN.[4,5]

This results in considerable and serious disability, varying from transient or persistent anesthesia to paresthesia to dysesthesia,[4-7] the prognosis of which depends on the severity of nerve damage.[4,8,9]

Several imaging modalities can assist in preoperative risk assessment of the mandibular canal, such as

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panoramic radiographs, conventional multislice computed tomography (MSCT), and cone-beam computed tomography (CBCT). The benefits of CBCT are shorter scan times and decreased radiation dose compared with MSCT. Furthermore, it is more cost-effective.[10,11]

Data from the CBCT can be used to trace and visualize the mandibular canal using 3-dimensional (3D) image-based planning software. First, the course of the canal is marked. Thereafter, by interpolating these points, a virtual replica is reconstructed. This "mandibular canal tracing procedure" enables an assessment of the position of the canal in several directions because multiplanar and 3D reconstructions of the canal are provided.[12,13]

A review of literature shows that CBCT images are often used to establish the position of the mandibular canal.[12-15] However, only a few studies have addressed the validity of this presurgical assessment.[16,17] Until the present study, the mandibular canal diameter has not been the subject of any study. The objective of this research was to compare the visual representation of the mandibular canal with its anatomic reality by determining the accuracy of mandibular canal measurements performed on CBCT images compared with measurements performed on digitized histologic sections.

Materials and Methods

To establish the accuracy of position and diameter measurements of the mandibular canal on CBCT views, 2 freshly frozen cadaver heads, 1 dentate and 1 edentate (according to the V classification of Cawood and Howell[18]), were selected (the heads had been donated for scientific research). Dimensions measured on CBCT images were compared with histologic sections of the corresponding region. In each lower jaw, 4 sites were selected, ie, the second molar region and the second premolar region on the left and right sides. At these sites, position markers, consisting of titanium microscrews (KLS Martin, Gebrüder Martin GmbH and Co, Tuttlingen, Germany) with a length of 5 mm and a diameter of 1.5 mm, were placed perpendicular to the arch at the free gingival margin in the vestibular sulcus.

The cadaver heads were fixed and stabilized in an upright position. Scout views were taken to position the mandible in the middle of the field of view (FOV). CBCT images were acquired using the i-CAT 3D Imaging System (Imaging Sciences International, Inc, Hatfield, PA). The scan specifications were a peak tube voltage of 120 kV, pulses of 1.2 mA, scanning time of 40 seconds, a maximum FOV of 22 cm, and an isotropic voxel size of 0.400 mm. Data from the CBCT were exported into Digital Imaging and Communications in Medicine (DICOM) format.

After the scanning procedure, the lower jaws were segmented into smaller specimens and surplus soft tissue was removed, allowing histologic processing. These blocks were fixed in neutral buffered formaldehyde 4%, subsequently dehydrated in graduated ethanol solutions (70% to 100%), and embedded in methylmethacrylate (MMA). After polymerization, undecalcified samples were prepared in 10-μm-thick slices in a cross-sectional plane along the markers.[19] Methylene blue and basic fuchsin stain were used to visualize the cell and bone components. Images of the histologic sections were captured and digitized using a Carl Zeiss light microscope and AxionVision 4.6 software (Carl Zeiss MicroImaging GmbH, Göttingen, Germany) and subsequently converted to Joint Photographic Experts Group (JPEG) format and imported into Adobe Photoshop CS4 11.0 (Adobe Systems Incorporated, San Jose, CA).

The measurement scale was set to establish true size dimensions. With the digitized ruler tool, distances from the middle of the canal to the outer surfaces of the mandibular body were measured (Fig 1A-D). Also, the diameter of the canal was determined (Fig 1E, F). These measurements were used as reference values for the corresponding scores as determined on the CBCT images.

To establish the position of the mandibular canal on CBCT views, the mandibular canals were traced using Procera System planning software (NobelGuide, Nobel Biocare, Göteborg, Sweden). For quick tracing, the panoramic images were used. In addition, cross-sectional planes were used to refine the position of the canal.[12] To measure the same linear distances in the corresponding cross-sectional CBCT images, the linear measurement tool was used (Figs 2a-d, 3e, f). Brightness and contrast settings were fixed at levels that discriminated between the various structures. The magnification settings were adjusted to fit the size of the screen for optimal display. To define the intraobserver variation, all mandibular tracings and measurements were repeated 8 times with an interval of 7 days. A second observer independently repeated this procedure under the same circumstances.

Data are presented as mean and standard deviation (SD). For analysis of the difference between CBCT and histologic measurements and between observers, the Student *t* test was used. To quantify the relation between differences in CBCT and histologic measurements as seen by the 2 observers, the intraclass correlation coefficient (ICC) was calculated. In accordance with the notation for the ICC as introduced by Shrout and Fleiss,[20] an ICC(2,2) was required. The dentate and edentate measurements were evaluated separately. The absolute and relative differences were calculated.