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Evaluation of the accuracy of linear measurements on multi-slice and cone beam computed tomography scans to detect the mandibular canal during bilateral sagittal split osteotomy of the mandible

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Abstract. The aim of this study was to compare the accuracy of linear measurements of the distance between the mandibular cortical bone and the mandibular canal using 64-detector multi-slice computed tomography (MSCT) and cone beam computed tomography (CBCT). It was sought to evaluate the reliability of these examinations in detecting the mandibular canal for use in bilateral sagittal split osteotomy (BSSO) planning. Eight dry human mandibles were studied. Three sites, corresponding to the lingula, the angle, and the body of the mandible, were selected. After the CT scans had been obtained, the mandibles were sectioned and the bone segments measured to obtain the actual measurements. On analysis, no statistically significant difference was found between the measurements obtained through MSCT and CBCT, or when comparing the measurements from these scans with the actual measurements. It is concluded that the images obtained by CT scan, both 64-detector multi-slice and cone beam, can be used to obtain accurate linear measurements to locate the mandibular canal for preoperative planning of BSSO. The ability to correctly locate the mandibular canal during BSSO will reduce the occurrence of neurosensory disturbances in the postoperative period.

Key words: multi-slice computed tomography; cone beam computed tomography; orthognathic surgery; dimensional measurement accuracy.

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The bilateral sagittal split osteotomy (BSSO), aimed at correcting mandibular deformities, was made popular as a surgical technique by Trauner and Obwegeser in 1957.[1] Since then, the BSSO has become a standard procedure in the treatment of mandibular deformities and has been used to both advance and retract the mandible in orthognathic surgeries. General acceptance of this technique has led to a series of modifications, the most relevant of which were reported by Dal Pont in 1961[2] and Epker in 1977[3]; these led to a simplified and safer surgical technique with more stable results.[4]

Despite its versatility and many advantages, the BSSO can present complications, such as unfavourable fracture during surgery, paresthesia, and relapse.[5] Neurosensory disturbances are routinely expected, mainly due to the proximity of the osteotomies performed in the external cortical bone to the mandibular canal, through which the inferior alveolar nerve (IAN) passes.[6] Paresthesia, or an alteration in IAN sensitivity after BSSO, is the most commonly encountered neurosensory disturbance. According to some authors, this is expected in nearly 30–40% of cases,[7,8] whereas others have reported it to occur in up to 85–100% of patients at 1 month post-surgery.[9,10] Direct damage to the IAN can occur during osteotomy through the use of burs, saw blades, or chisels, through the use of retractors, and even during segment fixation with wires or screws. Indirect damage to the IAN may be caused by postoperative oedema.[11,12] Factors that can influence the risk of paresthesia include the patient's age, magnitude of the mandibular movement, degree of intraoperative manipulation of the IAN, and width of the bone marrow between the mandibular canal and the external cortical bone of the mandible.[6]

The use of computed tomography (CT) to detect anatomical structures has been employed in a wide range of surgical specialties in an attempt to reduce the risk of traumatic damage to anatomical structures such as blood vessels and nerves.[6] Many studies suggest that the use of CT examinations, as compared to conventional radiography, provides more precise data for the detection of the mandibular canal pathway.[13–17] Of the currently available CT examination modalities, the most commonly used are multi-slice computed tomography (MSCT) and cone beam computed tomography (CBCT).

Multi-slice technology is a diagnostic imaging method in which thin slices of anatomical regions are generated through volumetric and helicoidal acquisition, making it possible to obtain a more precise and safe evaluation compared to conventional tomography.

In the acquisition of the CBCT image, a three-dimensional X-ray beam in the form of a cone crosses the object and comes into contact with a two-dimensional detector, providing the volumetric acquisition. Software programs then generate the images in three orthogonal planes.[18,19] The CBCT device operates by means of an electric current that is substantially less (around 5 mA) than that of the MSCT device (80–200 mA). This generates fewer X-rays photons, thus reducing the radiation dose.[20,21] However, due to the reduction in number of photons, the images have more noise, and their contrast is therefore less than that of MSCT, thus reducing the capacity to evaluate soft tissues. This does not, however, interfere significantly in the evaluation of hard tissues, such as bones and teeth.[21]

Given the high risk of damage to the IAN in mandibular sagittal osteotomies, the study of the mandibular canal and its relationship with the adjacent cortical bone of the mandible becomes very important.[9,22–24] The aim of the present study was to evaluate the accuracy of the measurements obtained from CBCT and MSCT scans taken in the region of the mandibular canal through comparison with measurements of anatomical slices from dry mandibles (actual measurements). This study also sought to determine which CT technique – cone beam or multi-slice – presents the higher index of accuracy and reliability in the measurement of anatomical structures, in an attempt to diminish the risk of damage to the IAN during BSSO.

Materials and methods

Approval was obtained from the local ethics committee prior to study commencement. Eight dry edentulous human mandibles were selected from the collection of anatomical parts of the University Department of Anatomy. Three bilaterally equal sites were selected on each of the mandibles. These sites demarcate the areas in which osteotomies are performed near the mandibular canal pathway, presenting a high risk of damage to the IAN. The sites were identified with the letters A (Trans), B (Angle), and C (Retro), representing the regions of the lingula, angle, and mandibular bodies, respectively (Fig. 1). Thus, six sites were identified for each mandible, giving a total of 48 sites for the eight jaws. Prior to performing the CT measurements, tomographic markers were produced using orthodontic steel wire (0.9 mm in diameter) and acrylic resin, and positioned over the mandibles as described by Lee and Morgano[25] and Weingart and Düker[26] (Fig. 1).

The mandibles were placed in an acrylic box with a base of 15 × 15 cm and sides of 5.0 cm in height. The acrylic box was supported by a photographic tripod to ensure the stability of the entire arrangement. After positioning each mandible with its respective tomographic markers, the acrylic box was filled with 750 ml of water to promote the attenuation of the X-ray beams and simulate the soft tissues of the jaws, as described by Butterfield et al.[27]

MSCT and CBCT scans

The dry mandibles were examined using a 64-slice CT scanner (Somatom Sensation 64; Siemens Medical Solutions, Erlangen, Germany) and by CBCT (i-CAT Next Generation; Imaging Sciences International, Hatfield, PA, USA). The mandibles were positioned with their respective tomographic markers in each unit. For the 64-slice CT, the following parameters were used to acquire the images: scan time of 5 s, 130 kV, 100 mA; collimation of 64 × 0.6 mm; matrix size of 512 × 512 pixels; field of view of 174 mm × 174 mm; slice thickness of 0.6 mm, with overlapping reconstructions; resolution of 0.4 × 0.4 × 0.4 mm voxel size. For the CBCT, the following exposure factors were selected: large field of vision (13 cm), 120 kV, 7 mA, 20-s exposure time, with a resolution of 0.2 × 0.2 × 0.2 mm in voxel size (Fig. 2).

CT image measurements

Linear measurements were made in each of the tomographic images of the selected regions by three professionals with experience in MSCT and CBCT. Dental Slice software (Bioparts, Brasília, DF, Brazil) was used for this purpose.

For cut A (Trans), the distances between the tip of mandibular lingula (its most anterior and lingual aspect) and the following points were measured: anterior border of the mandibular ramus, buccal surface of the mandible closest to the mandibular lingula, and posterior border of the mandible. For cuts B (Angle) and C (Retro), the distances between the mandibular canal (the nearest cortical part of the mandibular canal) and the following points were measured: lower border of the mandible, buccal surface closest to the mandibular canal, lingual surface closest