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Analysis of sexual dimorphism by locating the mandibular canal in images of cone-beam computed tomography

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ABSTRACT

The aim of this study was to evaluate sexual dimorphism in anthropometric measurements on mandibular images obtained by cone beam computed tomography (CBCT). One hundred sixty Brazilian individuals (74 men and 86 women), aged between 18 and 60 years, were included in the study. In the CBCT images 8 measurements were performed: distance from the mandibular foramen to the most anterior part of the mandibular ramus; distance from the mandibular foramen to the most posterior part of the ramus; distance from the upper channel to the alveolar ridge of the mandible; distance from the upper channel to the bottom of the mandibular canal; distance from the channel to the mandibular alveolar ridge (lingual); distance from the channel to the mandibular alveolar ridge (buccal); distance from the mental foramen to the top of the alveolar ridge; and distance from the mental foramen to the base of the mandible. Analysis of variance was used to test the existence of difference, between sexes, in the mean values of these measurements and the binary logistic regression model was developed to predict the sex. Optimal model was obtained with 5 measurements with an accuracy of 86.1%. In conclusion, the formula developed in this study can be used together with other criteria as a tool to sexual identification in forensic settings.

1. Introduction

The study of identity is a form of individualizing human beings by the sum of their individual characteristics. The methods used by researchers to reach this goal is the identification process. Among several techniques used in identification, we focus on the study of criminal identification, which may include studies of living or dead persons. Because of the difficulty in identification, many bodies remain unidentified and new methods to facilitate identification are necessary [1–6].

The identification of sex is considered to be an important step in the reconstruction of the biological profile of an unknown individual in the forensic context. The techniques used are based on assessments of the morphological characteristics of the pelvis and skull, but in some cases the basin or the pelvis is in a fragmentary state. In the forensic setting, anthropologists have long used teeth as an additional tool to determine sex because of their ability to resist destruction after death. In this situation, the use of data from a specific population is important because sexual dimorphism varies among different populations [7–11].

Sexual dimorphism is a method that has been used for many years within forensic dentistry for human identification. This method is better in adults because of the morphological influences that affect bone structure such as the hormones that control growth, bone development and developments during puberty. In contemporary populations, there is a relative scarcity of specific morphometric patterns for estimating sex from bone findings from unidentified human remains. There is basically a lack of historical evidence or documentation on the use of human skeletons available for study [12–17].

Previous studies have indicated that the relative position of the lower alveolar channel and its respective foramina (mental and mandibular) in adults can be used to estimate sexual dimorphism and age. Arguably, these differences can be used as proposed values for forensic identification of human remains [18].

Some studies have attempted to determine the influence of age and sex on the relative position of the inferior alveolar canal and its foramina on cone beam computed tomography (CBCT) images. In general, the results have demonstrated that the relative location of the channel associated with foramina of the lower jaw in adults

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remains relatively constant with increasing age or sex, although some studies have shown different results. New research results using different populations and with larger samples are needed to evaluate the relative position of the mandibular channel and the respective foramina to provide a probable sex determination in a specific population [18].

Craniometric features are closely connected to forensic dentistry, because they can aid in identifying an individual from a skull found detached from its skeleton. Computer tomography (CT) scans are an excellent imaging modality for evaluating the sinonasal cavities. They provide an accurate assessment of the paranasal sinuses, craniofacial bones, as well as other bones in the body [37–43].

In forensic medicine, numerous studies have used CT as an auxiliary method in the discovery of unidentified bodies post-mortem. A recent study used CT to estimate the age of human bodies using the third molar tooth, the medial epiphysis of the clavicle and sphenooccipital synchondrosis in a sample of Australian individuals [18] Other studies also have used CT as an aid to pathologists in determining the cause and manner of death; it is also invaluable for identification of human remains when traditional methods are not possible [3,19].

Thus, several authors have reported on the important benefits of CT in assisting coroners, but CBCT is a relatively new CT system that focuses on the head and neck. CBCT uses an X-ray beam and a detector system that move around the part of the body under examination. It is the test of choice in dentistry and has the advantage of much lower cost and smaller size of the equipment without losing reliability and accuracy of the image compared with multidetector computed tomography (MDCT) [20–24].

In this context, the aim of this study was to evaluate the sexual dimorphism of a mixed Brazilian population through the relative position of the mandibular channel and its foramina (mandibular and mental) using CBCT images. A more specific aim was to determine which measurements best differentiate between the sexes and the accuracy of the measurements performed on the images for the purpose of sex determination, and to create a formula with potential dimorphic variables using measurements of anatomic mandibular landmarks on CBCT images in Brazilians.

2. Methods

This retrospective study was approved by the Ethics Committee in Research of the Piracicaba Dental School, University of Campinas. A total of 160 CBCT images (74 images of the mandible of male patients and 86 images of the mandible of female patients) were included in the sample of adult patients, aged between 18 and 60 years, selected from a file examinations of patients seen at the Clinic of Dental Radiology, Faculty of Dentistry of Piracicaba, University of Campinas, located in Piracicaba, São Paulo state. A dentomaxillofacial radiologist visually selected the images for the study. Selection was based on exclusion of CBCT images with any kind of pathologic condition and mandibular fractures in the jaw region. The CBCT images were acquired using i-CAT™ tomography (Imaging Sciences, Hatfield, PA, USA) with the following scheme: 80 kVp, 4,8 mA; acquisition time 40 s, reconstruction 62 s with a voxel threshold of 0.3 and a field of view completely encompassing the mandible. All images used in this study were obtained with patients in a sitting position. The position of the head was maintained by the device, so that the midsagittal plane remained perpendicular to the plane of the ground and the plane of Camper (an imaginary line from the nose to the wing tragus) thus remaining parallel to the plane of the ground. During the examination, the patients remained still in maximum intercuspation. Measurements were then taken from the tomographic images.

2.1. Tomographic measurements

For the measurements, multiplanar reconstruction images generated by the software tools in OnDemand3D (Cybermed, Seoul, Korea) on a computer with a liquid crystal display were analyzed. All the measurements were performed using the same screen. Eight measurements were taken from the jaws in the CBCT images. Two of the measurements were taken from axial images in the region of the mandibular foramen (Fig. 1): The distance from the mandibular foramen to the most anterior part of the mandibular ramus: anterior mandibular foramen (AMaF). The distance from the mandibular foramen to the most posterior part of the ramus: posterior mandibular foramen (PMaF).

Four measurements were taken from the coronal view, with the CT slice located in the first molar (Fig. 2): The distance from the upper channel to the alveolar ridge of the mandible: superior inferior alveolar canal (SIAC). The distance from the bottom of the mandibular canal: inferior alveolar canal (IIAC). The distance from the channel to the mandibular alveolar ridge (lingual): lingual inferior alveolar canal (LIAC). The distance from the channel to the mandibular alveolar ridge (buccal): buccal inferior alveolar canal (BIAC)

Two measurements were taken from a coronal slice; this view showed the mental foramen (Fig. 3): The distance from the mental

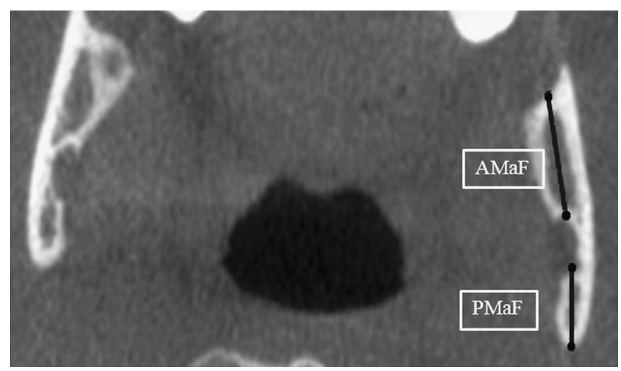

Fig. 1. (AMaF)—the distance from the mandibular foramen to the most anterior part of the mandibular ramus: anterior mandibular foramen; and (PMaF)—the distance from the mandibular foramen to the most posterior part of the ramus: posterior mandibular foramen.

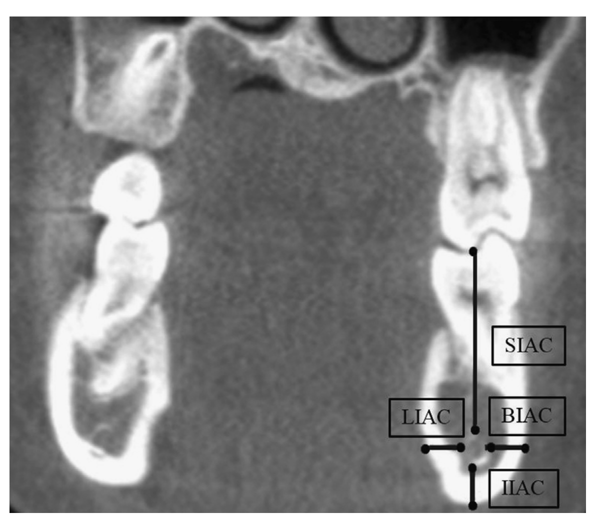

Fig. 2. (SIAC)—the distance from the upper channel to the alveolar ridge of the mandible. (IIAC)—the distance from the bottom of the mandibular canal. (LIAC)—the distance from the channel to the mandibular alveolar ridge (lingual). (BIAC)—the distance from the channel to the mandibular alveolar ridge (buccal).