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Validation study of a new method for sexual prediction based on CBCT analysis of maxillary sinus and mandibular canal

Thiago de Oliveira Gamba[a,*], Mayra Cristina Yamasaki[a], Francisco Carlos Groppo[b], Heraldo Luis Dias da Silveira[c], Solange Maria de Almeida Boscolo[a], Gerard C.H. Sanderink[d], W. Erwin R. Berkhout[d]

[a] *Division of Oral Radiology, Piracicaba Dental School, University of Campinas, Department of Oral Diagnosis, Limeira Avenue, 901, PO Box 52, Piracicaba, SP, Brazil*
[b] *Division of Pharmacology, Anesthesiology and Therapeutic, Piracicaba Dental School, University of Campinas, Department of Physiological Sciences, Limeira Avenue, 901, PO Box 52, Piracicaba, SP, Brazil*
[c] *Division of Oral Radiology, Federal University of Rio Grande do Sul, Department of Surgery and Orthopedics, Porto Alegre, Ramiro Barcelos Avenue, 2492, Porto Alegre, RS, Brazil*
[d] *Department of Oral and Maxillofacial Radiology, Academic Centre for Dentistry Amsterdam (ACTA), 4N-51 Gustav Mahlerlaan 3004, 1081 LA, Amsterdam, The Netherlands*

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ABSTRACT

Objective: The aim of this study was to evaluate the accuracy of two craniometric methods for sexual prediction (SP) using cone-beam computed tomography (CBCT) in the Dutch population and to construct a formula for each method and then the two combined.
Design: One-hundred sixty CBCT images were selected from a Dutch database (80 males and 80 females). The images were analyzed by two examiners taking seven measurements in the maxillary sinus (MS) region (first method) and nine in the mandibular canal (MC) region (second method). The most predictive measurements in both methods were used to develop an equation to determine the accuracy of each method.
Results: All measurements showed statistical difference between genders. Logistic regression results showed two variables with greater SP index with 75% accuracy in the first method and four variables with 71.9% accuracy in the second. The two methods combined showed another four variables with 78.5% accuracy.
Conclusion: All measurements showed statistically significant differences between sexes. The SP accuracy values were 75% for first 71.9% for the second method. When the two methods were combined, the accuracy increased to 78.5%. The formulas developed in this study can be applied as a complementary method for human identification in the Dutch population.

1. Introduction

The term identity can be defined as a feature set in an individual that can distinguish the said individual from others. Furthermore, identification is a process that aims to distinguish similar characteristics in missing individuals pre- and post-disappearing. In this sense, the human identification (HI) process is the first step in forensic dentistry when using the bone remains of disappeared individuals (Gamba, Alves, & Haiter-Neto, 2016).

The main methods of HI are the estimation of chronological age and height, and sex determination of an individual (Alshihri et al., 2015). The prediction or sexual differentiation plays an important role in the identification of skeletal remains of missing individuals (Angelis et al., 2015; Di Vella et al., 1994; Gamba et al., 2016). The skull is the method most commonly used for identification of bone remains in sexual prediction (SP). Anthropometry, in case craniometrics measurements, is performed in the skull, by linear, angular and/or volumetric measurements (Di Vella et al., 1994; Mahakkanukrauh et al., 2015; Rainio, Lalu, Ranta, & Penttilä, 2001; Ramamoorthy, Pai, Prabhu, & Muralimanju, 2016).

Some contemporary imaging methods allow the same procedure as that done with calipers to be performed quickly and accurately. One method with great potential in aiding forensic dentistry is fan-beam computed tomography (FBCT) (Meng, 2010). The main advantage of FBCT is that it helps uncover features of very disfigured bodies and clarify issues that may arise at the time of case review by forensic

* Corresponding author.
E-mail addresses: thiagodeo.gamba@gmail.com (T.d.O. Gamba), mcyamasaki@uol.com.br (M.C. Yamasaki), fcgroppo@fop.unicamp.br (F.C. Groppo), heraldo.silveira@ufrgs.br (H.L.D. da Silveira), solangea@fop.unicamp.br (S.M.d.A. Boscolo), g.sanderink@acta.nl (G.C.H. Sanderink), e.berkhout@acta.nl (W.E.R. Berkhout).

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professionals (Biwasaka et al., 2009; Leth, 2009). There are other imaging methods similar to FBCT, such as cone-beam computed tomography (CBCT), which is focused on the imaging of the head and neck, that have the same accuracy for imaging hard tissues as CT, but with greater ease of access to perform surveys in clinics and universities compared with CT (Angel, Mincer, Chaudhry, & Scarbecz, 2011; Biwasaka et al., 2009; Gamba, Alves, & Haiter-Neto, 2014; Leth, 2009; Marmulla et al., 2005; von See et al., 2009).

Some researchers have suggested the use of tomographic images in SP. Many studies have indicated different anatomical structures with dimorphic potential, such as the maxillary sinus (MS). A study of MS measurements performed using CT in an Iraqi population found an accuracy of 73.9% for the association of the dimorphic measurements and provided results that can be used when other methods are inconclusive. However, these studies need to be reproduced in different populations in order to further compare and identify the specific characteristics of these morphologies in different population groups (Uthman, Al-Rawi, Al-Naaimi, & Al-Timimi, 2011).

Studies have used tomographic imaging in the evaluation of anatomical structures besides the MS, such as the relative position of the mandibular canal (MC) and its mandibular (MaF) and mental (MeF) foramina. Arguably, these different methods can be used as forensic markers for identifying human skeletal remains. Thus, it is important to analyze the use of CBCT images when combining different predictive methods to find more dimorphic measures that will increase the accuracy of SP and also identify specific characteristics in different populations around the world (Angel et al., 2011; Gamba et al., 2014).

The aims of this study were to select the craniometric variables with the greatest value in SP by using different craniometric methods, construct a formula for SP for each of the methods, and evaluate the SP accuracy of each anthropometric method in a Dutch experimental population.

2. Materials and methods

2.1. Sample selection

Two-hundred forty-five CBCT images were selected and divided into two groups. The first contained 160 CBCT images (80 images of male patients and 80 of female patients). The second group contained 85 images (42 images of male patients and 43 of female patients) that were used to test the model constructed from the first group (the formula created in the present study). Only images of adult patients aged between 20 and 60 years that covered the MS and mandibular regions completely were included in the sample. Later, the images were divided into four age groups (20–30, 31–40, 41–50, and 51–60 years) and into groups of 40 images (20 each from male and female patients). All images were selected from the examination database of patients from the department of Oral Radiology at the Academic Centre for Dentistry Amsterdam (ACTA), located in Amsterdam, Netherlands. No ethical approval was needed in the Netherlands because the CBCT scans were anonymously taken from a database. A single oral radiologist selected all the images for the present study. CBCT images with any pathological condition and/or fractures of the maxilla and mandible were excluded, as well as completely edentulous individuals or those with a bilateral absence of the upper and lower molars. CBCT images acquired from the database were obtained using the NewTom 5G CBCT scanner (QR srl, Verona, Italy). Only large field of view (15 × 12 cm) scans were selected, with the following acquisition parameters: 110 kVp, 2 mA, and 0.3-mm voxel size. All images used in this study were obtained from patients in the supine position, consistent with the regular position of patients when using this device. The scans were retrieved from the database in the DICOM format.

2.2. Tomographic measurements

The DICOM files were imported to OnDemand3D software (CyberMed, Seoul, South Korea) and multiplanar reconstruction (MPR) images were generated. Measurements were performed in two distinct regions of the skull. The first measurement (called the first method) was performed in the MS region and the second measurement (second method) in the MC region in three different locations: mandibular foramen region, first molar region, and mental foramen region. The examiners performed an alignment of the head of each patient both with respect to the measurements in the region of the MS and of the mandible. In addition, such alignment was performed separately in each of the analyzed regions. This alignment was performed for the first time in the sagittal plane, positioning the horizontal cursor line present in each MPR such that it joined the anterior and posterior nasal spines. The vertical line of the cursor was then positioned on the same anatomical points in the axial plane. Finally, the vertical cursor line demarcated the sagittal plane of the individual in the coronal plane. Each examiner was then able to perform a dynamic evaluation of the full volume of the image and find the largest measurements of height, width, and length. No adjustment for head size was applied to the groups. Initially, seven measurements were performed on the MS. Two were made in the coronal plane, consisting of the height of the right maxillary sinus (HRMS) (Fig. 1-1a) and height of the left maxillary sinus (HLMS) (Fig. 1-1b)). The other measurements were made on five axial planes and consisted of the length of the right maxillary sinus (LRMS) (Fig. 2-2a), length of the left maxillary sinus (LLMS) (Fig. 2-2b), width of the right maxillary sinus (WRMS) (Fig. 2-2c), width of the left maxillary sinus (WLMS) (Fig. 2-2d), and total width of the maxillary sinus (TWMS) (Fig. 2-2e). Similarly, nine other measurements were performed on the mandible and were divided into three specific areas. First, two measurements in the axial plane were performed for the MaF region: the distance from the MaF to the most anterior part of the mandibular ramus, the anterior mandibular foramen (AMaF) (Fig. 3-3a); and the distance from the MaF to the most posterior part of the ramus, the posterior mandibular foramen (PMaF) (Fig. 3-3b). Second, for the first molar region, five measurements were performed in the coronal plane consisting of the distance from the upper canal border to the crown of the first molar, the superior inferior first molar canal (SI1MC) (Fig. 3-3c); the distance from the upper canal border to the cortical bone, the superior inferior alveolar canal (SIAC) (Fig. 3-3d); the distance from the lower border of the mandibular canal to the base of mandible, the inferior inferior alveolar canal (IIAC) (Fig. 3-3e); the distance from the lingual canal border to the lingual cortical bone, the lingual inferior alveolar canal (LIAC) (Fig. 3-3f); and the distance from the buccal canal border to the buccal cortical bone, the buccal inferior alveolar canal (BIAC) (Fig. 3-3g). Finally, two measurements in the coronal plane were made in the region of the MeF: the distance from the

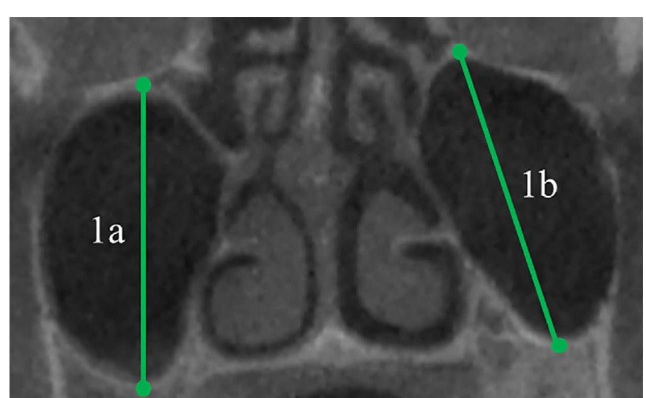

Fig. 1. CBCT image in the coronal view: (1a)- Height of the right maxillary sinus (HRMS) (1b)- Height of the left maxillary sinus (HLMS).