Forensic Science International 255 (2015) 9–15

Contents lists available at ScienceDirect

Forensic Science International

journal homepage: www.elsevier.com/locate/forsciint

Sexual dimorphism of the mandible in a contemporary Chinese Han population

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ARTICLE INFO

Article history:
Available online 19 June 2015

Keywords:
Mandible
Forensic anthropology
Sex dimorphism
Chinese
Cone beam computed tomography

ABSTRACT

A present limitation of forensic anthropology practice in China is the lack of population-specific criteria on contemporary human skeletons. In this study, a sample of 203 maxillofacial Cone beam computed tomography (CBCT) images, including 96 male and 107 female cases (20–65 years old), was analyzed to explore mandible sexual dimorphism in a population of contemporary adult Han Chinese to investigate the potential use of the mandible as sex indicator. A three-dimensional image from mandible CBCT scans was reconstructed using the SimPlant Pro 11.40 software. Nine linear and two angular parameters were measured. Discriminant function analysis (DFA) and logistic regression analysis (LRA) were used to develop the mathematics models for sex determination. All of the linear measurements studied and one angular measurement were found to be sexually dimorphic, with the maximum mandibular length and bi-condylar breadth being the most dimorphic by univariate DFA and LRA respectively. The cross-validated sex allocation accuracies on multivariate were ranged from 84.2% (direct DFA), 83.5% (direct LRA), 83.3% (stepwise DFA) to 80.5% (stepwise LRA). In general, multivariate DFA yielded a higher accuracy and LRA obtained a lower sex bias, and therefore both DFA and LRA had their own advantages for sex determination by the mandible in this sample. These results suggest that the mandible expresses sexual dimorphism in the contemporary adult Han Chinese population, indicating an excellent sexual discriminatory ability. Cone beam computed tomography scanning can be used as alternative source for contemporary osteometric techniques.

1. Introduction

Sexual dimorphism is expressed in most human bones. The pelvis is the most dimorphic, and can assign sex correctly up to 100% [1]. The second easily sexed bone is the skull, which can provide allocation accuracy of more than 90% [2]. As the most dimorphic bone of the skull [3], the mandible is often well preserved and useful for sex and race determination in forensic and archaeological cases, especially when the pelvis and intact skull are either missing or highly damaged.

Sex dimorphic characteristics of the mandible, including gonial angle, ramus length and breadth, bigonial breadth, and other morphologic indicators have been reported [4–6]. Among these indicators, the mandibular ramus flexure was used to distinguish sexes with 99% reliability in African Blacks [7], which rivalled the predictive accuracy of the complete pelvis. However, its reliability has fuelled debates among researchers. In a study by Kemkes–Grottenthaler [8], only 59% accuracy of sex allocation was obtained using the ramus flexure. In addition, the sexual dimorphisms of other mandibular traits were also found inconsistent in different literatures [9].

It is well known that skeletal characteristics vary among different populations; therefore, each population needs its own specific standards for sex assessment [10–14]. China is a multi-ethnic group country. A few existing reports have described the mandible attributes in certain geographically remote Chinese ethnic groups [15,16], among which the mandible metric

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http://dx.doi.org/10.1016/j.forsciint.2015.06.010
0379-0738/

standards for sex determination from Zhang's paper were widely accepted by most researchers [15]. But more than 19 years have elapsed since Zhang et al. [15] reported sexual dimorphism in dry mandible collections of heterogeneous Chinese population. The different population groups, secular trends and changed nutritional or environmental conditions might affect bone measurements. Thus, the standards proposed by Zhang are considered unsuitable and obsolete for the contemporary Chinese Han population. It becomes essential to establish updated population-specific sexing standards because of the great variations among various regional and ethnic population groups with the passing of time.

Both dry bones and X-radiographs were employed for skeletal measurements in most of previous studies. New methods, such as medical scanning, are developed constantly, making it possible to revisit the anatomy of the mandible more conveniently. At present, computerized or virtual methodologies become a growing trend in forensic anthropology, and can extend osteological resources beyond anatomic truth. The previous studies showed increased accuracy and reproducibility by computed tomography (CT) over traditional osteometry [17,18]. Cone beam computed tomography (CBCT) is a medical imaging technique consisting of X-ray computed tomography, in which the X-rays are divergent, forming a cone. The dedicated CBCT scanner has been used in oral and maxillofacial clinical practice since the late 1990s, and their application is becoming increasingly popular to date. This imaging device can acquire undistorted and good-quality 3D images with a low radiation dose [19], which allows precise localization and description of bone structures with a special software. So, sex estimation using CBCT images appears to have some advantages compared with conventional osteometric approaches.

The purpose of the present study was to investigate whether human mandible is sexually dimorphic and assess the accuracy of sex estimation using mandible measurements in the contemporary Han Chinese population. The traditional and geometric morphometric parameters were selected for sex determination. In addition, the study also evaluated the use of CBCT to reproduce anatomical measurements of the mandible.

2. Materials and methods

2.1. Population data

The sample used in this study consisted of 203 individuals (96 males, 107 females). The mandible CBCT data were obtained from the Department of Oral Radiology, Stomatology School, Wuhan University, China. Exclusion criteria were: non-Han Chinese origin; pathological changes in mandible, including fractures, bone tumors; systemic diseases such as metabolic–endocrinological diseases; growth disorders; severe osteoporosis. The study protocols were approved by the Medical Ethics Committee of Huazhong University of Science and Technology. A written informed consent was obtained from all participants. Subjects were 20–65 years old Chinese Han individuals. The sample was relatively equally distributed between ages with 96 males (age range, 20–65 years; mean, 42.2 ± 11.5 years) and 107 females (age range, 23–63 years; mean, 38.9 ± 10.7 years). No statistically significant difference in mean age between males and females was observed ($P > 0.05$).

2.2. Skeletal measurements

After sampling completion, three-dimensional images from CBCT scans of the mandibles were reconstructed using the SimPlant Pro 11.40 software. Each linear or angular parameter of the mandible was measured using the SimPlant Pro 11.40 software. The current study comprised eleven mandible measurements according to the previous reports [20,21]: bi-condylar breadth (BC), bi-gonial breadth (BG), bi-antegonial notch breadth (BA), bi-mental foramina breadth (BM), distance between mental foramen and mandibular inferior border (DMI), maximum mandibular ramus height (MRH), maximum mandibular ramus breadth (MRB), maximum mandibular length (MDL), maximum mandibular body length (MBL), mandibular angle (MDA), and mental angle (MA). DMI, MRH, MRB, MDL, MBL and MDA were measured on the left mandible. A schematic representation of the measurements is shown in Fig. 1. The various measurements are indicated and further explained in Table 1.

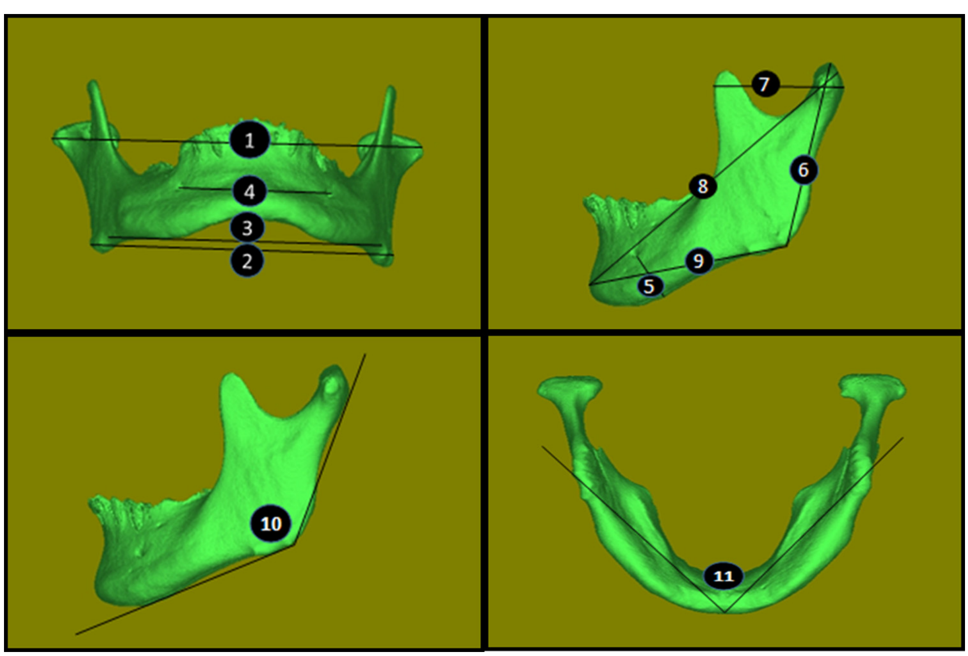

Fig. 1. Diagram showing landmarks for various mandible measurements. (1)–(9): Linear parameters of the mandible (1) bi-condylar breadth (BC); (2) bi-gonial breadth (BG); (3) bi-antegonial notch breadth (BA); (4) bi-mental foramina breadth (BM); (5) distance between mental foramen and mandibular inferior border (DMI); (6) maximum mandibular ramus height (MRH); (7) maximum mandibular ramus breadth (MRB); (8) maximum mandibular length (MDL); (9) maximum mandibular body length (MBL). (10)–(11): Angular parameters of the mandible (10) mandibular angle (MDA); (11) mental angle (MA).