

Morphometric analysis of the mandible in the Durban Metropolitan population of South Africa

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Background: The identification of an individual from skeletal remains plays a vital role in forensic investigation as it is essential for the identification of the individual's age, sex, and/or race and further analysis. Skeletal characteristics differ from one population group to another since population-specific osteometric standards exist for sex determination. Since the mandible is the largest, strongest and most durable compact facial bone, it is the best preserved after death. While sexual dimorphism of the mandible is indicated by its shape and size, morphometric analysis is more accurate in the determination of sex from the skull. The aim of this study was to evaluate the morphometric parameters of the mandible in the Durban Metropolitan population.

Materials and methods: Various morphometric parameters of the mandible were measured and assessed in 265 digital panoramic radiographs aged between 16 and 30 years ($n = 530$). Each parameter recorded was statistically analysed using SPSS to determine if a relationship existed between the parameter, and sex and age.

Results: In this study the morphometric parameters of the male mandibles were greater than that of the females. This concurred with the findings of previous studies. The length of the mandibular ramus on the right and left sides was statistically significant with sex.

Conclusions: This correlated with previous studies, indicating that the length of the mandibular ramus generally has higher sexual dimorphism than any other morphometric mandibular parameter ($p = 0.000$). However, only the length of the right mandibular body was statistically significant when compared with sex ($p = 0.040$). The findings of this study may assist forensic investigators, anatomists, anthropologists and maxillo-facial surgeons. (Folia Morphol 2017; 76, 1: 82–86)

Key words: mandible, morphometry, radiology, mandibular body, mandibular ramus

INTRODUCTION

Indira et al. [6] stated that the identification of an individual from skeletal remains plays a critical role in forensic investigation and is essential for the identification of age, sex and race, as well as further analysis. Since age and stature are dependent on the sex of the

individual, sex determination is considered to be the primary step in the identification of skeletal remains [6].

Unidentified skeletal remains in South Africa are currently classified according to the Northern hemispheric standards [7]. However, a study conducted within the white and black population groups native

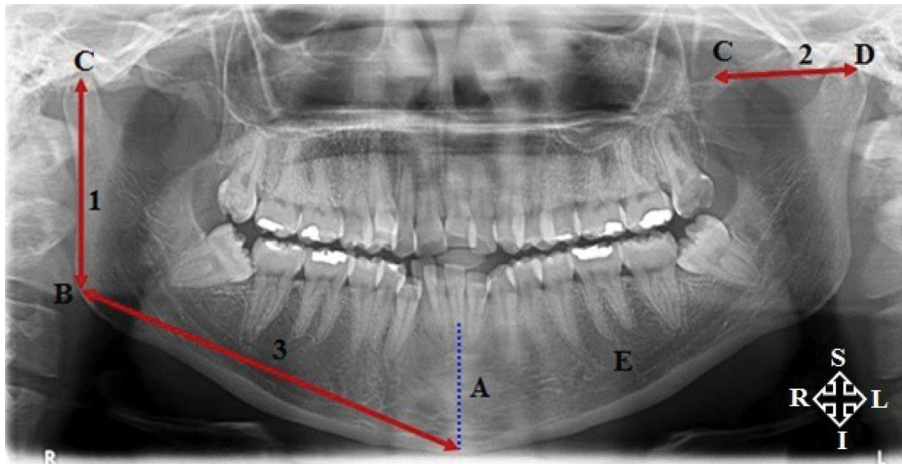


Figure 1. Measurements of the mandible on a panoramic X-ray of the jaw; A — mental protuberance; B — angle of the mandible; C — head of the mandible; D — coronoid process of the mandible; E — body of the mandible; I — inferior; L — left; S — superior; R — right; 1 — length of the ramus; 2 — width of the ramus; 3 — length of the body.

to South Africa showed that differences exist in the craniometric parameters when compared to the North American standards [7]. Iscan and Steyn [7] reported that “Prediction accuracy was considerably lower when North American-based formulae were tested on the South African population, indicating distinct craniometric differences between these populations.” Although, Indira et al. [6] reported that the sexual dimorphism of the mandible is indicated by its shape and size, morphometric mandibular analysis also proves to be accurate for the determination of sex.

As revealed by the recovered paleo-anthropological hominid specimens, the strength and durability of the mandible enables it to be best preserved after death [6, 13].

Therefore, the aim of this study was to evaluate the morphometric parameters of the mandible in the Durban Metropolitan population.

MATERIALS AND METHODS

Two hundred and sixty-five (124 males; 141 females) digital panoramic radiographs of South African Indian patients aged between 16 and 30 years were studied using the digital Kodak Dental Imaging Software (Version 6.12.17.0). The radiographs were obtained from the Radiology Departments of private dental practices in the Greater Durban Metropolitan area. Ethical clearance was obtained (BE.410/13).

The selection criteria were:

- Inclusion:
 - panoramic radiographs of patients between 16 and 30 years of age that showed no history of trauma and had complete patient records;

- patients belonging to the Indian race group within the KwaZulu-Natal region.

- Exclusion:

- panoramic radiographs of patients below 16 and above 30 years of age;
- poor quality radiographs;
- patients showing any fracture of the jaws.

Morphometric analysis

The mandibular size was measured between two chosen points using the mouse-drive method adopted by Indira et al. [6]:

- the **length of the ramus** of the mandible was recorded from the angle of the mandible to the head of the mandible (B to C) (Fig. 1; see ‘1’);
- the **width of the ramus** was measured from the head of the mandible to the coronoid process (C to D) (Fig. 1; see ‘2’);
- the **length of the body** of the mandible was recorded from the mental protuberance to the angle of the mandible (A to B) (Fig. 1; see ‘3’).

Statistical analysis

The comparison between age, sex and the data pertaining to the mandibular size was performed using the Statistical Package for Social Sciences (SPSS version 21.0). The Pearson χ^2 test and Independent Samples T-test were used to analyse the relationship between age, sex and morphometry of the mandible. A p-value of less than 0.05 was considered to be statistically significant. The reliability and validity of this study was maintained by measuring each morphometric parameter three times and an average was calculated, recorded and analysed.

Table 1. Morphometric analysis of the mandible with sex distribution

Parameters	Side	Measurements [mm]			P	
		Males	Females	Both	Sex	Age
Length of ramus	Right	59.6	53.9	56.5	0.000*	0.111
	Left	60.1	54.3	57.0	0.000*	0.153
Width of ramus	Right	36.0	35.5	35.8	0.625	0.537
	Left	35.1	34.2	34.6	0.414	0.479
Length of body	Right	86.5	83.0	84.6	0.040*	0.799
	Left	83.3	81.0	82.0	0.147	0.0735

*Statistically significant ($p < 0.05$)

Table 2. Length of the mandibular ramus in males and females

Author [year]	Population	Length of mandibular ramus [mm]	
		Male	Female
Burstone et al. (1978)	American	52.0	46.8
Mbajjorgu et al. (1996)	Zimbabwean	61.3	59.8
Fabian and Mpembeni (2002)	Tanzanian	49.9	44.2
Rai et al. (2007)	Indian	53.9	51.8
Keyayan et al. (2011)	Kenyan	57.7	52.0
Shamout et al. (2012)	Jordanian	53.2	49.1
Yassir (2013)	Iraqi	51.4	45.1
Present study (2014)	South African	59.9	54.1

RESULTS

Length of the mandibular ramus

The length of the mandibular ramus was longer on the left side in both males and females, with mean lengths of 57.0 mm and 56.5 mm recorded on right and left sides, respectively (Table 1). The length of the male mandibular ramus was longer than that of the female on both sides (Table 1). In addition, a statistically significant correlation was recorded for the length of the mandibular ramus and sex between right and left sides ($p = 0.000$).

Width of the mandibular ramus

The width of the mandibular ramus was greater in males than females on both right and left sides (Table 1). The width of the right mandibular ramus was identified to be greater than the left in both males and females, with mean widths of 35.8 mm and 34.6 mm on right and left sides, respectively. There was no significant difference in the width of the mandibular ramus between the two sexes (Table 1).

Length of the mandibular body

The length of the right mandibular body was longer than the left side in both males and females, with mean lengths of 84.6 mm and 82.0 mm, respectively (Table 1). In addition, the length of the mandibular body was longer in males than females on both sides. The comparison of the length of the right mandibular body with sex displayed a statistically significant difference ($p = 0.040$) (Table 1).

DISCUSSION

The accurate identification of human remains is essential in forensic medicine and anthropology, especially during criminal investigation and in the identification of accident or natural disaster victims [1, 6]. Racial, genetic and regional differences in functional activity of the mandible during the early stages of growth and development may affect its shape and size [14]. Consequently, the skeletal characteristics differ from one population group to another as population-specific osteometric standards exist for sex determination [6, 16, 21]. According to Indira et al. [6], there is paucity in the literature regarding the determination of mandibular morphometry through the use of digital panoramic radiographs [6].

The morphometric parameters in this study were found to be greater in male mandibles and this corroborated the results of Duthie et al. [3] and Indira et al. [6] as male bones are generally bigger and more robust.

Length of the mandibular ramus

The length of the right mandibular body was longer than the left in both males and females and a statistically significant relationship between the length of the mandibular ramus and sex was recorded on both sides of the mandible in this study ($p = 0.000$) (Table 2). The results of the current study confirmed that of previous

Table 3. Width of the mandibular ramus in males and females

Author (year)	Population	Width of mandibular ramus [mm]	
		Male	Female
Suzuki and Takahashi (1975)	Japanese	32.9	31.9
Ranganath et al. (2008)	Indian	38.8	40.7
Vinay and MangalaGowri (2013)	Indian	41.7	38.9
Present study (2014)	South African	35.6	34.9

Table 4. Length of the mandibular body in males and females

Author (year)	Population	Length of mandibular body [mm]	
		Male	Female
Mbajjorgu et al. (1996)	Zimbabwean	77.8	72.3
Jayakaran et al. (2000)	Indian	74.4	70.6
Onngkana et al. (2009)	Thai	89.4	85.3
Keyayan et al. (2011)	Kenyan	99.8	93.4
Vinay and MangalaGowri (2013)	Indian	75.4	72.5
Yassir (2013)	Iraqi	74.9	69.9
Present study (2014)	South African	84.9	82.0

studies [2, 4, 9, 11, 14, 17, 23], as the afore-mentioned authors reported the length of the mandibular ramus to be longer in males than in females (Table 2). In addition, Rai et al. [14] and Indira et al. [6] stated that the length of the mandibular ramus generally showed a higher sexual dimorphism than any other mandibular morphometric parameters. It is evident that morphometric differences in the mandible exist between the northern and southern hemispheres as South Africa and Zimbabwe identified longer mandibular rami than countries in the northern hemisphere (America, Iraq and India) (Table 2). This also confirmed the findings of Iscan and Steyn [7] who documented a difference in the craniometric dimensions between South African and North American populations.

Width of the mandibular ramus

The width of the mandibular ramus in this study was greater in males than females which corroborated the findings of Vinay and MangalaGowri [19]. Conversely, Ranganath et al. [15] found that the mandibular ramus was longer in females (Table 3). Although no statistically significant relationship with

age or sex was reported in this study ($p > 0.05$) the result compared favourably with the findings of Rai et al. [14]. However, the afore-mentioned authors did not provide an explanation for their findings. In this study, the mean width of the mandibular ramus was considerably less than that recorded by Rai et al. [14] and Vinay and MangalaGowri [19], but greater than that of the Japanese population as reported by Suzuki and Takahashi [18] (Table 3).

Length of the mandibular body

The length of the male mandibular body in this study was longer than the female and this concurred with previous studies [8, 9, 11, 12, 20, 23] (Table 4). The mean length of the mandibular body in the current study was longer than the Indian [8, 20, 23]; Iraqi [23] and Zimbabwean populations [11]. However, it was smaller than the Kenyan [9] and Thai [12] population groups (Table 4). The afore-mentioned data suggested that differences not only exist between the northern and southern hemispheres but also within the hemispheres and may be a result of population-specific differences. Only the relationship between the length of the right mandibular body and sex displayed a statistically significant difference in this study ($p = 0.040$). There appeared to be paucity in the literature regarding this particular relationship. In this regard, Luca et al. [10] proposed that mastication and dietary habits may influence the growth of the mandible. They recorded that individuals who consumed an abrasive diet had larger jaws in comparison to those that had a soft diet. In addition, Weiner [22] reported that individuals tend to favour either their right or left side; therefore, this study may suggest that individuals tend to favour chewing on their right side.

Consequently, Humphrey et al. [5] stated that almost any site of mandibular bone deposition, resorption, or remodelling has the potential to become sexually dimorphic, therefore the mandibular condyle and ramus present as the specific sites associated with the greatest morphological changes in size and remodelling during growth. In addition, Indira et al. [6] stated that the development of the muscles of mastication may influence the sexual dimorphism of the mandibular ramus as the masticatory forces exerted differ between the sexes.

CONCLUSIONS

All morphometric parameters recorded in this study were greater in males than in females. Further-

more, the present study documented differences in the morphometric parameters between the southern (specifically Durban, South Africa) and northern hemispheric populations. The provision of morphometric data relating to the mandible may assist forensic investigators, anatomists, anthropologists and maxillo-facial surgeons, as this may be useful in providing anthropological and surgical data that may be used in medico-legal and dental procedures.

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