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Evaluation of Mandibular Morphometry in Human Skeletal Remains for Sex Identification

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Abstract

Background: Understanding the anatomy of the mandible and its variations based on age, sex, and race is essential for physicians, surgeons, medico-legal experts, and anthropologists to make accurate interpretations in both clinical and forensic settings. **Aim and Objective:** To evaluate sex determination using morphometric parameters of the human mandible. **Materials and Methods:** A total of 122 human mandibles were collected from the Department of Anatomy, Index Medical College Hospital & Research Centre, Indore. Various morphological and morphometric features of the mandibles were studied. **Results:** Among the measured parameters, six key morphometric variables—ramus height, body thickness, anthropometric arch width, inter-incisor width, mandibular index, and mandibular angle—were found to be the most significant in sex determination. These parameters together enabled the identification of sex with an accuracy of up to 75.2% in the South Indian population. Statistical analysis supported the relevance of these parameters in distinguishing sex. **Conclusion:** The study suggests that the human mandible can be sexed with approximately 75% accuracy using six dominant morphometric parameters. However, these should be used with caution and not considered solely sufficient for definitive sex determination in osteometric studies.

Keywords: Mandible bone, Ramus, Angle, Index

Introduction

The mandible is the largest, strongest, and only movable bone of the skull, comprising a curved body that is convex anteriorly and two broad rami that ascend posteriorly. Each ramus features a coronoid and a condylar process. The lingula, a tongue-shaped bony projection, is located on the medial surface of the mandibular ramus near the posterior margin of the mandibular foramen [1]. Identifying the exact location of the mandibular foramen in radiographs can be challenging due to its radiolucency and the superimposition of contralateral mandibular structures [2].

In forensic and anthropological investigations, the mandible plays a crucial role in personal identification, especially in cases involving fragmented or decomposed remains. After the pelvis, the mandible is considered one of the most reliable bones for determining sex due to its durability and prominent sexual dimorphism [3–5]. The teeth, along with the mandible and skull, are among the best-preserved parts of human remains and can provide valuable information about age, sex, and race [6].

Sex determination is more accurate after puberty, as morphological differences in skeletal features become more pronounced. The mandibular angle, height and breadth of the ramus, and the size of the condyles are among the key features that differ between males and females. Generally, mandibular condyles are smaller in females [7]. Radiographic examination of the mandible has been shown to offer sex determination accuracy rates as high as 88% [8].

Evaluating the morphometric parameters of the mandible—including the mandibular angle and dimensions of the ramus—can thus contribute significantly to anthropological assessments and medico-legal investigations [9–12]. A thorough understanding of the variations in mandibular morphology by age, sex, and race enhances the accuracy of diagnostic and identification processes in both clinical and forensic contexts.

Materials and Methods

The present study was conducted on **122 adult dry human mandibles** of unknown sex in the Department of Anatomy, Index Medical College Hospital & Research Centre, Indore. These mandibles were obtained from various graveyards. Only intact bones free from pathological lesions or fractures were included, while completely edentulous mandibles with absorbed alveolar margins were excluded. The specimens were estimated to belong to individuals aged approximately **18 to 60 years**.

A total of **22 morphometric parameters** were measured using a **sliding caliper** and **mandibulometer** to assess their utility in sex determination. The parameters included:

- Symphyseal height
- Coronoid height
- Minimum breadth of ramus
- Maximum breadth of ramus
- Height of ramus (right and left)
- Body height
- Body thickness
- Body length
- Bigonial diameter
- Bicondylar diameter
- Bi-mental breadth
- Mandibular angle
- Length of lower jaw
- Bicoronoid width
- Mandibular index

The study was conducted following **ethical approval** from the Institutional Ethics Committee.

Statistical Analysis:
Data were analyzed using **SPSS software**. A **p-value < 0.05** was considered statistically significant.

Results

A total of **122 dry adult human mandibles** of unknown sex, free from pathological deformities and fractures, were selected for this study from the Department of Anatomy, Index Medical College Hospital & Research Centre, Indore. Mandibles with completely resorbed alveolar margins (edentulous) were excluded. The specimens were estimated to be from individuals aged approximately **18 to 60 years**.

Each mandible was examined for external and internal morphological features, and **13 selected morphometric parameters** (as outlined in the methodology) were carefully measured. The data obtained from these measurements were systematically recorded and are presented in **Table 1**.

If you already have Table 1 prepared and would like help formatting or interpreting the data (e.g., calculating means, standard deviations, or performing comparisons), feel free to share it!

Table 1: Descriptive statistics

Sr. No.	**Name of the variable**	Male (n=70) (Mean ± SD)	Female (n=52) (Mean ± SD)	P- Value
1	Symphyseal height	27.64 ± 3.7	22.53 ± 4.63	< 0.05
2	Coronoid height	61.44 ± 4.91	50.15 ± 6.87	0.0001
3	***Gonial angle***	126.41± 14.84	137.5 ± 8.96	< 0.0000085
4	***Bigonial width***	96.44 ± 8.11	88.64 ± 5.44	< 0.05
5	***Ramus breadth***	42.48 ± 6.84	39.03 ± 5.23	< 0.003
6	Ramus height	67.59 ± 5.52	53.63 ± 8.14	< 0.001
7	***Bicondylar breadth***	106.11 ± 5.90	106.21 ± 6.81	0.931
8	***Mandibular length***	75.7 ± 4.4	69.7 ± 4.7	< 0.05
9	***Lower jaw length***	59.46 ± 5.19	55.57± 6.2	< 0.05
10	***Mandibular index***	53.52± 4.7	52.88± 8.33	0.591
11	***Body thickness***	16.18 ± 2.59	14.28 ± 2.44	< 0.000073
12	***Bimental breadth***	27.64 ± 3.7	22.53 ± 4.63	< 0.05
13	***Body height***	26.33± 5.4	21.5 ± 3.83	< 0.05

Discussion

This study was conducted in the Department of Anatomy, Index Medical College Hospital & Research Centre, Indore, Madhya Pradesh, India, using 122 adult dry human mandibles of unknown sex. After excluding damaged or pathologically affected bones, the selected mandibles were analyzed using various morphometric parameters, as detailed in the methodology section.

Symphyseal height ranged from 22.7 mm to 36.9 mm, with a mean value of 27.64 mm. When compared to known-sex data, 122 of the 244 mandibles were categorized as male, 70 as female, and 52 remained unclassified. However, the significance of symphyseal height alone in determining sex diminishes when other parameters are considered.

Ramus height was measured on both right and left sides. The right side showed a slightly higher mean value—by about 3 mm—than the left. This asymmetry may be attributed to dominant chewing habits, although no previous literature strongly supports this hypothesis, warranting further investigation.

Body thickness varied from 12 mm to 20 mm (mean: 16.18 mm), helping classify 70 mandibles as male and 50 as female. **Body length** ranged from 60 mm to 82 mm, with a mean of 74 mm. While body height, length, and thickness aid in sex differentiation, some studies suggest these are not highly significant for sex determination on their own [13].

Anthropometric arch width ranged between 33 mm and 54 mm (mean: 43.5 mm), with notable differences between male and female mandibles. This parameter was found to be a significant differentiator between sexes.

Mandibular angle ranged from 116.7° to 141°, with a mean of 126.41°. Based on this, 70 mandibles were classified as male and 50 as female. Literature suggests that males typically exhibit more everted and larger gonial angles, while females present with inverted or more rounded angles [14–16]. Male mandibles often show well-developed, flaring gonial regions [17], and rougher lateral mandibular angles compared to females, whose mandibular angles are smoother and more gracile [18–19]. Our findings support these observations, with female mandibles in our study presenting higher gonial angles than males.

Bicondylar diameter ranged from 101 mm to 121 mm, with a mean of 106.11 mm. Smaller condyles, typically observed in females, resulted in lower bicondylar diameters. Sharp tubercles on the anterior aspects of the condyles, considered stress indicators, were noted [20].

The **mandibular index**, calculated using bicondylar breadth and length of the lower jaw (multiplied by 100), was also found to be a useful parameter in sex determination.

Conclusion

Each morphometric parameter, when considered individually, provides a varying degree of accuracy in determining the sex of the mandible. However, the predictive accuracy increases significantly when multiple parameters are considered in combination. The present study reveals that the sex of an unknown mandible can be determined with reasonable accuracy—up to approximately 75%—by assessing a combination of key measurements such as ramus height, body thickness, anthropometric arch width, inter-incisor width, mandibular index, and mandibular angle. These findings highlight the mandible's value as an important tool in forensic and anthropological identification, although it should be used as part of a broader osteometric assessment rather than as a sole determinant.

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