



## MORPHOMETRIC ANALYSIS OF THE HUMAN MANDIBLE AND ITS CLINICAL RELEVANCE IN ORTHODONTIC DIAGNOSIS

Preeti Panduranrao Pawde<sup>1</sup>, Dr Manish Gupta<sup>2</sup>, Dr Rajendra Singh<sup>3\*</sup>

<sup>1</sup>, Ph.D Scholar, Dept.of Anatomy, Malwanchal University, Indore Email ID:

[drpreetisolanke77@gmail.com](mailto:drpreetisolanke77@gmail.com)

<sup>2</sup>, Assistant Professor, Dept. of Anatomy, IMCH&RC, Indore Email ID:

[manishgupta091@gmail.com](mailto:manishgupta091@gmail.com)

<sup>3\*</sup>, Assistant Professor, Dept. of Anatomy, IMCH&RC, Indore Email ID:

[rajendrasingh211@gmail.com](mailto:rajendrasingh211@gmail.com)

**\*Corresponding Author:** Dr.Rajendra Singh,

<sup>3\*</sup>, Assistant Professor, Dept. of Anatomy, IMCH&RC, Indore Email ID:

[rajendrasingh211@gmail.com](mailto:rajendrasingh211@gmail.com)

---

### Abstract

#### Background:

The mandible is the largest and strongest bone of the facial skeleton and plays a crucial role in mastication, speech, and maintenance of facial symmetry. Morphometric analysis of the mandible is important in orthodontic diagnosis, forensic identification, and craniofacial research due to significant anatomical variation among individuals.

#### Aim:

To evaluate various morphometric parameters of the human mandible and assess their clinical relevance in orthodontic diagnosis.

**Materials and Methods:** This observational cross-sectional study was conducted in the Department of Anatomy, Index Medical College, Indore, India. A total of 290 dry adult human mandibles were examined, including 166 male and 124 female specimens. Various morphometric parameters were measured, including gonial angle, bigonial width, bicondylar breadth, ramus breadth, mandibular length, lower jaw length, coronoid height, body height, and symphyseal height. Statistical analysis was performed using an independent *t*-test, and  $p < 0.05$  was considered statistically significant.

#### Results:

The study revealed significant sexual dimorphism in most mandibular parameters. The gonial angle was significantly greater in females ( $137.99 \pm 6.29^\circ$ ) than in males ( $129.63 \pm 6.92^\circ$ ,  $p < 0.001$ ). In contrast, bigonial width, bicondylar breadth, ramus breadth, mandibular length, coronoid height, body height, and symphyseal height were significantly greater in male mandibles compared to female mandibles ( $p < 0.001$ ). These findings indicate that male mandibles are generally larger and more robust than female mandibles.

#### Conclusion:

The present study demonstrates marked sexual dimorphism in several mandibular morphometric parameters. These measurements have important applications in orthodontic diagnosis, forensic anthropology, and craniofacial surgery, as variations in mandibular dimensions influence facial profile, occlusion, and mandibular growth patterns. The morphometric data obtained may serve as useful reference values for clinical and anthropological studies.

**Keywords:** Mandible, Morphometric analysis, Facial skeleton, Orthodontic diagnosis, Forensic anthropology

## Introduction

The mandible is the largest and strongest bone of the facial skeleton and forms the lower jaw, representing a major structural component of the craniofacial complex. It plays a vital role in several fundamental functions, including mastication, speech articulation, and maintenance of facial symmetry and aesthetics [1,2]. Structurally, the mandible supports the lower dentition and provides attachment sites for numerous muscles involved in chewing and facial expression. Owing to its complex anatomy and functional demands, the mandible exhibits notable morphological and dimensional variability among individuals [3].

In recent decades, morphometric analysis of the mandible has become increasingly significant in various scientific and clinical disciplines such as orthodontics, forensic anthropology, and oral and maxillofacial surgery [3,4]. Precise measurement of mandibular structures enables researchers and clinicians to evaluate differences in craniofacial growth patterns and population characteristics. Variations in mandibular dimensions may arise from several factors, including genetic background, environmental influences, growth and developmental processes, and the biomechanical forces generated by muscle attachments [2,5].

A comprehensive understanding of mandibular morphology is therefore essential for diagnosing craniofacial anomalies, planning orthodontic treatments, and performing reconstructive or corrective maxillofacial surgeries [4]. Additionally, morphometric studies contribute valuable information in forensic identification and anthropological research, where mandibular features can assist in determining sex, age, and population affinity [5]. Consequently, detailed evaluation of mandibular measurements is important for both clinical practice and scientific investigation, thereby improving diagnostic accuracy and treatment outcomes.

## Materials & Methods

This observational cross-sectional study was conducted in the Department of Anatomy at Index Medical College, a part of Malwanchal University, located in Indore, Madhya Pradesh, India. Following approval from the Institutional Ethical Committee, a comprehensive analysis was conducted involving 290 dry human mandibles. The aim of this study was to measure and analyze various morphological parameters of the mandible.

A total of 290 mandibles were analyzed in the study, including 166 male and 124 female specimens. Various morphometric parameters were measured, including gonial angle, bigonial width, ramus breadth, bicondylar breadth, mandibular length, lower jaw length, body thickness, coronoid height, bimental breadth, symphyseal height, and body height of the mandible.

Statistical analysis was performed to determine differences between male and female mandibles. The significance level was set at  $p < 0.05$ .

## Results

Table 1 shows that the gonial angle was measured in 166 male and 124 female mandibles. The mean gonial angle was  $129.63 \pm 6.92^\circ$  in males and  $137.99 \pm 6.29^\circ$  in females. The range was  $115.79\text{--}143.47^\circ$  in males and  $125.42\text{--}150.57^\circ$  in females. The difference between males and females was statistically significant ( $t = -10.7$ ,  $p < 0.001$ ).

| <b>Table 1: The gonial angle recorded in the study specimens</b> |                         |                         |                                             |
|------------------------------------------------------------------|-------------------------|-------------------------|---------------------------------------------|
| <b>Measurement</b>                                               | <b>Male</b>             | <b>Female</b>           | <b>P-value &lt; 0.001<br/>t-value -10.7</b> |
| No. of bones                                                     | 166                     | 124                     |                                             |
| Range (degrees)                                                  | 115.79- 143.47          | 125.42 –150.57          |                                             |
| Mean $\pm$ SD (degrees)                                          | $129.63 \pm 6.92^\circ$ | $137.99 \pm 6.29^\circ$ |                                             |

**In this study**, the bigonial width was measured in 290 mandibles, comprising 166 male and 124 female specimens. The mean bigonial width was  $94.95 \pm 5.19$  mm in males and  $90.75 \pm 6.39$  mm in females, with ranges of 84.58–105.32 mm and 77.96–103.53 mm, respectively. Male mandibles demonstrated a significantly greater bigonial width compared to females ( $t = 6.0$ ,  $p < 0.001$ ). (Graph 1)

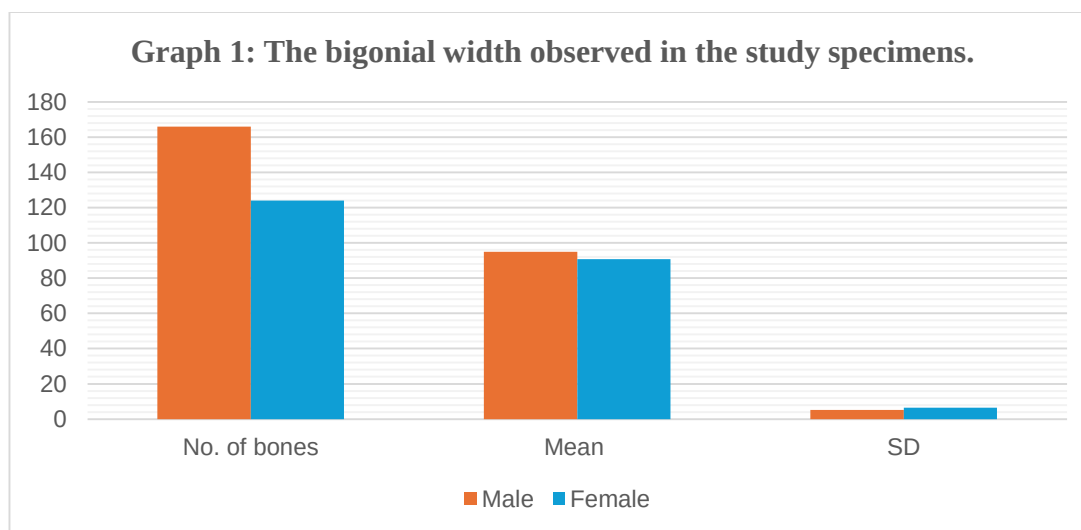
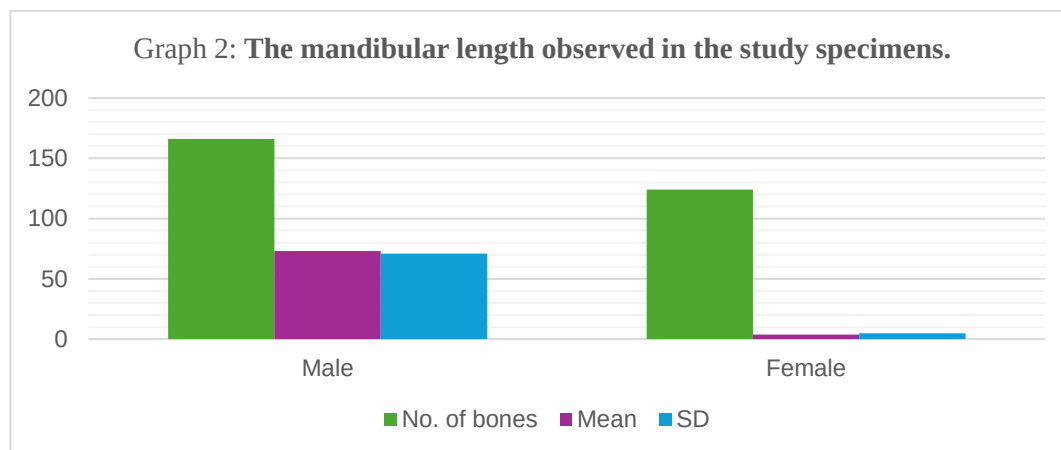


Table 2 presents the measurements of bicondylar breadth for the study specimens. A total of 290 mandibles were examined, comprising 166 male and 124 female specimens. In male mandibles, the bicondylar breadth ranged from 102.54 mm to 121.31 mm, with a mean value of  $111.93 \pm 4.69$  mm. In contrast, female mandibles ranged from 86.25 mm to 116.83 mm, with a mean of  $101.54 \pm 7.65$  mm. The findings indicate that the bicondylar breadth was noticeably greater in male mandibles compared to female mandibles. Statistical analysis using an independent t-test revealed that this difference was highly significant ( $t \approx 13.35$ ,  $p < 0.001$ ), suggesting a clear sexual dimorphism in this parameter.

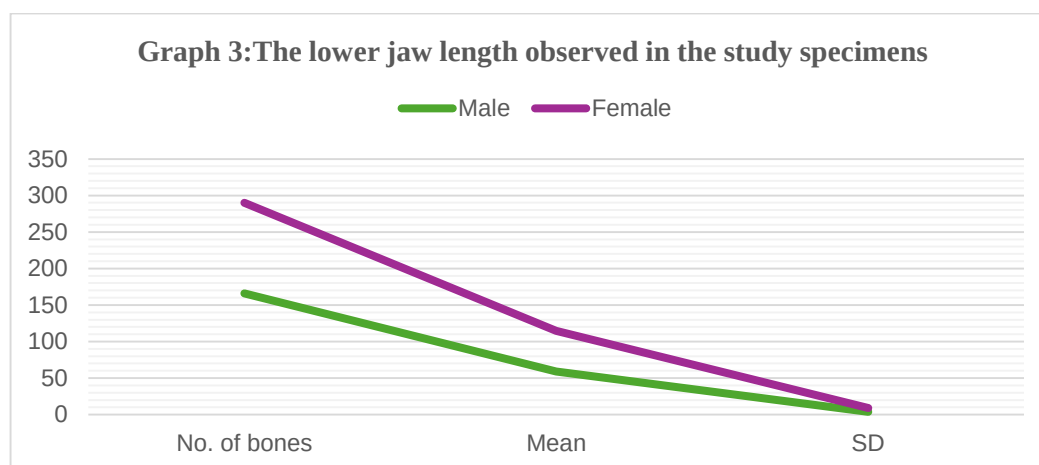
| <b>Table 2: The bicondylar breadth was observed in the study specimens.</b> |                   |                   |                                                                 |
|-----------------------------------------------------------------------------|-------------------|-------------------|-----------------------------------------------------------------|
| Measurement                                                                 | Male              | Female            | <b>P-value &lt;0.001<br/>t-value <math>\approx 13.35</math></b> |
| No. of bones                                                                | 166               | 124               |                                                                 |
| Range (mm)                                                                  | 102.54 – 121.31   | 86.25-116.83      |                                                                 |
| Mean $\pm$ SD (mm)                                                          | $111.93 \pm 4.69$ | $101.54 \pm 7.65$ |                                                                 |

Table 3 presents the measurements of ramus breadth recorded in the study specimens. The ramus breadth in male mandibles ranged from 36.75 mm to 58.31 mm, with a mean value of  $47.53 \pm 5.39$  mm. In female mandibles, the measurements ranged from 31.35 mm to 52.86 mm, with a mean value of  $42.11 \pm 5.38$  mm. The analysis demonstrates that the average ramus breadth was greater in males than in females. Statistical evaluation confirmed that the observed difference between the two groups was statistically highly significant ( $t \approx 8.47$ ,  $p < 0.001$ ), indicating that ramus breadth may serve as an important morphometric parameter for distinguishing between male and female mandibles.

| <b>Table 3: The ramus breadth observed in the study specimens</b> |                  |                  |                                                                |
|-------------------------------------------------------------------|------------------|------------------|----------------------------------------------------------------|
| Measurement                                                       | Male             | Female           | <b>P-value &lt;0.001<br/>t-value <math>\approx 8.47</math></b> |
| No. of bones                                                      | 166              | 124              |                                                                |
| Range (mm)                                                        | 36.75 – 58.31    | 31.35-52.86      |                                                                |
| Mean $\pm$ SD (mm)                                                | $47.53 \pm 5.39$ | $42.11 \pm 5.38$ |                                                                |



This study shows that, the mandibular length, measured in 290 mandibles (166 males and 124 females), ranged from 65.64–80.57 mm in males (mean  $73.11 \pm 3.73$  mm) and 61.25–80.72 mm in females (mean  $70.99 \pm 4.87$  mm), with males demonstrating a slightly greater mean value that was statistically highly significant ( $t \approx 4.05$ ,  $p < 0.001$ ), while Table 7 & Graph 7 indicate that the lower jaw length ranged from 51.45–66.57 mm in males (mean  $59.01 \pm 3.78$  mm) and 45.25–66.12 mm in females (mean  $55.69 \pm 5.22$  mm), with males showing a significantly greater mean length compared to females ( $t \approx 6.02$ ,  $p < 0.001$ ). [Graph 2 & 3]



The **measurements of coronoid height of the mandible** observed in the present study specimens. A total of **166 male mandibles** and **124 female mandibles** were included in the analysis.

The **range of coronoid height in male specimens** was **53.67 to 73.47**, whereas in **female specimens** it ranged from **43.78 to 62.56**. The **mean coronoid height in males** was  **$63.57 \pm 4.95$** , while the **mean value in females** was  **$53.17 \pm 4.70$** .

A statistical comparison between male and female groups was performed using an independent-samples **t-test**. The calculated **t-value** was **approximately 18.2**, with a **p-value less than 0.001**, indicating a **highly statistically significant difference** between the two groups.

These findings suggest that **male mandibles exhibit significantly greater coronoid height compared to female mandibles**, demonstrating **marked sexual dimorphism in this parameter in the present study sample**. (Table 4)

| <b>Table 4: The Measurement of Coronoid Height in the Present Study Specimens</b> |                  |                  |                                                                |
|-----------------------------------------------------------------------------------|------------------|------------------|----------------------------------------------------------------|
| <b>Measurement</b>                                                                | <b>Male</b>      | <b>Female</b>    | <b>P-value &lt;0.001<br/>t-value <math>\approx 18.2</math></b> |
| No. of bones                                                                      | 166              | 124              |                                                                |
| Range                                                                             | 53.67 – 73.47    | 43.78-62.56      |                                                                |
| Mean $\pm$ SD                                                                     | $63.57 \pm 4.95$ | $53.17 \pm 4.70$ |                                                                |

In this study, mandibular body height was measured in 290 specimens (166 males and 124 females). In males, the values ranged from 23.85–34.63 mm, with a mean of  $29.24 \pm 1.80$  mm, whereas in females, they ranged from 16.57–28.31 mm, with a mean of  $22.44 \pm 1.96$  mm. The mean body height was significantly greater in males, with a highly significant difference ( $t \approx 30.2$ ,  $p < 0.001$ ), indicating marked sexual dimorphism.

Similarly, the symphyseal height measured in the same specimens ranged from 23.52 to 37.86 mm in males (mean  $30.69 \pm 2.39$  mm) and from 15.97 to 28.68 mm in females (mean  $22.33 \pm 2.12$  mm). The male mandibles exhibited a significantly greater symphyseal height than those of females, with the difference highly statistically significant ( $t \approx 31.4$ ,  $p < 0.001$ ), further demonstrating clear sexual dimorphism.

## Discussion

The present study evaluated multiple morphometric parameters of the human mandible in 290 dry adult mandibles (166 male and 124 female) and demonstrated clear sexual dimorphism in most mandibular measurements. These findings highlight the anatomical variability of the mandible and its significance in orthodontic diagnosis, forensic identification, and maxillofacial surgical planning. One of the important parameters evaluated in this study was the gonial angle, which showed a significantly higher mean value in females ( $137.99 \pm 6.29^\circ$ ) compared to males ( $129.63 \pm 6.92^\circ$ ). Similar findings have been reported in several studies, where females tend to exhibit a relatively larger gonial angle due to differences in mandibular growth patterns and muscular attachment forces. **Sharma et al. [6]** and **Indira et al. [7]** also observed a greater gonial angle in females compared to males in Indian populations. Comparable findings were reported internationally by **Franklin et al. [8]**, who suggested that sexual dimorphism in the gonial angle may be influenced by differences in masticatory muscle activity and craniofacial growth patterns.

The present study also demonstrated that bigonial width was significantly greater in males ( $94.95 \pm 5.19$  mm) than in females ( $90.75 \pm 6.39$  mm). This observation is consistent with previous research indicating that male mandibles generally possess greater transverse dimensions due to stronger muscle attachments and larger skeletal size. Similar results were reported by **Saini et al. [9]** in a North Indian population and by **Franklin et al. [8]** in South African populations, both of whom found that bigonial breadth is a reliable parameter for sex determination.

Another important morphometric parameter evaluated in this study was bicondylar breadth, which showed a significantly higher mean value in males ( $111.93 \pm 4.69$  mm) compared to females ( $101.54 \pm 7.65$  mm). These findings agree with studies conducted by **Giles [10]** and **Franklin et al. [8]**, who also reported larger bicondylar breadth in male mandibles. The greater bicondylar breadth in males may be attributed to overall larger craniofacial dimensions and increased mechanical loading from stronger masticatory muscles.

Similarly, ramus breadth was observed to be significantly higher in male mandibles ( $47.53 \pm 5.39$  mm) than in female mandibles ( $42.11 \pm 5.38$  mm). These findings are comparable with those reported by **Vinay et al. [11]** and **Indira et al. [7]** in Indian populations. The greater ramus dimensions in males may be related to increased muscle mass and functional loading during mastication.

Analysis of mandibular length and lower jaw length also revealed higher mean values in males than in females, indicating significant sexual dimorphism. These results are consistent with studies by **Humphrey et al. [12]** and **Saini et al. [9]**, which reported that male mandibles generally exhibit greater overall length and robustness due to genetic and hormonal influences on skeletal growth.

The present study further demonstrated that coronoid height was significantly greater in males ( $63.57 \pm 4.95$  mm) than in females ( $53.17 \pm 4.70$  mm). This observation aligns with findings from **Sharma et al. [6]** and **Franklin et al. [8]**, who reported that coronoid height is strongly influenced by the temporalis muscle, which tends to be more developed in males.

In addition, mandibular body height and symphyseal height showed marked sexual dimorphism, with males exhibiting significantly greater values than females. These findings are consistent with previous studies conducted by **Saini et al. [9]** and **Vinay et al. [11]**, which also reported higher symphyseal

and body height measurements in male mandibles. These differences may be attributed to variations in bone density, muscle attachment forces, and overall craniofacial growth patterns between sexes. Overall, the results of the present study are largely consistent with previous research across both Indian and international populations, confirming that several mandibular parameters—including bicondylar breadth, bigonial width, ramus breadth, coronoid height, and mandibular body height—show significant sexual dimorphism. These morphometric variations highlight the importance of mandibular measurements in forensic anthropology for sex determination and in clinical orthodontics for treatment planning and evaluation of craniofacial growth patterns.

The findings of this study also emphasize the clinical importance of mandibular morphometry in orthodontic diagnosis, as variations in mandibular dimensions can influence occlusion, facial profile, and treatment outcomes. Therefore, accurate knowledge of mandibular morphology is essential for clinicians involved in orthodontics, oral surgery, and craniofacial reconstruction.

## Conclusion

The present study demonstrates significant sexual dimorphism in most morphometric parameters of the human mandible. Measurements such as bigonial width, bicondylar breadth, ramus breadth, mandibular length, coronoid height, body height, and symphyseal height were significantly greater in males, whereas the gonial angle was higher in females. These findings highlight the role of mandibular morphometry in sex determination and craniofacial assessment.

The results emphasize the clinical importance of mandibular measurements in orthodontic diagnosis and treatment planning, as variations in mandibular dimensions influence facial profile, occlusion, and mandibular growth patterns. Furthermore, the morphometric data obtained in this study may serve as a useful reference for forensic identification and anthropological research.

## References

1. Standring S. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 41st ed. Elsevier; 2016.
2. Moore KL, Dalley AF, Agur AMR. Clinically Oriented Anatomy. 8th ed. Wolters Kluwer; 2018.
3. White SC, Pharoah MJ. Oral Radiology: Principles and Interpretation. 8th ed. Elsevier; 2019.
4. Proffit WR, Fields HW, Sarver DM. Contemporary Orthodontics. 6th ed. Elsevier; 2019.
5. Krogman WM, İşcan MY. The Human Skeleton in Forensic Medicine. 2nd ed. Charles C Thomas, 1986.
6. Sharma M, Gorea RK, Gorea A, Abuderman A. A morphometric study of the human mandible for sex determination. *J Punjab Acad Forensic Med Toxicol*. 2016;16(1):10–14.
7. Indira AP, Markande A, David MP. Mandibular ramus: an indicator for sex determination – a digital radiographic study. *J Forensic Dent Sci*. 2012;4(2):58–62.
8. Franklin D, O'Higgins P, Oxnard CE, Dadour I. Determination of sex in South African blacks by discriminant function analysis of mandibular linear dimensions. *Forensic Sci Med Pathol*. 2008;4(3):175–181.
9. Saini V, Srivastava R, Rai RK, Shamal SN, Singh TB, Tripathi SK. Mandibular ramus: an indicator for sex in fragmentary mandible. *J Forensic Sci*. 2011;56(S1):S13–S16.
10. Giles E. Sex determination by discriminant function analysis of the mandible. *Am J Phys Anthropol*. 1964;22:129–135.
11. Vinay G, Mangala Gowri SR, Anbalagan J. Sex determination of human mandible using metrical parameters. *J Clin Diagn Res*. 2013;7(12):2671–2673.
12. Humphrey LT, Dean MC, Stringer CB. Morphological variation in great ape and modern human mandibles. *J Anat*. 1999;195(Pt 4):491–513.