



Original Article


## Morphometric Analysis of Clavicular Dimensions and Their Clinical Relevance: A Cross-Sectional Osteometric Study

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### ABSTRACT

**Background:** The clavicle is a unique long bone that plays a vital role in maintaining shoulder girdle stability and transmitting forces from the upper limb to the axial skeleton. Morphometric analysis of the clavicle is important in orthopedic surgery, forensic anthropology, and implant design. Population-specific osteometric data are essential due to variations in clavicular dimensions among different ethnic groups.

**Objectives:** To analyze the morphometric dimensions of adult human clavicles and evaluate their clinical relevance.

**Materials and Methods:** A descriptive cross-sectional osteometric study was conducted on 120 dry adult human clavicles (60 right and 60 left) obtained from the Department of Anatomy. Parameters measured included maximum clavicular length, midshaft circumference, sternal end width, acromial end width, and curvature index. Measurements were recorded using a digital Vernier caliper, measuring tape, and osteometric board. Data were analyzed using SPSS version 26.0. Descriptive statistics, independent Student's t-test, and Pearson correlation analysis were applied. A p-value <0.05 was considered statistically significant.

**Results:** The mean clavicular length was  $146.70 \pm 9.15$  mm, with the right clavicles ( $147.80 \pm 9.40$  mm) being significantly longer than the left clavicles ( $145.60 \pm 8.80$  mm) ( $p = 0.032$ ). The mean midshaft circumference was  $34.95 \pm 3.55$  mm, while the mean widths of the sternal and acromial ends were  $26.40 \pm 2.81$  mm and  $23.10 \pm 2.45$  mm, respectively. The mean curvature index was  $13.60 \pm 1.65\%$ . Significant positive correlations were observed between clavicular length and midshaft circumference ( $r = 0.48$ ,  $p < 0.001$ ), as well as with sternal and acromial end widths.

**Conclusion:** The study demonstrated significant morphometric variations in adult clavicles, particularly with respect to side-related differences in length. The findings provide baseline osteometric data that may be useful in orthopedic implant design, fracture management, and forensic identification.

**Keywords:** Clavicle, Morphometry, Osteometry, Clavicular Length, Forensic Anthropology.

### INTRODUCTION

The clavicle is a unique long bone positioned horizontally between the sternum and the scapula, forming an important component of the shoulder girdle. It functions as a strut that maintains the upper limb away from the trunk, facilitates a wide range of shoulder movements, and transmits forces from the upper extremity to the axial skeleton. Due to its superficial location and characteristic S-shaped curvature, the clavicle is prone to traumatic injuries and is one of the most frequently fractured bones in the human body.<sup>1</sup>

The clavicle possesses several distinctive anatomical features, including early ossification, absence of a medullary cavity, and variable curvature. These characteristics contribute to considerable variation in its dimensions among individuals and populations. Morphometric analysis of the clavicle involves the measurement of parameters such as maximum length, shaft circumference, widths of the sternal and acromial ends, and curvature patterns. Such measurements provide valuable information regarding anatomical variations and skeletal characteristics.<sup>2</sup>

Knowledge of clavicular morphometry has significant clinical importance, particularly in orthopedic surgery. Fractures of the clavicle account for approximately 2–5% of all fractures and are commonly managed using plate fixation or intramedullary devices. Accurate understanding of clavicular dimensions assists surgeons in selecting appropriate implants, planning surgical procedures, and reducing complications related to implant mismatch. Population-specific morphometric data are especially useful in the design of anatomically contoured plates and prosthetic devices.<sup>3</sup>

Apart from orthopedic applications, clavicular measurements are widely used in forensic anthropology and medicolegal investigations. The clavicle exhibits sexual dimorphism and can aid in sex determination, stature estimation, and identification of skeletal remains. Morphometric studies have demonstrated variations in clavicular dimensions among different ethnic and geographic populations, highlighting the need for region-specific osteometric databases.<sup>4</sup>

Several researchers have reported differences in clavicular length, width, and curvature between right and left sides as well as among different populations. However, available data remain limited for many regions of India. Establishing baseline morphometric values is therefore important for anatomists, orthopedic surgeons, forensic experts, and anthropologists.<sup>5</sup>

The present study was undertaken to analyze various morphometric parameters of adult human clavicles and evaluate their clinical relevance in orthopedic practice and forensic identification.

## **MATERIALS AND METHODS:**

### **Study Design and Setting**

A descriptive cross-sectional osteometric study was conducted in the Department of Anatomy of a tertiary care teaching institution. The study was carried out over a period of one year from January 2025 to December 2025 using dry adult human clavicles available in the departmental osteology collection.

### **Study Material**

The study included a total of 120 dry adult human clavicles comprising 60 right-sided and 60 left-sided bones. The clavicles were examined for completeness and anatomical integrity before inclusion in the study. Bones showing evidence of deformity, fractures, pathological lesions, or erosion affecting anatomical landmarks were excluded to ensure measurement accuracy. Institutional ethical clearance was obtained prior to commencement of the study.

### **Sample Size**

A sample size of 120 clavicles was considered adequate based on previous morphometric studies conducted on human clavicles and the availability of specimens in the departmental collection.

### **Inclusion Criteria**

- Adult dry human clavicles of either side.
- Intact clavicles with clearly identifiable anatomical landmarks.
- Bones free from visible deformities and damage.

### **Exclusion Criteria**

- Broken or incomplete clavicles.
- Bones showing pathological changes.
- Congenital deformities affecting normal morphology.
- Eroded specimens with indistinct anatomical landmarks.

### **Morphometric Parameters Studied**

The following osteometric parameters were measured:

#### **1. Maximum Clavicular Length (mm)**

The maximum distance between the most medial point of the sternal end and the most lateral point of the acromial end was measured using an osteometric board.

#### **2. Midshaft Circumference (mm)**

The circumference at the midpoint of the shaft was measured using a flexible measuring tape. The midpoint was identified by determining the midpoint of the total clavicular length.

#### **3. Width of Sternal End (mm)**

The maximum superoinferior diameter of the sternal end was measured using a digital Vernier caliper.

#### 4. Width of Acromial End (mm)

The maximum superoinferior diameter of the acromial end was measured using a digital Vernier caliper.

#### 5. Curvature Index (%)

The curvature index was calculated to assess the degree of clavicular curvature using the formula:

$$\text{Curvature Index (\%)} = (\text{Maximum Height of Curvature} \times 100) / \text{Total Clavicular Length}$$

This parameter reflects the characteristic S-shaped configuration of the clavicle.

#### Instruments Used

The following instruments were utilized for obtaining measurements:

- Digital Vernier caliper with an accuracy of 0.01 mm.
- Osteometric board for measuring maximum length.
- Flexible non-elastic measuring tape for circumference measurements.
- Data recording sheets for documentation of observations.

Before commencement of the study, all instruments were calibrated according to manufacturer specifications to minimize measurement errors.

#### Data Collection Procedure

Each clavicle was assigned a unique identification number. The side of the bone was determined using standard anatomical features. All measurements were obtained by the principal investigator under uniform conditions to reduce observer variability.

Each parameter was measured three times, and the average value was considered for statistical analysis. Measurements were recorded in millimeters to maintain consistency and accuracy.

#### Statistical Analysis

The collected data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) version 23.0. Continuous variables were expressed as mean, standard deviation, minimum values, and maximum values. Comparisons between right and left clavicles were performed using the Independent Samples t-test. Correlations between clavicular length and other morphometric parameters were assessed using Pearson's correlation coefficient. A p-value of less than 0.05 was considered statistically significant.

#### RESULTS:

A total of 120 adult dry human clavicles were included in the study, comprising 60 right-sided and 60 left-sided specimens. Various morphometric parameters including maximum clavicular length, midshaft circumference, width of the sternal end, width of the acromial end, and curvature index were analyzed. (Table 1)

**Table 1. Distribution of Clavicles According to Side**

Side	Number (n)	Percentage (%)
Right	60	50.0
Left	60	50.0
Total	120	100

The average clavicular length was  $146.70 \pm 9.15$  mm. The mean midshaft circumference was  $34.95 \pm 3.55$  mm. The mean widths of the sternal and acromial ends were  $26.40 \pm 2.81$  mm and  $23.10 \pm 2.45$  mm respectively. The mean curvature index was  $13.60 \pm 1.65\%$ . (Table 2)

**Table 2. Descriptive Statistics of Morphometric Parameters**

Parameter	Mean $\pm$ SD	Minimum	Maximum
Length (mm)	$146.70 \pm 9.15$	126.40	166.80
Midshaft Circumference (mm)	$34.95 \pm 3.55$	28.10	43.20
Sternal End Width (mm)	$26.40 \pm 2.81$	20.80	33.10
Acromial End Width (mm)	$23.10 \pm 2.45$	18.20	29.00
Curvature Index (%)	$13.60 \pm 1.65$	10.20	17.80

The mean clavicular length was significantly greater on the right side compared to the left side ( $p = 0.032$ ). No statistically significant side differences were observed for midshaft circumference, sternal end width, acromial end width, or curvature index. (Table 3)

**Table 3. Comparison of Morphometric Parameters Between Right and Left Clavicles**

Parameter	Right (n=60) Mean $\pm$ SD	Left (n=60) Mean $\pm$ SD	p-value
Length (mm)	$147.80 \pm 9.40$	$145.60 \pm 8.80$	0.032*

Midshaft Circumference (mm)	35.20 ± 3.60	34.70 ± 3.50	0.421
Sternal End Width (mm)	26.70 ± 2.90	26.10 ± 2.70	0.263
Acromial End Width (mm)	23.40 ± 2.50	22.80 ± 2.40	0.174
Curvature Index (%)	13.80 ± 1.70	13.40 ± 1.60	0.089

\*Statistically significant ( $p < 0.05$ )

Pearson correlation analysis demonstrated a moderate positive correlation between clavicular length and midshaft circumference ( $r = 0.48$ ,  $p < 0.001$ ). Significant positive correlations were also observed between clavicular length and widths of both the sternal and acromial ends. A weak but statistically significant positive correlation was found between clavicular length and curvature index. (Table 4)

**Table 4. Pearson Correlation Analysis Between Clavicular Length and Other Parameters**

Variables Compared	Correlation Coefficient (r)	p-value
Length vs Midshaft Circumference	0.48	<0.001*
Length vs Sternal End Width	0.34	0.002*
Length vs Acromial End Width	0.29	0.008*
Length vs Curvature Index	0.22	0.017*

\*Statistically significant ( $p < 0.05$ )

## DISCUSSION:

Morphometric analysis of the clavicle provides important information for anatomical studies, orthopedic surgery, forensic identification, and implant design. The clavicle exhibits considerable variation in its dimensions among different populations owing to genetic, environmental, and functional factors. The present study evaluated various morphometric parameters of 120 adult dry clavicles and demonstrated significant variations in clavicular dimensions.

The mean clavicular length observed in the present study was  $146.70 \pm 9.15$  mm. These findings are comparable with those reported by Murshed, who documented similar clavicular dimensions in adult populations and emphasized the existence of population-based variations in clavicular morphology.<sup>6</sup> Clavicular length is an important parameter in orthopedic reconstruction and fixation procedures because implant selection and plate contouring largely depend on the dimensions of the bone.

In the present study, the mean length of the right clavicle was significantly greater than that of the left clavicle ( $p = 0.032$ ). This finding is consistent with the observations of Huang et al. and Cunningham et al., who reported side-related asymmetry in clavicular dimensions and suggested that differences in mechanical loading and limb dominance may contribute to these variations.<sup>8,9</sup> Such asymmetry should be considered during preoperative planning and implant placement.

The mean midshaft circumference was  $34.95 \pm 3.55$  mm. The clavicular shaft is subjected to various biomechanical forces during upper limb movements, and its dimensions influence the strength and stability of the bone. Mazzocca et al. reported that the morphology of the clavicular shaft plays a significant role in determining fracture patterns and fixation outcomes.<sup>10</sup> The mean widths of the sternal and acromial ends were  $26.40 \pm 2.81$  mm and  $23.10 \pm 2.45$  mm respectively. The sternal end was wider than the acromial end, which is in agreement with the findings of Kaur et al. and Gupta and Priya.<sup>11,12</sup> Knowledge of these dimensions is useful during surgical procedures involving the sternoclavicular and acromioclavicular joints and in the design of anatomically contoured implants.

The mean curvature index in the present study was  $13.60 \pm 1.65\%$ . The characteristic S-shaped curvature of the clavicle contributes to force transmission between the upper limb and axial skeleton. Andermahr et al. emphasized that variations in clavicular curvature have important implications for intramedullary fixation and plate contouring.<sup>7</sup>

Correlation analysis revealed a significant positive relationship between clavicular length and other morphometric parameters, particularly midshaft circumference. Similar observations were reported by Murshed, indicating that larger clavicles tend to possess proportionately greater shaft dimensions and articular end widths.<sup>6</sup> These relationships may be useful in anthropometric and forensic assessments when complete skeletal elements are unavailable.

The clinical significance of clavicular morphometry has increased with the widespread use of operative management for clavicular fractures. Accurate knowledge of clavicular dimensions facilitates appropriate implant selection, improves surgical outcomes, and reduces complications associated with implant mismatch.<sup>8</sup> In addition, clavicular measurements have important forensic applications in sex estimation and skeletal identification. Jit and Singh demonstrated the usefulness of clavicular measurements in differentiating skeletal remains within Indian populations.<sup>13</sup>

## CONCLUSION:

The present study demonstrated measurable variations in the morphometric dimensions of adult human clavicles. The right clavicle showed a significantly greater mean length than the left clavicle, while positive correlations were observed between clavicular length and other morphometric parameters. The sternal end was also found to be wider than the acromial end.

These findings provide useful baseline data for orthopedic surgeons, anatomists, and forensic experts. Knowledge of clavicular morphometry can aid in implant design, surgical planning, fracture management, and skeletal identification. Further studies with larger sample sizes and sex-wise analysis are recommended to validate and expand these observations.

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