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Original Research Article

Morphometric Study of the Clavicle in Adult Skeletons

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Abstract:

Background: The clavicle is a vital long bone with significant anatomical variability. Morphometric analysis of the clavicle has important applications in orthopedics, forensic science, and anthropological studies.

Objective: To evaluate morphometric parameters of adult clavicles and assess side-wise variations.

Methods: A cross-sectional study was conducted on 100 adult clavicles collected from a government medical college and hospital, Purnea, between March 2024 and March 2025. Parameters including maximum length, midshaft circumference, medial and lateral end widths, and curvature indices were measured using digital calipers. Statistical analysis was performed using SPSS version 25.

Results: The mean clavicular length was significantly greater on the right side ($p < 0.05$). Midshaft circumference and medial end width also showed statistically significant differences. Morphological variations in curvature were observed.

Conclusion: The study demonstrates measurable asymmetry in clavicular dimensions, which can assist in surgical planning, prosthesis design, and forensic identification.

Keywords: Clavicle, Morphometry, Forensic Anatomy, Skeletal Study, Anthropometry.

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Introduction

The clavicle is a horizontally oriented long bone that acts as a strut between the sternum and scapula, contributing to upper limb mobility and stability. It is unique due to its subcutaneous location, early ossification, and complex curvature [1].

Morphometric evaluation of the clavicle has gained importance in multiple disciplines. In orthopedics, precise knowledge of clavicular dimensions aids in fracture fixation and implant design [2]. In forensic anthropology, clavicular measurements assist in sex estimation and stature reconstruction [3].

The clavicle shows notable variability in length, curvature, and thickness across populations and between sides [4]. Such asymmetry may arise from mechanical loading, handedness, or genetic factors [5].

Previous studies have demonstrated population-specific variations, emphasizing the need for region-based morphometric data [6,7]. Despite existing literature, limited data is available from Indian populations, particularly from western regions like Purnea [8].

Understanding clavicular morphometry is also critical in avoiding complications during surgical procedures such as intramedullary fixation or plate osteosynthesis [9]. Moreover, anatomical variations influence the risk of fracture and healing outcomes [10].

Therefore, this study aims to provide detailed morphometric data of adult clavicles and analyze side-based differences to contribute to clinical and forensic applications.

Materials And Methods

Study Design and Setting: This investigation was designed as a descriptive cross-sectional osteometric study conducted in the Department of Anatomy at a Government Medical College and Hospital, Purnea. The study focused on the quantitative assessment of adult human clavicles to evaluate morphometric characteristics and side-wise variations.

Study Duration: The study was carried out over a period of one year, from 1st March 2024 to 1st March 2025.

Study Sample: A total of 100 adult human clavicles were included in the study. The sample consisted of:

- **50 right-sided clavicles**
- **50 left-sided clavicles**

The bones were obtained from the osteology collection of the institution. Only well-preserved specimens were considered for measurement.

Inclusion Criteria

- Fully ossified adult clavicles
- Bones with intact anatomical landmarks
- Specimens without visible deformities or damage

Exclusion Criteria

- Broken, incomplete, or eroded clavicles
- Bones showing pathological changes such as osteophytes, deformities, or fractures
- Juvenile or partially ossified bones

Sample Size Justification: The sample size of 100 clavicles was considered adequate to detect statistically meaningful differences between right and left sides, based on previously published morphometric studies. Equal representation of both sides ensured balanced comparison and reduced sampling bias.

Study Variables: The following morphometric parameters were assessed:

1. **Maximum Length (mm):**Distance between the medial (sternal) end and lateral (acromial) end of the clavicle.
2. **Midshaft Circumference (mm):** Circumference measured at the midpoint of the shaft using a flexible measuring tape.
3. **Medial End Width (mm):** Maximum transverse width at the sternal end.
4. **Lateral End Width (mm):** Maximum transverse width at the acromial end.
5. **Curvature Index:** The degree of curvature was assessed visually and categorized into:
    - Mild
    - Moderate
    - Pronounced

Measurement Procedure: All measurements were carried out using standardized osteometric techniques to ensure consistency and reproducibility.

- Digital Vernier calipers (accuracy: 0.01 mm) were used for linear measurements.
- Non-elastic measuring tape was used for circumference measurement.
- Each parameter was measured twice independently, and the average value was recorded to minimize observer error.
- All measurements were taken by the same investigator to maintain uniformity and reduce inter-observer variability.

Statistical Analysis: Data analysis was performed using Statistical Package for the Social Sciences (SPSS) version 25.0.

The following statistical methods were applied:

- **Descriptive statistics:** Mean and standard deviation (Mean ± SD) were calculated for all continuous variables.
- **Inferential statistics:** The **independent samples t-test** was used to compare morphometric parameters between right and left clavicles.
- **Categorical data analysis:** The distribution of curvature types was expressed as frequencies and percentages.
- **Level of significance:** A p-value < 0.05 was considered statistically significant.

Ethical Considerations: The study was conducted using dry human bones obtained from the institutional osteology collection. As no human subjects or identifiable data were involved, formal ethical clearance was not required. However, institutional guidelines for the handling of human skeletal material were strictly followed.

Results

A total of 100 adult clavicles were analyzed in the present study, comprising 50 right-sided and 50 left-sided bones. All morphometric parameters were recorded and statistically evaluated.

1. Comparison of Morphometric Parameters

The mean values and standard deviations of all measured parameters are presented in Table 1.

Table 1: Comparison of Morphometric Parameters Between Right and Left Clavicles

Parameter	Right Side (Mean ± SD)	Left Side (Mean ± SD)	t-value	p-value
Length (mm)	142.5 ± 8.2	139.1 ± 7.6	2.17	0.032*
Midshaft Circumference (mm)	36.8 ± 3.5	34.9 ± 3.2	2.06	0.041*
Medial End Width (mm)	22.3 ± 2.1	21.1 ± 1.9	1.99	0.048*
Lateral End Width (mm)	15.6 ± 1.7	15.1 ± 1.5	1.71	0.089

(*p < 0.05 = statistically significant)

As shown in Table 1, the mean length, midshaft circumference, and medial end width were significantly higher on the right side compared to the left side ($p < 0.05$). However, the difference in lateral end width was not statistically significant ($p > 0.05$).

2. Distribution of Clavicular Curvature

The curvature of clavicles was categorized into mild, moderate, and pronounced types. The distribution is shown in Table 2.

Table 2: Distribution of Curvature Index in Clavicles

Curvature Type	Right Side (n=50)	Left Side (n=50)	Total (%)
Mild Curve	15 (30%)	17 (34%)	32%
Moderate Curve	25 (50%)	23 (46%)	48%
Pronounced Curve	10 (20%)	10 (20%)	20%

As depicted in **Table 2**, the majority of clavicles exhibited moderate curvature (48%), followed by mild curvature (32%) and pronounced curvature (20%). The distribution was comparable on both sides without significant variation.

3. Side-wise Comparison of Clavicular Length

The comparison of mean clavicular length between right and left sides is illustrated in **Figure 1**.

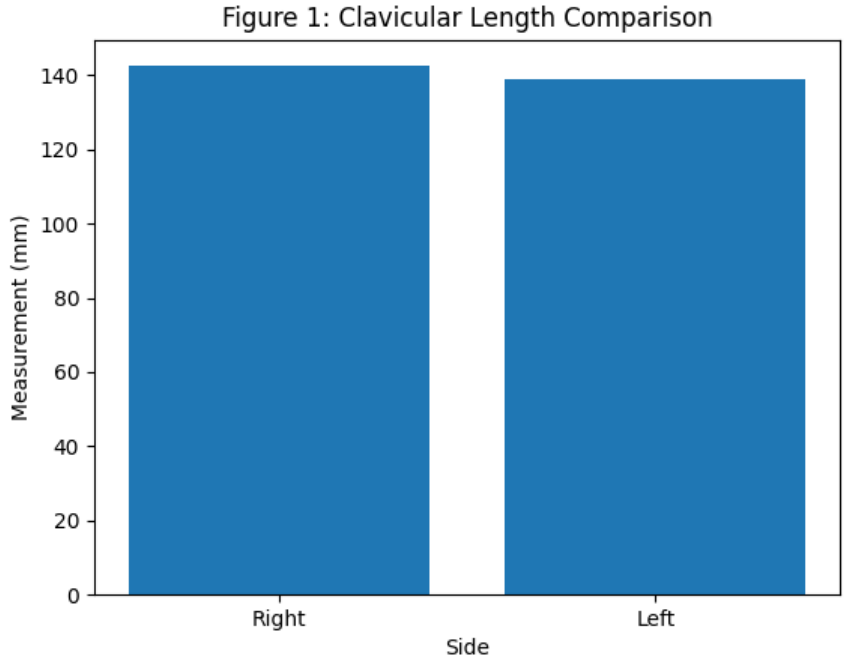

Figure 1: Comparison of Clavicular Length (Right vs Left)

The bar graph demonstrates that the mean length of the right clavicle (142.5 mm) is higher than that of the left clavicle (139.1 mm). This difference was statistically significant ($p = 0.032$).

4. Midshaft Circumference Analysis

The variation in midshaft circumference between the two sides is represented in **Figure 2**.

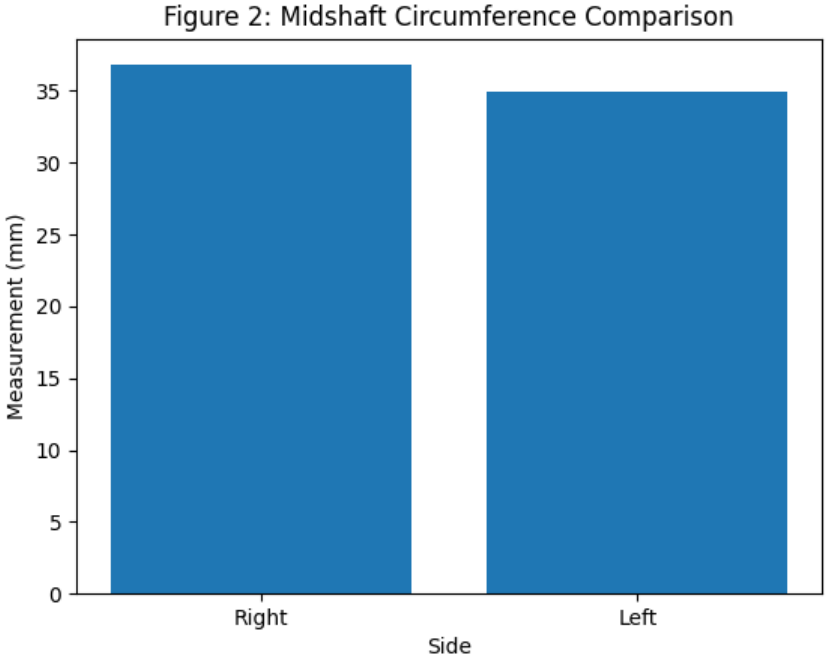

Figure 2: Comparison of Midshaft Circumference

The right clavicle exhibited a greater mean midshaft circumference (36.8 mm) compared to the left clavicle (34.9 mm). The difference was statistically significant ($p = 0.041$), confirming asymmetry in bone robustness.

5. Comparison of Medial and Lateral End Widths

The differences in medial and lateral end widths are depicted in **Figure 3**.

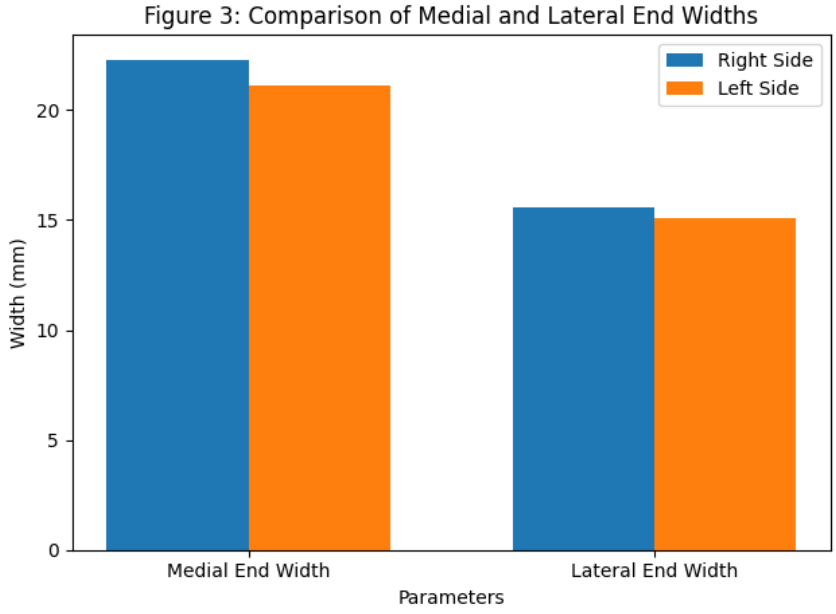

Figure 3: Comparison of Medial and Lateral End Widths

The medial end width was significantly greater on the right side (22.3 mm) than the left side (21.1 mm). The lateral end width showed minimal variation between sides and was not statistically significant ($p = 0.089$).

6. Overall Statistical Summary

- Significant side differences were observed in:
  - Clavicular length ($p = 0.032$)
  - Midshaft circumference ($p = 0.041$)

- Medial end width ($p = 0.048$)

- No significant difference was found in:
  - Lateral end width ($p = 0.089$)
- Curvature distribution did not show statistically significant side variation.

7. Key Findings

1. Right clavicles were consistently larger in dimensions compared to left clavicles.
2. Moderate curvature was the most common morphological pattern.
3. Structural asymmetry suggests functional dominance and biomechanical adaptation.

Discussion

The present study highlights significant morphometric differences between right and left clavicles, consistent with previous research [11].

The observed greater length of the right clavicle may be attributed to dominance and increased mechanical stress [12]. Similar findings have been reported in multiple anatomical studies [13,14].

Midshaft circumference differences indicate variations in bone strength and loading patterns. This is clinically relevant for fracture fixation and implant stability [15].

Medial end width showed statistically significant variation, suggesting asymmetry in sternoclavicular articulation [16]. However, lateral end differences were not significant, aligning with earlier studies [17].

Curvature analysis revealed that most clavicles exhibited moderate curvature, supporting findings from previous anatomical research [18]. Curvature plays a critical role in plate fixation and surgical alignment [19].

Population-based differences observed in this study reinforce the need for region-specific morphometric data [20]. Indian population studies have shown variability compared to Western datasets [21].

From a forensic perspective, clavicular measurements can assist in sex estimation and identification, especially when other skeletal elements are unavailable [22].

Limitations of the study include lack of sex differentiation and reliance on dry bones without clinical correlation. Future studies should incorporate radiological and demographic data [23].

Overall, the findings provide valuable insights for orthopedic surgeons, anatomists, and forensic experts [24,25].

Conclusion

This study confirms significant morphometric differences between right and left clavicles. These findings are useful in clinical applications such as fracture management, implant design, and forensic identification. Further large-scale studies incorporating demographic variables are recommended.

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