

Innovations

Preliminary Study of the Length and Curvature of the Clavicle and their Clinical Significance

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Abstract

Introduction: The clavicle is a horizontal subcutaneous bone at the root of the neck with sternal and acromial ends that is often fractured. Its shaft curves with the medial two-thirds convex forward and the lateral one-third concave forward. The medial curve withstands compression, whereas the lateral curve enables a greater range of shoulder motion. Clavicle fractures occur in 2-5% of adults and 10-15% of children. Most fractures occur at the junction of the medial two-thirds and lateral one-third of the shaft. Owing to discrepancies in earlier findings and a lack of studies in Andhra Pradesh, India, we investigated clavicular anatomy with a particular focus on its curvatures in relation to intramedullary nailing by comparing the right and left clavicles. **Materials and methods:** A total of 100 adult clavicles (50 right-sided and 50 left-sided) of unknown age and sex were examined. Morphometric features, including the length of the clavicle, medial angle, lateral angle, and sum of the two angles, were recorded. Measurements were performed using a protractor and digital Vernier caliper. **Results:** The mean lengths of the clavicle observed on the right and left sides were 140.33 ± 8.00 mm and 141.42 ± 8.91 mm, respectively. The mean medial angles of the clavicle observed on the right and left sides were $151.39^\circ \pm 5.35^\circ$ and $152.38^\circ \pm 4.74^\circ$, respectively. The mean lateral angles of the clavicle observed on the right and left sides were $142.64^\circ \pm 6.86^\circ$ and $143.19^\circ \pm 7.69^\circ$, respectively. The mean sum of the two angles or total curvature of the clavicle observed on the right and left sides were $291.03^\circ \pm 9.36^\circ$ and $292.57^\circ \pm 9.84^\circ$, respectively. **Conclusion:** This study on clavicular curvatures revealed no statistically significant differences between the right and left sides in terms of length, medial and lateral angles, and total curvature. These findings contribute to our understanding of clavicular anatomy and symmetry, which may have implications for orthopedic procedures, forensic anthropology, and biomechanics.

Key words: Clavicle, Medial angle, Morphometry, Lateral angle, Parsons method, Vernier caliper

Introduction

The clavicle is a subcutaneous long bone (1) positioned horizontally at the root of the neck. It features sternal and acromial ends, with a shaft shaped like an italic "f" in the middle. The shaft was curved, with the medial two-thirds convex forward and the lateral one-third concave forward. In individuals who perform manual labor, the clavicle tends to be thicker and more curved, with pronounced ridges for muscle attachment. In females, the clavicle is generally shorter than that in males (2). As stated by A. K. Datta (3), the clavicle serves several purposes: (a) It functions as a support to position the scapula laterally, allowing the upper limb to move freely away from the trunk. (b) It conveys the weight of the upper limb to the axial skeleton. (c) It safeguards the neurovascular structures located at the root of the neck.

The medial and lateral curvatures of the clavicle contribute significantly to its biomechanical properties. The medial curve, which is convex anteriorly, enhances the clavicle's ability to withstand compressive forces transmitted from the upper limb. The lateral curve, which is concave anteriorly, facilitates articulation with the acromion process of the scapula, allowing for a greater range of shoulder motion. Additionally, these curvatures create a spring-like mechanism that helps absorb and distribute forces, thereby protecting the underlying neurovascular structures.

The clavicle's shape changes from tubular medially to flat laterally at the junction of the middle and lateral thirds of the shaft, which is the most frequent site of clavicular fractures (4). Clavicle fractures are prevalent injuries, occurring in 2-5% of adults and 10-15% of children (5), and account for 44-66% of all shoulder fractures (6). Approximately 70-80% of these fractures occur at the junction of the medial two-thirds and lateral one-third of the shaft. Displacement is observed in approximately 73% of all midshaft clavicle fractures, and the nonunion rate is around 5%; however, it can be significantly higher in cases with displaced fractures (7).

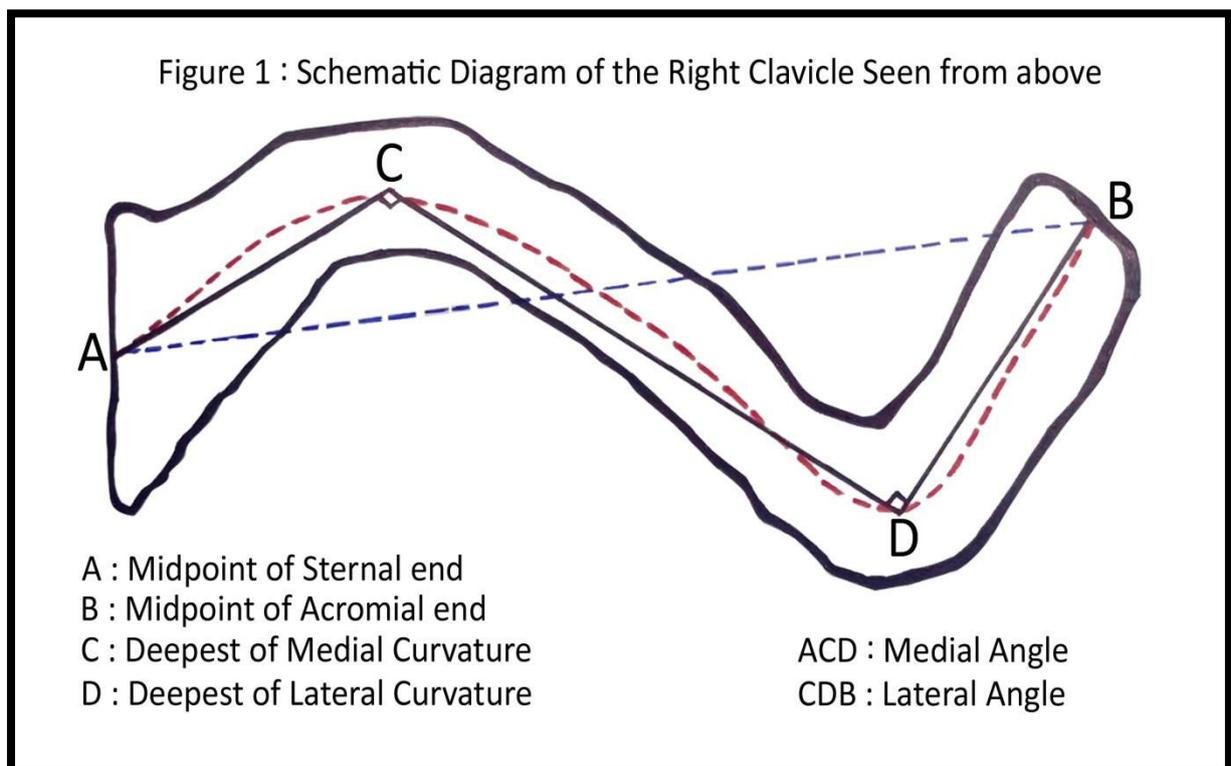
Intramedullary fixation is a common method for treating clavicular fractures. In addition to traditional plate fixation, the use of titanium elastic nails (TEN) for intramedullary fixation is gaining popularity. These surgical procedures are employed for clavicular fractures when standard treatment is unsuccessful, leading to malunion or nonunion (8). These procedures necessitate a comprehensive understanding of the anatomical variations of the clavicle.

Previous research by Jit and Singh (9), Kaur et al. (10), Haque (11), and Parsons (12) indicated that the average length of left clavicles exceeded that of the right. However, Trotter et al. (1) and Singh and Gangrade (13) argued that right-sided limb bones are typically longer than those on the left side. Haque (14) also noted that the angles of the left clavicle are greater. The reason for this difference is unclear. Measuring the curvature of the clavicle assists in surgical procedures, such as intramedullary nailing.

The curvature of the clavicle has not been studied extensively. The discrepancies in earlier findings and the lack of studies on clavicular curvatures in the population of Andhra Pradesh, India, strongly motivated this research. Consequently, we investigated the anatomy of the human clavicle, with a particular focus on its curvatures in relation to intramedullary nailing. This study aimed to identify the comparative differences between the right and left clavicles and between the medial and lateral curvatures of both sides using specific metrics.

Materials and Methods:

We conducted a cross-sectional observational study in the Department of Anatomy, Konaseema Institute of Medical Sciences and Research Foundation, Amalapuram, India. A total of 100 adult human dry clavicles (50 right-sided and 50 left-sided) of unknown age and sex were included in this study. The clavicles were procured from the bone bank of the Anatomy Department. Bones with visible damage or pathological deformities were excluded from the study. Measurements of both the right and left clavicles were recorded using a protractor and digital Vernier caliper with an accuracy of up to 0.01 mm. The following procedure was followed to record the morphometric parameters of the clavicles, as shown in figure 1 and presented in Table 1.



- The length of the clavicle was determined using a Vernier Caliper by measuring the maximum linear distance between its two ends.

- The Parsons (12) method was used to assess clavicular curves. The clavicle was positioned on a white sheet of paper, ensuring that both ends were horizontally aligned (Figure-1).
- The outline of the clavicle was traced on paper.
- Midpoints at the sternal and acromial ends were identified and labelled as points 'A' and 'B', respectively, and connected by a straight line.
- The central axis of the clavicle was depicted as a curved line positioned midway between the anterior and posterior borders along the length of the clavicle. This curved line features two convexities: the medial two-thirds curve anteriorly and the lateral one-third curve posteriorly.
- The deepest points on these curves, where the convexities were most pronounced, were marked as points 'C' and 'D' and connected by a straight line.
- Finally, these points were linked with midpoints 'A' and 'B' at the respective ends using lines CA and DB, forming two angles: medial angle ACD, representing the curvature of the medial two-thirds, and lateral angle CDB, indicating the curvature of the lateral one-third.
- The angles were measured using a protractor.
- The total curvature of the clavicle was the sum of these two angles.

Data analysis and visualization were performed using descriptive statistical techniques, such as the mean and standard deviation. Statistical analysis of the data obtained was performed using an unpaired t-test ($p < 0.05$ was considered significant) using the IBM SPSS Version 21. The results obtained in the current study were compared with those reported by various authors in their previous studies.

Results

The results obtained from the morphometric evaluation of 100 dry human clavicles (50 right-sided and 50 left-sided) are recorded and shown in Table 1.

Table 1: Range, mean, standard deviation, and p-value of various parameters measured in the present study.

Parameter	Right side		Left side		P-value
	Range	Mean±S D	Range	Mean±S D mm	
Length of the clavicle	128.73 – 159.43 mm	140.33 ±8.00 mm	128.57 – 159.50 mm	141.42 ± 8.91 mm	0.564
Medial angle	144° – 165°	151.39° ±5.35°	138° – 162°	152.38° ±4.74°	0.495
		142.64°		143.19°	

Lateral angle	133° – 156°	±6.86°	134° – 155°	±7.69°	0.790
Sum of two angles (Total curvature of clavicle)	276° – 307°	291.03° ±9.36°	275° – 309°	292.57° ±9.84°	0.588

The mean lengths of the clavicle observed on the right and left sides were 140.33±8.00 mm and 141.42±8.91 mm, respectively, with a p-value of 0.564, which was not statistically significant.

The mean medial angles of the clavicle observed on the right and left sides were 151.39°±5.35° and 152.38°±4.74°, respectively, with a p-value of 0.495, which was not statistically significant.

The mean lateral angles of the clavicle observed on the right and left sides were 142.64°±6.86° and 143.19°±7.69°, respectively, with a p-value of 0.790, which was not statistically significant.

The mean sum of the two angles or total curvature of the clavicle observed on the right and left sides were 291.03°±9.36° and 292.57°±9.84°, respectively, with a p-value of 0.588, which was not statistically significant.

All measurements, such as the length of the clavicle, medial angle, lateral angle, and sum of the two angles on the left side, were higher than those observed on the right side, but the differences were not statistically significant.

Discussion

Numerous researchers have investigated asymmetries between the right and left clavicles. This has been accomplished using various methodologies, including the direct measurement of dry clavicles, examination of clavicles from fresh or preserved cadavers, application of radiographic techniques on cadaveric clavicles, and radiographic assessments in living individuals (15). These studies were conducted in diverse populations. Upon comparing and analyzing the current data with those from previous studies, several differences and similarities were identified. In a comparative analysis of research conducted by different authors on the average curvature angle of the clavicles across various racial groups, it was observed that these clavicle measurements varied even among closely related racial groups and differed across races (16).

The clavicle exhibits significant differences in length, curvature, and symmetry between the right and left sides. Research indicates that the left clavicle is generally longer and more curved than the right clavicle in most people (17). This asymmetry is believed to be linked to handedness, varying mechanical loads during growth, and anatomical differences (18). Typically, the clavicle on the dominant side is shorter and sturdier because of increased muscular stress and activity.

The S-shaped curvature of the clavicle may vary between sides, with the dominant side often exhibiting a more pronounced curve. These anatomical distinctions affect the biomechanical function and susceptibility to injury. For

example, a more curved left clavicle may better resist compressive forces, potentially lowering the fracture risk. In contrast, a straighter right clavicle may be more prone to certain stress patterns, particularly in athletes who frequently perform overhead motions. However, the extent of asymmetry can differ widely among individuals and populations, with some studies noting minimal differences between the sides (19).

The results obtained for the length of the clavicle, medial and lateral angles, and sum of the two angles in the present study were compared with the values observed by various authors in populations of other regions in previous studies and are shown in Tables 2 and 3.

Table 2: Comparison of the length of the clavicle observed in the present study with the values observed by various authors in populations of other regions in previous studies

Author	Population/Region	Right side	Left side
Parsons (12)	England	145.00	146.50
Terry (20)	American Negros	147.10	148.80
Terry (20)	American Whites	152.90	154.10
Oliver (21)	France	146.00	146.80
Jit and Singh (9)	Amritsar, India	137.90	138.60
Singh and Gangrade (13)	Varanasi, India	138.60	135.90
Haque (14)	Nepal	143.20	145.50
Sudha (22)	South India	137.60	137.40
Present study	Andhra Pradesh, India	140.33	141.42

The mean lengths of the clavicle observed on the right and left sides were 140.33 ± 8.00 mm and 141.42 ± 8.91 mm, respectively, which were higher than the values observed by Jit and Singh, Singh and Gangrade, and Sudha but lower than the values observed by Parson, Terry, Oliver, and Haque.

Table 3: Comparison of the medial angle, lateral angle, and sum of the two angles of the clavicle observed in the present study with the values observed by various authors in populations of other regions in previous studies.

Author	Region	Medial angle Right	Medial angle Left	Lateral angle Right	Lateral angle Left	Sum of two angles Right	Sum of two angles Left
Parsons (12)	England	154	154	149	149.50	302.50	303.50
Terry (20)	American Negros	152.32	152.60	141.24	144.68	292.94	296.42
Oliver (21)	France	150.60	151.40	143.40	143.00	294.25	294.40
Kaur (10)	North India	151.68	151.89	143.96	148.46	292.55	297.18
Haque (14)	Nepal	150.97	151.50	139.76	141.73	290.73	293.23
Sudha (22)	South India	147.50	146.00	142.05	144.00	289.59	290.73
Present study	Andhra Pradesh, India	151.39	152.38	142.64	143.19	291.03	292.57

The mean medial and lateral angles of the clavicle observed on the right and left sides were $151.39^{\circ} \pm 5.35^{\circ}$, $142.64^{\circ} \pm 6.86^{\circ}$, and $152.38^{\circ} \pm 4.74^{\circ}$, $143.19^{\circ} \pm 7.69^{\circ}$, respectively which were similar to the values observed by Terry, Oliver, Kaur and Haque but was lower than the values observed by Parson and higher than the value observed by Sudha.

The mean sum of the two angles of the clavicle observed on the right and left sides were $291.03^{\circ} \pm 9.36^{\circ}$ and $292.57^{\circ} \pm 9.84^{\circ}$, respectively. The sum of the two angles on the right side was similar to the values observed by Terry, Kaur, and Haque but lower than the values observed by Parson and Oliver but higher than the value observed by sudha. The sum of the two angles on the left side was lower than the values observed by Parson, Terry, Oliver, Kaur, and Haque but higher than the value observed by Sudha.

The study showed a correlation between length and angle, indicating that clavicles with shorter lengths had larger total angles and vice versa. Bilateral asymmetry in clavicular characteristics may be attributed to uneven vascularization, activity-related changes, or mechanical stress on the dominant hand side (23). Auerbach and Ruff (24) highlighted that racial and genetic factors influence the differences in clavicular characteristics. Mechanical forces offer another explanation for the bilateral asymmetry observed in the clavicles (1). According to Mohsin et al. (25), variations in adult clavicles arise from postnatal rather than from fetal development factors. The results will assist in clinical evaluation, surgical planning, and designing orthopedic implants. They are also important for orthopedic surgery, forensic anthropology, and biomechanics.

Conclusion

In conclusion, this study on clavicular curvatures revealed no statistically significant differences between the right and left sides in terms of length, medial and lateral angles, and total curvature. Although measurements on the left side consistently showed slightly higher values than those on the right, these differences were not substantial enough to be considered significant. These findings contribute to our understanding of clavicular anatomy and symmetry, which may have implications for orthopedic procedures, forensic anthropology, and biomechanics. However, further research with larger sample sizes and diverse populations is necessary to confirm these results and explore potential factors influencing clavicular morphology.

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