



Morphometric Study of Clavicle with Its Clinical Implications – An Observational Study

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Background: Clavicle fractures are common, and they account for 2.6% of all fractures. The middle third of the clavicle is the most common site of fracture. **Aim:** Hence, the aim of this study was to evaluate various morphometric parameters of clavicle which will help the orthopedic surgeons manage the different types of clavicle fractures. **Methods:** The study was conducted on 93 dry human clavicles. Various measurements were taken. A comparison of parameters on the right and left sides and between sexes was also done. Later, the results were analyzed statistically. **Results:** Comparing right and left side parameters revealed that only medial articulating surface length was significant ($P = 0.030$). Sex was determined using two parameters: length of clavicle and midshaft circumference. Comparing male and female parameters revealed that all parameters were significant except the breadth of the rhomboid fossa ($P = 0.066$). **Conclusion:** From our study, we conclude that the results can assist orthopedic surgeons in performing various operative procedures on the clavicle.

Key words: Clavicle, fractures, morphometry, orthopedic surgeons

INTRODUCTION

The clavicle, also known as the collar bone, is a subcutaneous bone that lies transversally at the root of the neck.¹

Most commonly fracture occurs in the midshaft of the clavicle. Previously, they were managed conservatively, but now, they are managed surgically. This is because in conservative treatment there are more chances of malunion which can lead to glenoid malpositioning, which further leads to functional deficits during the abduction.² Surgical treatments have less chance of nonunion, and they have better patients' outcomes.³

Operative procedures are gaining popularity due to the limitations of conservative management.⁴

The most common operative procedure which is done for the management of these fractures is plating. However, there are a lot of disadvantages of this procedure such as broad exposure, prominent implant, skin irritation, and more chances of infection.⁵ Intramedullary fixation is the

most common surgical operation done for fracture shaft clavicle. Hence, Kirschner wires (K-wires), Rockwood or Hagie pins, intramedullary screws, and titanium elastic nails are the intramedullary devices that are gaining popularity in treating clavicle fractures.⁶ At both medial and lateral curvatures the direction of the medullary canal changes, the medial one does not cause problems in intramedullary fixation due to its broad measurements. Due to the narrow size of the lateral curvature, it causes difficulties in negotiating an intramedullary device.⁷

The surgeons should have proper knowledge about the dimensions of the clavicle in both sexes to get the correct size, shape, and morphometry of intramedullary devices which are easy to insert surgically and can provide stable fixation.⁸

Hence, this research was conducted to estimate various dimensions of the clavicle which will help in the development of various intramedullary devices used for intramedullary fixation during fractures of the clavicle.

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MATERIALS AND METHODS

Study type

This was a prospective observational study.

Duration of study

The study duration was 6 months (June 2024–October 2024).

Sample size

The sample size was 93 (43 right and 50 left) dry human clavicle bones belonging to the age group (40–80 years) available in the Department of Anatomy.

Inclusion criteria

- Only adult clavicles were included
- Anatomically normal clavicles in good condition were included.

Exclusion criteria

Clavicles with pathological deformities or traumatic defects were excluded.

Sex was determined using two parameters – length of the clavicle and midshaft circumference. There were 53 male and 40 female clavicles.

The study was conducted in accordance with the Declaration of Helsinki, and institutional ethical clearance was waived off as the study was done on bones that had been stored in the department for many years.

The following measurements were taken [Figures 1-4]:

1. Length of the clavicle: The distance was measured from the medial to the lateral end of the clavicle

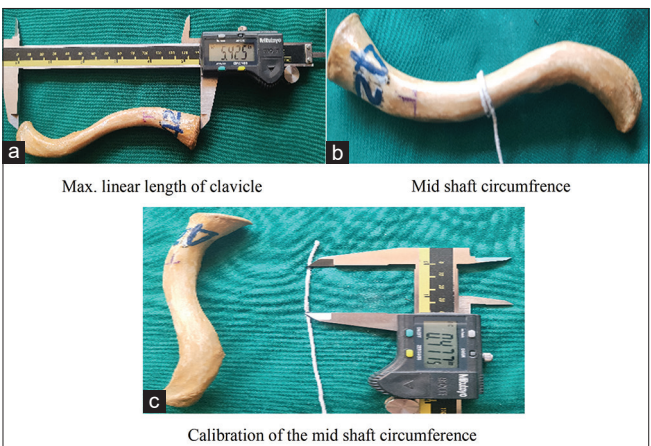


Figure 1: Measurements done on clavicle: (a) Maximum linear length of clavicle, (b) Midshaft circumference, (c) Calibration of midshaft circumference

2. Midshaft circumference: The midpoint of the shaft of the clavicle was denoted by a marker while measuring the total length of the bone. Then, the circumference of that area of the shaft was measured by a thread later that measurement of the thread was transferred to the digital Vernier caliper
3. Maximum diameter of midshaft: At the middle of the shaft, maximum diameter was noted
4. Minimum diameter of midshaft: At the middle of the shaft, minimum diameter was noted
5. Maximum breadth at the sternal end: The anterior-to-posterior lengths of the sternal end were measured
6. Length of medial articulating surface: The superior-to-inferior lengths of the medial articulating surface were measured
7. Breadth of medial articulating surface: The anterior-to-posterior lengths of the medial articulating surface were measured
8. Maximum breadth at acromial end: The anterior-to-posterior lengths of the acromial end were measured
9. Length of lateral articulating surface: The superior-to-inferior length of the lateral articulating surface was measured
10. Breadth of lateral articulating surface: The anterior-to-posterior length of the lateral articulating surface was measured
11. Length of rhomboid fossa: The superior-to-inferior length of the rhomboid fossa was measured
12. Breadth of rhomboid fossa: The anterior-to-posterior length of the rhomboid fossa was measured
13. Weight of clavicle: The weight of each dry clavicle was documented with the assistance of an electronic weighing machine.

Tools used

A digital Vernier caliper with a precision of 0.001 mm was utilized to measure all the parameters. Thread was used to measure midshaft circumference. To avoid intra-observer and inter-observer bias, each measurement was undertaken twice by two people and afterward its average was noted.

In addition to these morphometric measurements, any variation in clavicle morphology was also noted.

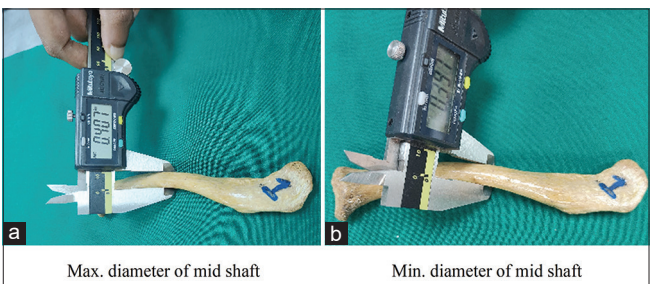


Figure 2: Measurements done on clavicle: (a) Maximum diameter of midshaft, (b) Minimum diameter of midshaft

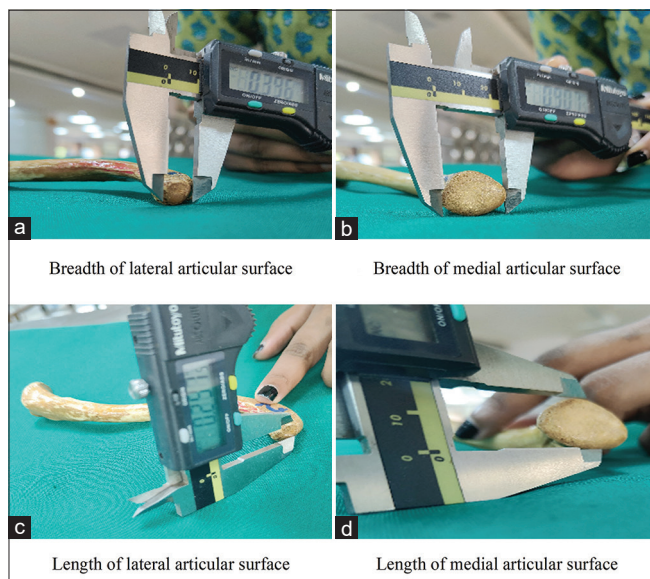


Figure 3: Measurements done on clavicle: (a) Breadth of lateral articular surface, (b) Breadth of the medial articular surface, (c) Length of lateral articular surface, (d) Length of the medial articular surface

Statistical analysis

The data were evaluated using SPSS (Statistical Package for Social Sciences, version 20.0, SPSS Inc., Chicago, IL, USA) software. Normal distribution was verified with the Shapiro–Wilk test. An independent *t*-test was used for normally distributed parameters, and the Mann–Whitney U test was used for nonnormally distributed parameters to compare among sex. To compare the right and left parameters, an independent *t*-test (for normally distributed data) and a Mann–Whitney U test (for nonnormally distributed data) were applied.

RESULTS

The descriptive statistics of all the parameters of the right and left sides with their comparison using the Mann–Whitney test (nonnormally distributed data) and the independent *t*-test (normally distributed data) are shown in Table 1.

When comparing right and left side parameters, it was noted that only medial articulating surface length was significant ($P = 0.030$). The rest of the parameters were not significant.

The descriptive statistics for male and female parameters, along with their comparison using the Mann–Whitney test (for nonnormally distributed data) and the independent *t*-test (for normally distributed data), are presented in Table 2.

On comparing between male and female parameters, it was noted that all parameters were significant ($P < 0.05$) except breadth of the rhomboid fossa ($P = 0.066$).

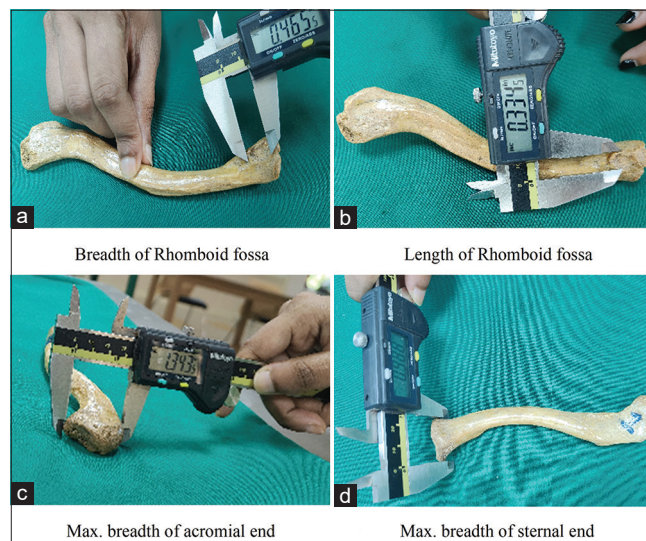


Figure 4: Measurements done on clavicle: (a) Breadth of rhomboid fossa, (b) Length of Rhomboid fossa, (c) Maximum breadth of acromial end, (d) Maximum breadth of sternal end

When comparing the right and left parameters in males, it was found that only the medial and lateral articulating surface breadths were statistically significant, with $P = 0.004$ and 0.036 , respectively. All other parameters were not significant.

In females, the comparison of right and left parameters revealed that only the maximum breadth of the acromial end was significant, with $P = 0.044$. The remaining parameters showed no significant differences.

In 43 right clavicles, the rhomboid fossa was present in 37 clavicles (86.04%) and absent in 6 clavicles (13.9%). In the 50 left clavicles, the rhomboid fossa was present in 47 clavicles (94%) and absent in 3 clavicles (6%).

DISCUSSION

The clavicle has a complicated and varying bony anatomy. When an adult or child falls with an outstretched hand, the wrist is the most fractured bone due to an indirect force.⁹ Nowadays, surgical treatments such as external and internal fixation are preferred over conservative methods. These surgical approaches require a detailed understanding of the bone's various dimensions.

Patted *et al.* found that the clavicles in females are significantly shorter than those of males ($P = 0.000$). The mean length of the right and left clavicles was 141.5 and 143.5 mm, respectively. The midshaft width of the clavicle was significantly narrower in females compared to males ($P = 0.00$).⁷ Kundu *et al.* found that the length of the clavicle was less in females as compared to males and less on the right side as compared to the left side.¹⁰ Yang

Table 1: Descriptive statistics of all the parameters of the right and left sides with their comparison using the Mann–Whitney test (nonnormally distributed data) and independent *t*-test (normally distributed data)

Parameters	Mean±SD	<i>P</i>
Length of clavicle (mm)		
Right	135.76±11.84	0.100
Left	139.76±11.19	
Midshaft circumference (mm)		
Right	37.25±4.29	0.899
Left	37.12±5.73	
Maximum diameter of midshaft (mm)		
Right	14.48±2.20	0.331
Left	14.96±2.41	
Minimum diameter of midshaft (mm)		
Right	11.04±1.85	0.819
Left	11.14±2.04	
Maximum breadth of sternal end (mm)		
Right	18.34±3.45	0.606
Left	18.00±3.04	
Medial articulating surface length (mm)		
Right	19.93±3.22	0.030*
Left	21.54±3.75	
Medial articulating surface breadth (mm)		
Right	21.06±4.39	0.430
Left	20.40±3.76	
Maximum breadth of acromial end (mm)		
Right	19.60±3.03	0.658
Left	19.30±3.51	
Lateral articulating surface length (mm)		
Right	14.11±2.96	0.229
Left	13.36±3.04	
Lateral articulating surface breadth (mm)		
Right	8.72±2.31	0.210
Left	8.16±1.97	
Length of the fossa (mm)		
Right	20.65±4.80	0.291
Left	21.80±5.08	
Breadth of the fossa (mm)		
Right	9.13±2.90	0.419
Left	8.57±3.32	
Dry weight (g)		
Right	16.97±5.69	0.775
Left	17.31±5.71	

**P* value is considered significant <0.05 level (two-tailed). SD=Standard deviation

Table 2: Descriptive statistics of all the parameters of male and female with their comparison using Mann–Whitney test (nonnormally distributed data) and independent *t*-test (normally distributed data)

Parameters	Sex	Mean±SD	<i>P</i>
Length of clavicle (mm)	Male	145.64±8.70	<0.001*
	Female	127.67±5.58	
Midshaft circumference (mm)	Male	39.96±4.60	<0.001*
	Female	33.50±2.93	
Maximum diameter of midshaft (mm)	Male	15.90±2.20	<0.001*
	Female	13.20±1.39	
Minimum diameter of midshaft (mm)	Male	12.07±1.65	<0.001*
	Female	9.80±1.50	
Maximum breadth of sternal end (mm)	Male	19.69±2.68	<0.001*
	Female	16.12±2.73	
Medial articulating surface length (mm)	Male	22.13±3.53	<0.001*
	Female	19.02±2.85	
Medial articulating surface breadth (mm)	Male	22.62±3.10	<0.001*
	Female	18.17±3.80	
Maximum breadth of acromial end (mm)	Male	21.07±2.70	<0.001*
	Female	17.27±2.68	
Lateral articulating surface length (mm)	Male	14.88±2.85	<0.001*
	Female	12.15±2.47	
Lateral articulating surface breadth (mm)	Male	9.24±1.86	<0.001*
	Female	7.32±2.00	
Length of the fossa (mm)	Male	23.11±4.98	<0.001*
	Female	18.55±3.50	
Breadth of the fossa (mm)	Male	9.33±2.95	0.066
	Female	8.05±3.30	
Dry weight (g)	Male	20.96±3.75	<0.001*
	Female	12.10±3.37	

**P* value is considered significant <0.05 level (two-tailed). SD=Standard deviation

et al. found that the mean length was 15.6 in males and 14.3 in females, which was statistically significant ($P < 0.001$), which means the male clavicle is lengthier than the female's. The bone diameters at the sternal end, acromial end, and middle shaft are significantly larger in males compared to females.¹¹ In our study, all measured parameters were also greater in males than in females, and these differences were statistically significant. These results were similar to our results. This shows that sexual dimorphism exists in clavicles which should be kept in mind while doing any surgical intervention. This gender difference may require different plate designs for male and female patients with midshaft clavicular fractures.

Sushmita *et al.* found that the average length of the clavicle on the right and left sides was 12.43 and 12.40 cm, respectively. The mean midshaft circumference on the right and left sides was 3.08 and 3.13 cm, respectively. The mean weight of the clavicle on the right and left sides was 14.71 and 13.12 g, respectively. On comparing all three parameters (average length, mid-shaft circumference and weight of clavicle) on the right and left sides, it was noted that the mean length and midshaft circumference were not significant as the P value was 0.903, 0.57 while weight comparison was significant as the P value was 0.025.¹² These results were different from the results of our study. These differences may be ethnic, as research was conducted in the eastern population, while our study was carried out in the southern population. As there are right and left asymmetries noted in the studies, these differences should be noted while presurgical planning for clavicle fracture fixation and in the designing of intramedullary clavicle fixation implants.

Ishwarkumar *et al.* found that the average length, midshaft circumference, and maximum breadth of the sternal and acromial ends of the clavicles were greater in males as compared to females.¹³ Aira *et al.* found that both right-sided and female clavicles were shorter as compared to left sides and male clavicles.¹⁴ In our study also, all these parameters were more in males as compared to females. In our study also, the left side clavicles were longer as compared to the right side. These sexual dimorphisms can be due to biomechanical loadings, division of labor, and different activity patterns in males and females.

Nagarchi *et al.* found that the mean lengths of the male and female clavicles were 142.90 and 132.30 mm, respectively.¹⁵ These results were similar to those of our study. It is believed that males typically engage in more strenuous and demanding tasks than females, which may explain why female clavicles are smaller than those of males.

Walters *et al.* found that the average length of the right and left clavicles was 151.60 and 148.20 mm, respectively.¹⁶ In our study, the average length of the right and left clavicles was 135.7 and 139.7 mm, respectively. The differences observed in our research may be attributed to racial factors, as the study was conducted on a South African population, while we focused on a South Indian population.

These morphometric parameters of the clavicle will enhance our understanding of its complexity, which is clinically significant for clavicle restoration, fracture management, and the refinement of implants.

Limitations and future scope of research

- Angles were not measured
- Future studies can be done on radiological scans, 3D imaging, and cadavers to correlate clinically.

CONCLUSION

The study was conducted on 93 (43 right and 50 left) dry human clavicles. They were categorized into 53 males and 40 females based on the length of the clavicle and midshaft circumference. Various morphometric measurements were noted.

Comparing the parameters between the right and left sides revealed that only the length of the medial articulating surface was significant ($P = 0.030$). On comparing between male and female parameters, it was noted that all parameters were significant ($P < 0.05$) except breadth of the rhomboid fossa ($P = 0.066$).

In a comparison of the right and left clavicles among males, it was found that only the medial and lateral articulating surface breadths were statistically significant, with $P = 0.004$ and 0.036, respectively.

In females, the comparison between the right and left clavicles revealed that only the maximum breadth of the acromial end was significant, with $P = 0.044$. Among the 43 right clavicles examined, the rhomboid fossa was present in 37 clavicles, accounting for 86.04%. In the 50 left clavicles studied, the rhomboid fossa was present in 47 clavicles, representing 94%.

Data availability statement

The data that support the findings of this study are available from the corresponding author, Gupta C, upon reasonable request.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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