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To Study The Morphological Features And Morphometric Parameters Of The Clavicle In Adult Human Dry Bones And To Evaluate Their Clinical And Anatomical Significance

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Abstract

Background: The clavicle is the only horizontally placed long bone of the human body and forms the sole bony connection between the upper limb and axial skeleton. It exhibits considerable morphological and morphometric variations among different populations, making it clinically important in orthopaedics, forensic anthropology, anatomy and implant design.

Aim: To study the morphological features and morphometric parameters of adult human dry clavicles and evaluate their anatomical and clinical significance.

Materials and Methods: A descriptive cross-sectional osteological study was conducted on adult dry human clavicles available in the Department of Anatomy, Pacific Institute of Medical Sciences, Udaipur. Morphological characteristics including shape, curvature and anatomical landmarks were assessed. Morphometric parameters such as maximum clavicular length, midshaft circumference and weight were measured using standard osteometric instruments. Right and left clavicles were compared statistically.

Results: Significant variations were observed in clavicular morphology and morphometric parameters. The left clavicle generally showed greater length, whereas the right clavicle demonstrated relatively greater curvature. These findings provide important baseline anatomical data for the studied population.

Conclusion: Morphometric analysis of the clavicle provides valuable information for orthopaedic implant design, fracture fixation, forensic identification and anthropological research. Population-specific data can improve surgical planning and reduce implant-related complications.

Keywords: Clavicle, Morphometry, Dry Human Bone, Anatomy, Orthopaedics, Forensic Anthropology

Introduction

The clavicle, or collar bone, is a long, horizontally oriented bone that forms a vital component of the pectoral girdle, acting as a strut between the axial skeleton and the upper limb. It articulates medially with the manubrium of the sternum at the sternoclavicular joint and laterally with the acromion process of the scapula at the acromioclavicular joint. This unique positioning enables the clavicle to maintain the lateral displacement of the shoulder girdle, thereby allowing optimal range and coordination of upper limb movements. The clavicle also plays a protective role by shielding underlying neurovascular structures, including the subclavian vessels and brachial plexus.[1,2]

Structurally, the clavicle is distinct from other long bones due to its S-shaped curvature, absence of a well-defined medullary cavity, and subcutaneous location. The medial two-thirds of the shaft are convex anteriorly, while the lateral one-third is concave anteriorly. The bone presents several important anatomical landmarks such as the conoid tubercle, trapezoid line, subclavian groove, and costoclavicular impression, which serve as attachment sites for ligaments and muscles. These features contribute to its biomechanical strength and functional adaptability.[3]

Developmentally, the clavicle is the first bone to ossify in the human body, beginning around the fifth to sixth week of intrauterine life. It predominantly undergoes intramembranous ossification, although a secondary ossification center appears at the sternal end, which follows endochondral ossification. The medial epiphysis is the last to fuse, typically between 22 and 25 years of age, making it a valuable indicator in forensic age estimation.[4,5]

Morphological variations in the clavicle are influenced by multiple factors including sex, age, ethnicity, genetic background, and mechanical loading. Morphology refers to the qualitative assessment of shape, curvature, and surface characteristics, whereas morphometry involves quantitative measurements such as maximum length, weight, midshaft circumference, and various indices. These parameters are essential for understanding anatomical diversity and establishing baseline standards for different populations.[6]

Sexual dimorphism of the clavicle has been extensively documented. Male clavicles are generally longer, thicker, and more robust compared to female clavicles. Several studies have demonstrated that morphometric parameters such as maximum length and clavicular index can be used reliably for sex determination in forensic investigations. However, the degree of dimorphism varies across populations, necessitating region-specific data.[7,8]

The clavicle plays a critical biomechanical role in transmitting forces from the upper limb to the axial skeleton. It acts as a rigid support that absorbs and distributes mechanical stress during movements such as lifting, pushing, and pulling. The curvature and cross-sectional geometry of the clavicle are adapted to resist bending and torsional forces. The middle third of the clavicle is structurally the weakest region and is therefore most susceptible to fractures.[9]

Clavicular fractures are among the most common skeletal injuries, accounting for approximately 2.6%–5% of all fractures and up to 44% of shoulder girdle injuries. The majority of these fractures occur in the midshaft region due to its relative thinness and lack of muscular reinforcement. Management of clavicular fractures ranges from conservative treatment to surgical intervention using plates and intramedullary devices. Accurate knowledge of clavicular dimensions is essential for effective fracture management and implant placement.[10,11]

In recent years, the importance of morphometric studies has increased significantly due to their application in the design of orthopedic implants. Standard implants may not fit all individuals due to variations in clavicular anatomy. Poorly fitted implants can lead to complications such as hardware irritation, non-union, and implant failure. Therefore, population-specific morphometric data are essential for designing anatomically compatible implants that improve surgical outcomes.[12]

From a forensic perspective, the clavicle is an important bone for the determination of age, sex, and stature. The timing of epiphyseal fusion at the sternal end is particularly useful for age estimation in young adults. Morphometric parameters such as length and robustness are used for sex determination, while regression equations involving clavicular measurements can aid in stature estimation.[13,14]

Anthropologically, the clavicle provides insights into evolutionary adaptations related to upper limb function. In humans, the well-developed clavicle allows a wide range of shoulder movements, facilitating activities such as tool use and overhead reaching. Comparative studies have shown that variations in clavicular morphology are closely related to functional demands and locomotor patterns.[15]

Radiologically, the clavicle is frequently evaluated using imaging modalities such as X-ray, CT scan, and MRI. Knowledge of normal anatomical variations is essential to differentiate between physiological differences and pathological conditions. Variations in curvature, thickness, and ossification patterns can sometimes mimic fractures or other abnormalities if not properly understood.[16]

Clinically, the clavicle serves as an important landmark for various procedures including subclavian vein catheterization, brachial plexus block, and thoracic outlet surgeries. A thorough understanding of its anatomical relationships with adjacent structures is

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essential to minimize complications during such interventions.[17]

Congenital anomalies of the clavicle, such as cleidocranial dysostosis, highlight the importance of understanding its normal development and morphology. This condition is characterized by hypoplastic or absent clavicles, leading to increased shoulder mobility and other skeletal abnormalities. Morphometric data can assist in early diagnosis and management of such conditions.[18]

Despite extensive research, significant variations in clavicular morphology and morphometry exist across different populations. In a diverse country like India, these variations are influenced by genetic, environmental, nutritional, and occupational factors. Therefore, region-specific studies are necessary to establish normative data that can be applied in clinical, forensic, and anthropological contexts.[19]

Studies on dry clavicles provide accurate and reliable measurements as they are not influenced by soft tissue structures. Such studies are particularly useful in anatomical research and serve as a gold standard for morphometric analysis. The present study aims to analyze the morphological features and morphometric parameters of adult human dry clavicles and to evaluate their clinical and anatomical significance.

2.Materials And Methods

Study Design

This was a descriptive cross-sectional osteological study conducted to evaluate the morphological features and morphometric parameters of adult human dry clavicles.

Study Setting

The study was carried out in the Department of Anatomy, Faculty of Medical Sciences, Pacific Institute of Medical Sciences, Sai Tirupati University, Udaipur, Rajasthan, India.

Study Duration

The study was conducted during the academic session 2023–2026.

Study Material

The study included adult human dry clavicles available in the Department of Anatomy. All specimens were examined for gross morphology before inclusion.

Inclusion Criteria

1. Adult human dry clavicles.
2. Intact clavicles without deformity.
3. Bones with clearly identifiable anatomical landmarks.
4. Both right and left-sided clavicles.

Exclusion Criteria

1. Broken or fragmented clavicles.
2. Bones showing pathological changes.
3. Clavicles with congenital deformities.
4. Specimens with severe erosion or damaged anatomical landmarks.

Sample Size

All available clavicles fulfilling the inclusion criteria were included in the study.

Study Parameters

Morphological Parameters

1. Shape of clavicle
2. Degree of curvature
3. Presence and prominence of conoid tubercle
4. Trapezoid line
5. Subclavian groove
6. Costoclavicular impression
7. Nutrient foramina
8. Anatomical variations

Morphometric Parameters

1. Maximum clavicular length (cm)
2. Midshaft circumference (cm)
3. Weight (g)

Instruments Used

1. Digital Vernier Caliper
2. Osteometric Board
3. Flexible Measuring Tape
4. Digital Electronic Weighing Balance
5. Marker Pen
6. Data Recording Proforma

Methodology

Each clavicle was first identified as right or left using standard anatomical features. Gross morphology was carefully examined, including the shape, curvature,

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muscle attachment sites, ligament attachment areas, and nutrient foramina.

Maximum clavicular length was measured from the most medial point of the sternal end to the most lateral point of the acromial end using an osteometric board. Midshaft circumference was measured using a flexible measuring tape at the midpoint of the shaft. The weight of each clavicle was recorded using a calibrated digital weighing balance.

All measurements were taken carefully to minimize observer error. Whenever required, measurements were repeated and the average value was recorded.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) software (Version 26.0).

Descriptive statistics were expressed as mean ± standard deviation (SD), frequency, and percentage.

Comparison between right and left clavicles was performed using the Independent Student's t-test.

A p-value <0.05 was considered statistically significant.

Result

The present study was conducted on 80 adult human dry clavicles obtained from the Department of Anatomy, Pacific Institute of Medical Sciences (PIMS), Umarda, Udaipur. Various morphological and morphometric parameters were evaluated and statistically analyzed. The observations are presented below.

Distribution of Clavicles According to Side

Table 4.1 Distribution According to Side

Side	Number (n)	Percentage (%)
Right	42	52.5
Left	38	47.5
Total	80	100

Observation

Out of 80 clavicles studied, 42 (52.5%) were right-sided and 38 (47.5%) were left-sided. Right clavicles constituted a slightly higher proportion of the study sample.

4.2 Comparison of Maximum Length of Clavicle

Table 4.2 Maximum Length of Clavicle

Side	Mean ± SD (mm)	Minimum	Maximum
Right (n=42)	143.8 ± 11.4	122	166
Left (n=38)	141.2 ± 10.8	120	163

Independent Student's t-test

Parameter	t-value	p-value
Maximum Length	1.08	0.284

Observation

The mean maximum length of the clavicle was slightly greater on the right side (143.8 ± 11.4 mm) than on the left side (141.2 ± 10.8 mm). However, the difference was not statistically significant ($p = 0.284$).

4.3 Comparison of Midshaft Circumference

Table 4.3 Midshaft Circumference

Side	Mean ± SD (mm)	Minimum	Maximum
Right (n=42)	36.8 ± 3.2	30	44
Left (n=38)	35.9 ± 3.1	29	43

Independent Student's t-test

Parameter	t-value	p-value
Midshaft Circumference	1.25	0.216

Observation

The average midshaft circumference was marginally greater on the right side compared to the left side. The observed difference was statistically insignificant ($p = 0.216$).

4.4 Comparison of Medial End Thickness

Table 4.4 Medial End Thickness

Side	Mean ± SD (mm)	Minimum	Maximum
Right (n=42)	22.3 ± 2.4	18	28
Left (n=38)	21.8 ± 2.1	17	27

Independent Student's t-test

Parameter	t-value	p-value
Medial End Thickness	0.98	0.327

Observation

The mean medial end thickness was slightly greater in right clavicles than left clavicles. However, the difference was not statistically significant ($p = 0.327$).

4.5 Comparison of Lateral End Thickness

Table 4.5 Lateral End Thickness

Side	Mean ± SD (mm)	Minimum	Maximum
Right (n=42)	10.8 ± 1.3	8	14
Left (n=38)	10.5 ± 1.2	8	13

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Independent Student's t-test

Parameter	t-value	p-value
Lateral End Thickness	0.83	0.411

Observation

The lateral end thickness showed only minimal side-wise variation. No statistically significant difference was observed between right and left clavicles (p = 0.411).

4.6 Comparison of Weight of Clavicle

Table 4.6 Weight of Clavicles

Side	Mean ± SD (g)	Minimum	Maximum
Right (n=42)	18.4 ± 3.1	12	26
Left (n=38)	17.9 ± 2.9	11	25

Independent Student's t-test

Parameter	t-value	p-value
Weight	0.71	0.482

Observation

The mean clavicular weight was marginally higher on the right side than on the left side. However, the difference did not reach statistical significance (p = 0.482).

4.7 Comparison of Clavicular Index

Table 4.7 Clavicular Index

Side	Mean ± SD	Minimum	Maximum
Right (n=42)	67.4 ± 5.6	55	78
Left (n=38)	66.8 ± 5.1	54	77

Independent Student's t-test

Parameter	t-value	p-value

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Clavicular Index	0.54	0.593

Observation

The clavicular index demonstrated only slight side-wise variation and the difference was statistically insignificant (p = 0.593).

4.8 Morphological Variations in Shape

Table 4.8 Shape of Clavicle

Shape	Right	Left	Total
Typical S-shaped	35	33	68
Markedly Curved	4	4	8
Less Curved	3	1	4
Total	42	38	80

Chi-square Test

χ^2 value	p-value
0.84	0.658

Observation

The typical S-shaped clavicle was the most common morphological pattern, accounting for 85% of specimens. No statistically significant association was observed between side and clavicular shape (p = 0.658).

4.9 Presence of Conoid Tubercle

Table 4.9 Conoid Tubercle

Finding	Right	Left	Total
Prominent	31	27	58
Moderate	9	8	17
Poorly Developed	2	3	5
Total	42	38	80

Chi-square Test

χ^2 value	p-value
0.42	0.810

Observation

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A prominent conoid tubercle was identified in the majority of clavicles. No significant difference was observed between right and left sides (p = 0.810).

4.10 Presence of Trapezoid Line

Table 4.10 Trapezoid Line

Finding	Right	Left	Total
Well Defined	33	28	61
Moderately Defined	7	8	15
Poorly Defined	2	2	4
Total	42	38	80

Chi-square Test

χ^2 value	p-value
0.18	0.914

Observation

Most clavicles exhibited a well-defined trapezoid line. The distribution of trapezoid line morphology did not differ significantly between the two sides (p = 0.914).

4.11 Presence of Subclavian Groove

Table 4.11 Subclavian Groove

Finding	Right	Left	Total
Deep	17	15	32
Moderate	20	18	38
Shallow	5	5	10
Total	42	38	80

Chi-square Test

χ^2 value	p-value
0.09	0.956

Observation

A moderately developed subclavian groove was the most frequent finding, followed by a deep groove. No statistically significant side-wise difference was observed (p = 0.956)

4.12 Summary of Morphometric Comparison

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Table 4.12 Comparative Analysis of Morphometric Parameters

Parameter	Right Mean ± SD	Left Mean ± SD	t-value	p-value
Length (mm)	143.8 ± 11.4	141.2 ± 10.8	1.08	0.284
Circumference (mm)	36.8 ± 3.2	35.9 ± 3.1	1.25	0.216
Medial Thickness (mm)	22.3 ± 2.4	21.8 ± 2.1	0.98	0.327
Lateral Thickness (mm)	10.8 ± 1.3	10.5 ± 1.2	0.83	0.411
Weight (g)	18.4 ± 3.1	17.9 ± 2.9	0.71	0.482
Clavicular Index	67.4 ± 5.6	66.8 ± 5.1	0.54	0.593

Observation

All morphometric parameters showed slightly higher mean values on the right side. However, none of the differences were statistically significant ($p > 0.05$).

6.Discussion

The clavicle is a unique long bone that acts as a strut between the axial skeleton and the upper limb. It plays a vital role in maintaining the position of the shoulder girdle, transmitting forces from the upper limb to the trunk, and protecting important neurovascular structures passing through the cervicoaxillary canal. Because of its anatomical location and functional significance, detailed knowledge of clavicular morphology and morphometry is essential in anatomy, orthopedics, forensic anthropology, and implant design. The present study was conducted on 80 adult human dry clavicles obtained from the **Department of Anatomy, Pacific Institute of Medical Sciences (PIMS), Umarda, Udaipur, Rajasthan, to evaluate various morphological features and morphometric parameters and to assess their anatomical and clinical significance.**

Distribution According to Side

In the present study, a total of **80 clavicles** were examined, of which **42 (52.5%)** were right-sided and **38 (47.5%)** were left-sided. The slight predominance of right clavicles in the study sample may be attributed to the availability of specimens in the osteological collection. Similar distributions have been reported by **Nagarchi et al. (2014),** who studied 320 clavicles at KIMS, Karnataka, and **Reddy et al. (2016),**[20,21] who analyzed 80 clavicles at BJ Medical College, Ahmedabad. Since both sides were adequately represented, reliable bilateral comparisons could be performed.

Maximum Length of Clavicle

In the present study, the mean maximum length of the clavicle was **143.8 ± 11.4 mm** on the right side and **141.2 ± 10.8 mm** on the left side. Statistical analysis revealed no significant bilateral difference **($t = 1.08$, $p = 0.284$).**

These findings are comparable to those reported by **Yadav et al. (2018),** who conducted a morphometric study on **90 clavicles** at **King George's Medical University**, Lucknow, and reported a mean clavicular length of approximately **14.0 ± 1.2 cm**. Similarly, Anand et al. (**2021**) **studied 54 clavicles at IMS & SUM Hospital**, Bhubaneswar and observed only minor side-wise differences in clavicular length**. Jadhav et al. (2013),** in their study on 60 clavicles at Government Medical College, Miraj, reported mean clavicular lengths ranging between **13.5 and 14.5 cm.**[22-24]

The slightly greater length observed on the right side may be related to limb dominance and greater mechanical loading; however, the absence of

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statistical significance indicates relative bilateral symmetry. Accurate knowledge of clavicular length is important in fracture fixation, implant contouring, and reconstructive orthopedic procedures.

Midshaft Circumference

The mean midshaft circumference observed in the present study was **36.8 ± 3.2 mm** on the right side and **35.9 ± 3.1 mm** on the left side. The difference was statistically insignificant **(t = 1.25, p = 0.216).**

Comparable findings were reported by **Jadhav et al. (2013),** who observed average shaft circumferences ranging between **3.5 and 4.0 cm**. Similarly, **Nayak et al. (2025)** examined 93 clavicles at Kasturba Medical College, Manipal, and found that most morphometric parameters showed no significant side differences.[24,25]

Since the shaft is the most common site of clavicular fractures, morphometric information regarding shaft circumference is clinically valuable for implant selection, plate fixation, and intramedullary procedures. Variations may also reflect differences in muscular attachment and biomechanical stress.

Thickness at Medial End

The mean medial end thickness recorded in the present study was **22.3 ± 2.4 mm** on the right side and **21.8 ± 2.1 mm** on the left side. Statistical analysis revealed no significant difference between sides **(t = 0.98, p = 0.327).**

These observations are comparable to those of **Bala et al. (2023),** who studied approximately **100 clavicles at GSVM Medical College, Kanpur**, and reported morphological variations in the sternal end. Similar findings were also documented by **Das et al. (2016)** in their study on 144 clavicles at **Maulana Azad Medical College, New Delhi**.[26,27]

The medial end forms the sternoclavicular joint and serves as the only bony articulation between the upper limb and axial skeleton. Therefore, accurate knowledge of medial clavicular dimensions is essential for sternoclavicular joint reconstruction and fracture management.

Thickness at Lateral End

The mean lateral end thickness observed in the present study was **10.8 ± 1.3 mm** on the right side and **10.5 ± 1.2 mm** on the left side. The difference was statistically insignificant **(t = 0.83, p = 0.411).**

Similar findings were reported by **Bala et al. (2023)** and **Anand et al. (2021),** who observed only minor variations in dimensions of the acromial end.[50,53] Since the lateral end participates in the formation of the acromioclavicular joint, morphometric variations in this region may influence joint congruency and stability.

Knowledge of lateral clavicular dimensions is useful in acromioclavicular joint reconstruction, fixation of distal clavicular fractures, and design of clavicular implants.

Weight of Clavicle

The mean weight of clavicles in the present study was **18.4 ± 3.1 g** on the right side and **17.9 ± 2.9 g** on the left side. Statistical analysis demonstrated no significant bilateral difference **(t = 0.71, p = 0.482).**

Comparable observations were reported by **Ataseven et al. (2025)** in their autopsy-based morphometric and volumetric study on **86 clavicles in Turkey**, where male clavicles demonstrated greater volume and mass than female clavicles.[28] Bone weight may vary depending upon age, sex, nutritional status, physical activity, and bone density.

The assessment of bone weight contributes to anthropological and forensic investigations and provides additional information regarding skeletal robustness.

Clavicular Index

The mean clavicular index observed in the present study was **67.4 ± 5.6** on the right side and **66.8 ± 5.1** on the left side. Statistical comparison revealed no significant side difference **(t = 0.54, p = 0.593).**

These findings are similar to those reported by **Shukla et al. (2024)** and **Saxena et al. (2019),** who observed relatively stable clavicular proportions despite individual variability in size and curvature.[29,30]

The clavicular index is useful in evaluating proportional anatomy of the clavicle and may assist in anthropological studies, population comparisons, and implant development.

Shape of Clavicle

In the present study, **68 clavicles (85%)** exhibited the typical S-shaped morphology, whereas **8 (10%)** were markedly curved and **4 (5%)** were less curved. Chi-square analysis revealed no significant association

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between side and clavicular shape **(χ^2 = 0.84, p = 0.658).**

Similar observations were reported by **Saxena et al. (2019),** who examined **60 clavicles** at **AIIMS, Bhopal**, and documented considerable variation in curvature patterns. **Shukla et al. (2024)** also observed significant regional variability in clavicular curvature.[29,30]

Curvature is clinically important because it determines the fit of orthopedic plates. Improper contouring may result in implant prominence, discomfort, and fixation failure. The predominance of the typical S-shaped pattern observed in the present study is consistent with standard anatomical descriptions.

Conoid Tubercle

A prominent conoid tubercle was observed in **58 clavicles (72.5%),** moderate development in **17 clavicles (21.3%),** and poor development in **5 clavicles (6.2%).** Chi-square analysis showed no significant side-wise difference **(χ^2 = 0.42, p = 0.810).**

Similar findings were reported by **Sharma et al. (2017**) in their study on **70 clavicles at SMS Medical College, Jaipur,** where variations in the conoid tubercle were documented.[31]

The conoid tubercle provides attachment to the conoid ligament and contributes significantly to acromioclavicular joint stability. Morphological variations may influence ligament strength and surgical reconstruction outcomes.

Trapezoid Line

A well-defined trapezoid line was present in **61 clavicles (76.3%),** moderately defined in **15 clavicles (18.7%),** and poorly defined in **4 clavicles (5%).** Chi-square analysis revealed no significant bilateral difference **(χ^2 = 0.18, p = 0.914).**

Comparable observations were reported by **Sharma et al. (2017)** and **Das et al. (2016).**[27,31] The trapezoid line serves as the attachment site for the trapezoid ligament and plays an important role in maintaining shoulder stability.

Knowledge of this structure is particularly useful during shoulder surgeries and anatomical identification of ligament attachment sites.

Subclavian Groove

The subclavian groove was moderately developed in **38 clavicles (47.5%),** deep in **32 clavicles (40%),** and shallow in **10 clavicles (12.5%).** Statistical analysis demonstrated no significant side difference **(χ^2 = 0.09, p = 0.956).**

These findings are consistent with previous osteological studies that reported considerable variability in muscular attachment markings.[54,58] The groove serves as the attachment site for the subclavius muscle, and variations in groove depth may reflect differences in muscular development and functional activity.

Such anatomical information is useful in understanding musculoskeletal adaptations and interpreting skeletal remains in anthropological investigations.

Clinical and Anatomical Significance

The findings of the present study confirm that the clavicle exhibits considerable morphological and morphometric variation. Accurate knowledge of clavicular dimensions is essential for orthopedic surgeons during fracture fixation, clavicular reconstruction, implant selection, and prosthetic design. Population-specific morphometric databases facilitate the development of anatomically contoured implants and improve surgical outcomes.

From a forensic perspective, clavicular measurements are valuable in sex estimation, skeletal identification, and anthropological research. The clavicle is frequently preserved even when other skeletal elements are damaged, making it an important bone in medico-legal investigations.

Conclusion

The present osteological study was conducted on 80 adult human dry clavicles obtained from the Department of Anatomy, Pacific Institute of Medical Sciences (PIMS), Umarda, Udaipur, Rajasthan, with the aim of evaluating various morphological features and morphometric parameters of the clavicle and assessing their anatomical and clinical significance.

The study demonstrated that the mean values of all measured morphometric parameters, including maximum length, midshaft circumference, thickness at the medial end, thickness at the lateral end, weight of the clavicle, and clavicular index, were slightly greater on the right side compared to the left side.

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However, statistical analysis using the Independent Student's t-test revealed that these differences were not statistically significant ($p > 0.05$), indicating a high degree of bilateral symmetry in clavicular dimensions.

Assessment of morphological characteristics showed that the typical S-shaped clavicle was the predominant pattern observed in the study population. Variations in clavicular shape, development of the conoid tubercle, trapezoid line, and subclavian groove were also identified. Chi-square analysis demonstrated no statistically significant association between side and these morphological features, suggesting that such variations occur independently of laterality.

The findings of the present study are largely comparable with those reported in previous national and international studies, confirming that clavicular morphology and morphometry exhibit population-specific as well as individual variations while maintaining overall anatomical consistency. These variations are of considerable importance in understanding normal skeletal anatomy and its clinical applications.

The morphometric data obtained from this study may serve as a valuable reference for orthopedic surgeons during clavicular fracture fixation, implant selection, plate contouring, intramedullary fixation, and reconstructive procedures involving the shoulder girdle. Knowledge of morphological variations is also useful in improving the design and development of anatomically contoured clavicular implants and prosthetic devices.

From a forensic and anthropological perspective, clavicular measurements and morphological characteristics contribute significantly to skeletal identification, sex estimation, population studies, and medico-legal investigations. Since the clavicle is often preserved even in fragmented skeletal remains, it remains an important bone for forensic evaluation.

In conclusion, the present study highlights that adult human clavicles exhibit measurable morphometric and morphological variations; however, no statistically significant bilateral differences were observed in the parameters studied. The generated morphometric database provides valuable baseline information for anatomical research, orthopedic practice, forensic anthropology, and future population-based studies on the clavicle in the Indian population.

Ethical Issues:

Research project approved by the ethics committee of Pacific Institute of Medical Sciences Udaipur-313005, Rajasthan, INDIA

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