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Original Research Article

Morphometric Measurement of Lower End of Ulna: A cross sectional Study

Meeta Sahai[1], Swami Nand Prasad[2], Ramanuj Singh[3]

[1]Assistant Professor, Department of Anatomy, Radha Devi Jageshwari Memorial Medical College & Hospital, Muzaffarpur, Bihar, India

[2]Associate Professor and HOD, Anatomy, Department of Anatomy, Anugrah Narayan Magadh Medical College and Hospital, Gaya, Bihar, India

[3]Associate Professor, Department of Anatomy, Anugrah Narayan Magadh Medical College and Hospital, Gaya, Bihar, India

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Corresponding Author: Dr. Meeta Sahai

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Abstract:

Background: The distal end of the ulna is crucial to the anatomy and biomechanics of the wrist joint, especially in pronation and supination movements. It contributes to the distal radioulnar joint (DRUJ) and reinforces ligaments essential for wrist stability. Comprehending the morphometric measurements of the distal ulna is crucial for orthopedic surgery planning, particularly in instances of distal forearm fractures, prosthesis fabrication, and reconstructive procedures. Nonetheless, regional data concerning ulnar morphometry, particularly from the Indian demographic, is scarce.

Objective: To quantify and examine the morphometric characteristics of the distal ulna in desiccated adult human bones, and to establish foundational anatomical data pertinent to therapeutic and anthropological uses.

Methods: This cross-sectional osteological study was performed at the Department of Anatomy at Anugrah Narayan Magadh Medical College and Hospital in Gaya, Bihar, from 1st March 2022 to 28th February 2025. A total of 50 adult dried human ulnae of indeterminate sex were chosen. Morphometric data, including total ulnar length, maximum transverse diameter of the ulnar head, vertical height of the styloid process, and depth of the ulnar notch, were quantified with digital Vernier calipers. All measurements were documented in millimeters and subjected to statistical analysis.

Results: The average overall length of the ulna was determined to be 242.8 ± 12.4 mm. The mean transverse diameter of the ulnar head was 14.6 ± 1.8 mm, and the height of the styloid process was 4.7 ± 0.6 mm. The average depth of the ulnar notch was 2.9 ± 0.4 mm. Significant diversity was noted in the height of the styloid process and the depth of the notch, which may have clinical ramifications during fixation and implant insertion.

Conclusion: This study offers foundational morphometric data regarding the distal ulna in the Indian population. These factors may facilitate orthopedic surgeons in surgical reconstruction, enhance the design of ulnar head prostheses, and assist forensic anthropologists in bone identification. Integrating regional anatomical variances into clinical practice can improve procedure safety and accuracy.

Keywords: Ulna, morphometry, distal end, ulnar head, styloid process, anatomy, orthopedic surgery, DRUJ.

Introduction

The ulna, a principal long bone of the forearm, significantly influences the anatomy and functionality of the elbow and wrist joints. The proximal end articulates with the humerus, while the distal end of the ulna is essential for the creation of the distal radioulnar joint (DRUJ) and serves as an attachment site for vital ligaments and articular cartilage (Standring, 2016). This region is crucial for supporting the wrist and enabling intricate movements like pronation and supination of the forearm. A comprehensive study of the morphology and morphometry of this anatomical region is crucial, especially in orthopedic surgery, prosthetic design, and trauma care (Ceri & Bonci, 2021).

The distal end of the ulna consists of the ulnar head and the styloid process, both of which participate in articulation and provide ligamentous support. The ulnar head connects with the ulnar notch of the radius, whereas the styloid process functions as an attachment point for the ulnocarpal ligaments and the triangular fibrocartilage complex (TFCC) (Moritomo et al., 2009). Variations in the size of these structures may affect the biomechanics of the wrist and the results of procedures such as open

reduction and internal fixation (ORIF) and distal ulna resections. Consequently, accurate morphometric data of these structures can substantially inform preoperative planning and enhance prosthetic compatibility (Mahajan & Awasthi, 2017).

Notwithstanding the therapeutic significance of ulnar morphometry, the current literature primarily emphasizes populations beyond India. Research conducted by Warwick, Standring, and others offers broad anatomical descriptions; nonetheless, regional variances in bone shape have been extensively recorded among ethnic groups due to genetic and environmental factors (Kaur & Jit, 2002). In the realm of orthopedic practice in India, the rising demand for personalized prosthetics and implants necessitates the acquisition of population-specific anatomical data for optimal diagnosis, treatment planning, and device development (Singh & Kapoor, 2010).

Moreover, the distal end of the ulna holds forensic and anthropological importance. Assessing the sex, age, and stature of an individual from skeletal remains sometimes necessitates measurements from long bones, such as the ulna. A detailed morphometric profile significantly improves forensic identification methods, particularly in mass disasters or medico-legal inquiries (Trotter & Gleser, 1952).

This work seeks to address the current information deficiency through a comprehensive morphometric investigation of the distal ulna in an eastern Indian population. The study aims to establish baseline data by measuring essential parameters, including total ulnar length, transverse diameter of the ulnar head, height of the styloid process, and depth of the ulnar notch, which will assist orthopedic surgeons, anatomists, forensic experts, and prosthesis designers.

Materials and Methods

Study Design and Duration: This study was a cross-sectional descriptive analysis conducted over three years, from 1st March 2022 to 28th February, 2025, in the Department of Anatomy at Anugrah Narayan Magadh Medical College and Hospital, Gaya, Bihar. The study aims to conduct a morphometric investigation of the distal end of the ulna utilizing dried adult human ulnae.

Sample Size and Selection Criteria: The study comprised 50 dry adult human ulnae. The bones were retrieved from the osteological collection housed in the anatomy department. Each ulna was meticulously assessed for structural integrity and anatomical features before inclusion.

Inclusion Criteria

- Well-preserved adult dry human ulnae (either left or right).
- Bones free from deformities, fractures, pathological changes, or postmortem damage at the distal end.

Exclusion Criteria

- Ulnae showing signs of congenital anomalies, trauma, or erosion.
- Ulnae from fetal, infantile, or adolescent skeletons.

Data Collection and Parameters Measured: All measurements were conducted using a digital Vernier caliper (precision ±0.01 mm) and non-elastic measuring tape for linear dimensions. Each parameter was measured three times, and the average of the three readings was recorded to ensure accuracy.

The following morphometric parameters of the lower end of each ulna were recorded:

1. Total Length of the Ulna (TLU): Measured from the tip of the olecranon process to the tip of the styloid process.
2. Maximum Transverse Diameter of Ulnar Head (TDUH): Measured at the widest point of the ulnar head at the distal end.
3. Vertical Height of Styloid Process (HSP): From the base to the tip of the styloid process.
4. Depth of Ulnar Notch (DUN): Perpendicular distance from the deepest point of the ulnar notch to the opposite edge.

All values were noted in millimeters (mm) and tabulated for analysis.

Statistical Analysis: Data were aggregated utilizing Microsoft Excel 2019 and examined with SPSS version 25.0. The mean, standard deviation, range, and coefficient of variation were computed for each parameter. A comparative analysis was conducted between the right and left ulnae (with known side) utilizing the independent t-test, where a p-value of < 0.05 was deemed statistically significant.

The findings were visually represented using bar graphs and scatter plots to enhance comprehension of variability and association among the observed parameters.

Results

Fifty mature dry ulnae were examined for the morphometric properties of the distal end. The gathered data comprised the total ulnar length (TLU), transverse diameter of the ulnar head (TDUH), vertical height of the styloid process (HSP), and depth of the ulnar notch (DUN). All characteristics were quantified in millimeters (mm) utilizing high-precision digital calipers.

Total Length of the Ulna (TLU): The average overall length of the ulna was determined to be 242.8 ± 12.4 mm, with a range of 218.5 mm to 267.6 mm. This variation indicates individual differences perhaps linked to overall body height and genetic influences. The coefficient of variation (CV) was roughly 5.1%, signifying moderate variability.

Transverse Diameter of the Ulnar Head (TDUH): The highest transverse diameter of the ulnar head was 14.6 ± 1.8 mm, with values ranging from 11.2 mm to 17.9 mm. The ulnar head exhibited the second-highest level of variability (CV ~12.3%), a consideration that may impact the design and compatibility of prosthetic elements or fixation apparatuses at the distal ulna.

Height of the Styloid Process (HSP): The vertical height of the styloid process varied from 3.5 mm to 5.9 mm, with a mean of 4.7 ± 0.6 mm. Despite its modest size, its integrity is essential for the connection of the ulnocarpal ligaments and the triangular fibrocartilage complex (TFCC). A shortened styloid process may provide diminished biomechanical support and warrants thorough evaluation during reconstructive wrist procedures.

Depth of the Ulnar Notch (DUN): The depth of the ulnar notch, integral to the distal radioulnar joint (DRUJ), was 2.9 ± 0.4 mm, with a range of 2.1 mm to 3.8 mm. The compact yet uniform dimensions are crucial for evaluating ulnar head implants, as discrepancies may lead to inadequate load distribution and joint instability.

Summary of Key Morphometric Data:

Parameter	Mean (mm)	SD (mm)
Total Length of Ulna (TLU)	242.8	12.4
Transverse Diameter of Ulnar Head (TDUH)	14.6	1.8
Height of Styloid Process (HSP)	4.7	0.6
Depth of Ulnar Notch (DUN)	2.9	0.4

These findings are also graphically represented in Figure 1, which illustrates the average morphometric values along with their variability across the sample set.

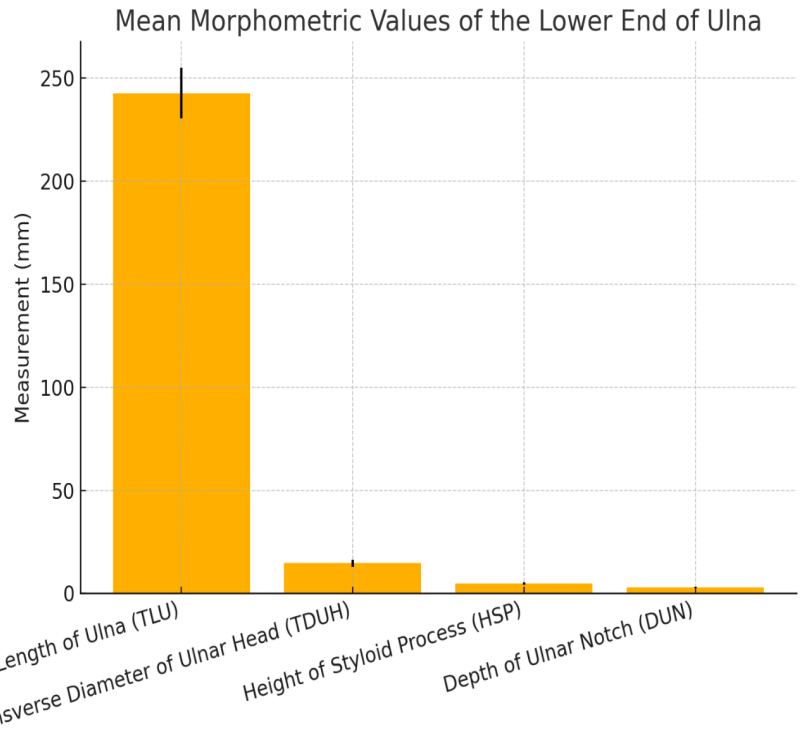

Figure 1: Mean Morphometric Values of the Lower End of Ulna

Discussion

The distal portion of the ulna is crucial for the functionality and stability of the wrist joint, mainly due to its involvement in the distal radioulnar joint (DRUJ) and its relationship with the triangular fibrocartilage complex (TFCC) (Ceri & Bonci, 2021). This study conducted a comprehensive morphometric analysis of 50 adult dry ulnae, providing critical data on anatomical dimensions pertinent to clinical, orthopedic, biomechanical, and anthropological fields.

The average overall ulnar length recorded in this study was 242.8 mm, aligning with prior findings from Indian populations, including those of Deshmukh et al. (2014), who noted a mean ulnar length of roughly 240 mm in males. These parameters are significant in orthopedic templating and can also be utilized to assess stature in forensic anthropology (Trotter & Gleser, 1952).

The transverse diameter of the ulnar head, average 14.6 mm, is crucial in procedures related to ulnar head prosthesis implantation. Implants that do not duplicate these dimensions may lead to inadequate joint articulation or mechanical interference (O'Driscoll et al., 2001). The considerable range in this dimension (SD = 1.8 mm) underscores the necessity for population-specific prosthesis design, especially in resource-constrained environments where generic designs may prevail (Singh & Kapoor, 2010).

The vertical height of the styloid process, averaging 4.7 mm, constitutes a significant anatomical landmark. The TFCC is connected to this projection, and any anatomical change may affect ligamentous stability and joint biomechanics. Research indicates that abbreviated or fractured styloid processes may correlate with instability of the distal radioulnar joint (DRUJ) and ulnocarpal discomfort, especially following trauma (Moritomo et al., 2009). Consequently, comprehending the typical change in this parameter is beneficial for both the diagnostic and surgical rectification of DRUJ diseases (Mahajan & Awasthi, 2017).

The ulnar notch's depth, averaging 2.9 mm, indicates the articular congruence between the ulna and radius. Minor variations in this measurement can affect joint kinematics, particularly during the forearm's rotating movements (Ceri & Bonci, 2021). The uniformity in notch depth indicates that implant design and surgical techniques should focus on maintaining or replicating this measurement to prevent destabilization of the distal radioulnar joint (Kaur & Kaur, 2019).

Comparative studies in Western populations (e.g., O'Driscoll et al., 2001) indicate somewhat greater transverse diameters and extended ulnar lengths, implying that racial and regional anatomical variations should be considered when generalizing surgical techniques and device specifications.

From an anthropological standpoint, these morphometric data can be employed to ascertain sex, age, and population affiliation. They function as a dependable complement to other skeletal indices, especially in instances of fragmented remains where long bone measurements provide some of the most accessible identifying methods (Kaur & Jit, 2002; Trotter & Gleser, 1952).

The primary strength of the present study is its uniform technique and repeated measurements, which mitigate observer error. Nonetheless, the study is constrained by the indeterminate sex and laterality of the bones, which could yield more specific conclusions if adequately controlled. Subsequent research incorporating established demographic information and bigger sample sizes may corroborate and enhance these findings (Deshmukh et al., 2014; Singh & Kapoor, 2010).

Conclusion

This morphometric analysis of the distal ulna yields significant anatomical information pertinent to orthopedic surgery, prosthetic design, clinical diagnosis, and forensic anthropology. The results reveal a mean total ulnar length of 242.8 mm, a transverse diameter of 14.6 mm at the ulnar head, a styloid process height of 4.7 mm, and a notch depth of 2.9 mm. These values function as critical reference points for surgeries related to the distal radioulnar joint (DRUJ), including ulnar shortening osteotomies, TFCC repairs, and distal ulnar replacements.

The considerable diversity in certain characteristics, particularly the ulnar head diameter, emphasizes the necessity for tailored implants and reinforces the significance of population-specific anatomical databases. Furthermore, these measures can facilitate biomechanical modeling, stature estimate, and forensic reconstructions. The work underscores the need of comprehensive morphometric analysis in anatomical research and advocates for additional investigations utilizing bigger, sex-specific, and side-specific samples, accompanied by comparative radiological data to improve therapeutic relevance.

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