

Title: Morphometric Analysis of the Radial Head in the Indian Population: Anatomical Variations and Surgical Relevance

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Abstract

Background: The radial head plays a critical role in elbow joint stability and forearm rotation. Despite this, existing prostheses are often designed without consideration of population-specific anatomical differences, particularly in the Indian population.

Objective: To determine and compare radial head morphometric parameters between the right and left sides in the Indian population, thereby providing a reference for prosthesis design and surgical planning.

Methods: This cross-sectional study was conducted on 100 adult dry human radius bones (50 right and 50 left) of unknown age and sex. Radial head measurements included anteroposterior diameter (APD), transverse diameter (TD), medial height (MH), and lateral height (LH), taken using digital Vernier calipers. The shape of the radial head was also classified. Statistical analysis was performed using Student's t-test in SPSS version 20.

Results: The mean APD was 20.44 ± 2.19 mm (right) and 20.85 ± 1.96 mm (left). TD averaged 19.73 ± 1.98 mm (right) and 20.24 ± 2.10 mm (left). MH was 9.54 ± 1.35 mm (right) and 9.67 ± 1.22 mm (left). LH measured 7.65 ± 1.42 mm (right) and 7.76 ± 1.53 mm (left). A borderline

statistical difference was observed in TD ($p = 0.0556$); other parameters showed no significant variation.

Conclusion: The morphometric data of the radial head observed in this study can serve as an essential anatomical reference for designing population-specific radial head prostheses and improving surgical outcomes in elbow injuries.

Keywords: Radial head, morphometry, Indian population, prosthesis design, elbow anatomy

Introduction The radial head is a key component of the elbow joint, contributing significantly to load transmission, rotational movement, and joint stability. Accurate knowledge of radial head anatomy is indispensable in the management of elbow fractures and dislocations, particularly for prosthesis design and reconstruction.

Most available radial head prostheses are based on Western morphometric data, which may not be ideal for the Indian population due to anatomical variations. A mismatch between implant and native bone anatomy can compromise joint mechanics and surgical outcomes. Hence, region-specific morphometric analysis is crucial.

This study investigates radial head dimensions in the Indian population to bridge this gap and provide data relevant for implant manufacturing and clinical practice.

Materials and Methods

Study Design and Sample: A total of 100 adult dry radius bones (50 right, 50 left) were obtained from anatomy departments of three medical institutions in India. Bones with deformities, fractures, or pathological signs were excluded.

Measurements: Measurements were taken using a digital Vernier caliper (accuracy: 0.01 mm).

Parameters measured included: - Anteroposterior Diameter (APD): Maximum AP diameter of the radial head - Transverse Diameter (TD): Maximum medial-lateral diameter - Medial Height (MH): Distance from radial lip to the medial neck junction - Lateral Height (LH): Distance from radial lip to the lateral neck junction

Each measurement was taken twice, and the average value was recorded.

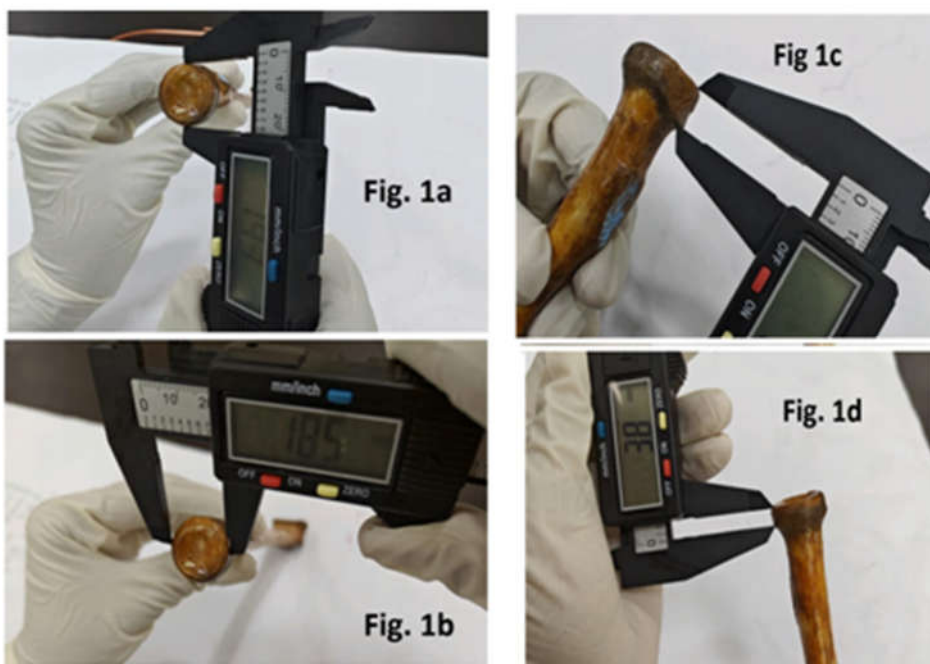
Shape Classification: Each radial head was classified as circular or elliptical based on visual and dimensional assessment.

Statistical Analysis: Data were analyzed using SPSS version 20. Mean and standard deviation were calculated. Differences between right and left sides were analyzed using Student's unpaired t-test. A p-value < 0.05 was considered statistically significant.

Results

The study's findings revealed APD on the right side ranged from a minimum of 14.4 to a maximum of 24.72, while on the left side showed a range from 16.62 to 24.94. TD ranged from 14.58 to 23.74 on the right side and from 16.65 to 24.61, on the left. MH on the right side ranged from 6.3 to 13.1 while on the left side showed a range from 7.79 to 12.1. LH on the right side ranged from 5.36 to 12.1, and on the left side from 5.69 to 13.1. The mean, maximum and minimum values of all parameters are shown in Table 1. The present study revealed a potential significance ($p = 0.0556$) in TD between the right and left sides, whereas APD, MH, and LH displayed none.

Descriptive Statistics:



Figures 1a and b : showing the method of measuring Maximum diameter of the radial head in anteroposterior and transverse plane respectively.

Figures 1c and d: showing method of measuring medial and lateral heights of the radial head respectively

PARAMETER	SIDE	NO.	MIN.	MAX.	MEAN
AP DIAMETER	Right	50	14.4	24.72	20.44
AP DIAMETER	Left	50	16.62	24.94	20.85
TRANSVERSE DIAMETER	Right	50	14.58	23.74	19.73
TRANSVERSE DIAMETER	Left	50	16.65	24.61	20.24
MEDIAL HEIGHT	Right	50	6.3	13.1	9.54
MEDIAL HEIGHT	Left	50	7.79	12.1	9.67
LATERAL HEIGHT	Right	50	5.36	12.1	7.65
LATERAL HEIGHT	Left	50	5.69	13.1	7.76

Table 1: The mean, maximum and minimum values of all parameters measured are shown

Discussion

Comparative analysis with prior Indian studies highlighted similarities and minor differences in various parameters, showcasing the consistency of some measurements and minor variations in others. Our findings are comparable to earlier Indian studies. For instance, Gupta et al. (2015) and Shastry et al. (2018) reported similar APD and TD values, supporting the reliability of our data. The borderline difference in TD suggests mild asymmetry, possibly influenced by handedness or biomechanical forces.

The clinical implications of these findings are significant. In surgical reconstruction or prosthesis replacement following radial head fractures, using anatomically accurate, population-specific data minimizes complications such as joint instability, limited range of motion, and early implant failure. Moreover, these measurements can assist surgeons in preoperative planning and intraoperative decisions.

Advanced 3D imaging modalities such as CT scanning and 3D surface reconstruction could further enhance the understanding of radial head geometry. Integrating morphometric data from dry bones with 3D reconstructions in living individuals will help in designing custom implants through computer-aided modeling and additive manufacturing technologies. This is particularly important in cases requiring patient-specific solutions, such as complex trauma or revision surgeries.

Our study underscores the necessity of incorporating such morphometric data into modern implant design and orthopedic education. By tailoring prosthetic dimensions to regional anatomical patterns, surgical outcomes can be optimized, and the longevity of implants improved.

The limitations of our study include lack of age and sex differentiation and reliance on dry bones. Future research should incorporate imaging techniques and demographic correlation.

Conclusion The morphometric data obtained in this study provide vital insights into the radial head anatomy of the Indian population. These measurements can guide the development of more anatomically accurate and population-specific prosthetic implants, ultimately improving clinical outcomes.

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