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Original Research Article

A Morphometric Study of Proximal End of Dry Adult Femur in Western Rajasthan

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Abstract

Introduction: The femur is the longest and strongest bone of the human body and plays a vital role in weight transmission and locomotion. Morphometric analysis of the proximal end of the femur is essential for orthopedic implant design, fracture fixation, and forensic identification. Regional anatomical variations necessitate population-specific data.

Objectives: To determine the mean morphometric parameters of the proximal end of dry adult femur in Western Rajasthan.

Methods: A cross-sectional observational study was conducted on 50 dry adult human femora (25 right and 25 left) available in the Department of Anatomy, Government Medical College, Pali, after ethical approval from the Institutional Ethics Committee. Fully ossified and undamaged femora were included. Parameters measured were femoral head diameter, femoral neck diameter, femoral neck length, femoral neck thickness, foveal pit depth, foveal longitudinal diameter, foveal transverse diameter, neck–shaft angle, intertrochanteric line length, and total femoral length. Measurements were taken using digital vernier calipers, osteometric board, and goniometer. Data were analyzed using statistical package for social science (SPSS) software, version 24.0, IBM Inc. Chicago, USA.

Results: The mean femoral head diameter was 42.48 ± 3.63 mm and femoral neck diameter was 32.94 ± 3.77 mm. femoral neck length measured 39.11 ± 6.64 mm and neck thickness was 32.15 ± 3.62 mm. The mean neck–shaft angle was 122.78 ± 10.81°. Intertrochanteric line length was 52.53 ± 6.02 mm, and total femoral length was 42.73 ± 2.73 cm.

Conclusion: The present study provides baseline morphometric data of the proximal femur in the Western Rajasthan population. These findings are useful for orthopedic surgical planning, prosthesis design, anthropological studies, and forensic applications.

Keywords: Proximal femur, morphometry, neck-shaft angle, fovea capitis, intertrochanteric line, dry bone study.

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Introduction

The femur is the longest, strongest, and heaviest bone of the human body and forms the skeletal framework of the thigh. Proximally, it articulates with the acetabulum to form the hip joint and distally with the tibia and patella to form the knee joint.[1,2] Due to its biomechanical significance in weight transmission and locomotion, the femur is of immense importance to anatomists, orthopedic surgeons, anthropologists, and forensic experts.[3]

The proximal end of the femur comprises the head, neck, greater and lesser trochanters, intertrochanteric line, and intertrochanteric crest. The femoral head is spherical and articulates with the acetabulum, while the neck connects the head to the shaft and forms the neck–shaft angle. Variations in these morphometric parameters influence hip stability, range of motion, and stress distribution across the joint.[3,4] Morphometric analysis involves quantitative measurement of anatomical structures. Proximal femoral morphometry varies according to sex, ethnicity, nutrition, and geographic region. [5]Such variations are clinically significant in total hip arthroplasty, fracture fixation, and prosthesis design. Implants that do not match the native anatomy may result in implant loosening, abnormal stress distribution, or reduced functional outcomes.[6,7]

Apart from clinical relevance, proximal femoral measurements aid in forensic identification and anthropological research. Correlation of proximal parameters with total femoral length can help reconstruct fragmentary skeletal remains.[8,9] Despite several studies across India, region-specific data from Western Rajasthan remain limited. The present study was undertaken to generate baseline morphometric data for this population

Aim and Objectives

Aim: To study the morphometric parameters of the proximal end of dry adult femur in Western Rajasthan

Objectives: To determine mean femoral head diameter, femoral neck diameter, femoral neck length, femoral neck thickness, foveal pit depth, foveal longitudinal diameter, foveal transverse diameter, neck–shaft angle, intertrochanteric line length, and total femoral length.

Materials and Methods

Study design and setting: cross-sectional observational study.

Study Duration: 6 months after getting approval from ethical committee.

Study Population: The study population comprised Dry adult human femora available in the department during the study period.

Inclusion Criteria

1. fully ossified dry adult femora
2. Femora that were free from visible damage or deformity
3. Both right and left femora were included.

Exclusion Criteria

1. Bones showing gross deformity, fracture, or pathological changes were excluded.
2. Specimens that were incomplete or damaged and unsuitable for accurate measurement were not included.

Sampling Method: Non-probability convenience sampling

Study Tool: A predesigned and pretested semi-structured proforma was used to record the specimen identification number, side of the femur (right/left), and all measured morphometric parameters including femoral head diameter, femoral neck diameter, femoral neck length, femoral neck thickness, foveal pit depth, foveal longitudinal diameter, foveal transverse diameter, neck–shaft angle, intertrochanteric line length, and total femoral length.

Procedure of Sampling and Data Collection: Each femur was assigned a unique identification number, and the side (right or left) was determined based on standard anatomical landmarks. All measurements were performed three times to minimize observer bias, and the mean value was recorded.

The bones were placed on a stable flat surface during measurement. Curved and straight parameters were carefully assessed to ensure accuracy. Special care was taken to avoid damage to the specimens during handling.

Instruments Used

- Digital Vernier Caliper (accuracy ±0.01 mm): For linear measurements including femoral head and neck diameters.
- Osteometric Board: To measure total femoral length.
- Goniometer: To measure neck–shaft angle.
- Measuring Tape / Colored Thread: For curved measurements such as intertrochanteric line length and other non-linear distances.

Parameters Studied

1. Femoral Head Diameter – Maximum transverse and anteroposterior diameter of the femoral head.
2. Femoral Neck Diameter – Maximum transverse diameter at the mid-neck region.
3. Femoral Neck Length – Distance from the base of the femoral head to the junction with the shaft.
4. Femoral Neck Thickness – Anteroposterior thickness at the narrowest point of the neck.
5. Foveal Pit Depth – Vertical depth of fovea capitis femoris.
6. Foveal Longitudinal Diameter – Maximum longitudinal length of fovea capitis femoris.
7. Foveal Transverse Diameter – Maximum transverse width of fovea capitis femoris.
8. Neck–Shaft Angle – Angle between the longitudinal axis of the neck and the shaft of the femur.
9. Intertrochanteric Line Length – Linear distance along the intertrochanteric line from greater to lesser trochanter.
10. Total Femoral Length – Distance from the highest point of the femoral head to the distal end of the medial condyle.

All recorded values were documented systematically in a predesigned proforma for further statistical analysis.

Ethics: Prior ethical approval was obtained from the Institutional Ethics Committee before the commencement of the study.

Data analysis: The data from filled schedules was entered into Microsoft Excel which further was analysed using statistical package for social science (SPSS) software, version 24.00 (trial version) ,

IBM Inc. Chicago, USA. Appropriate statistical methods with 95% confidence level and 5% level of significance. A p-value < 0.05 was considered statistically significant.

Table 1: Descriptive Statistics of Femoral Parameters

Parameter	Side	N	Mean	SD	Total (Mean ± SD)
Femoral Neck Diameter (mm)	Left	25	33.00	4.008	32.94 ± 3.77
	Right	25	32.88	3.517	
Femoral Head Diameter (mm)	Left	25	42.97	3.616	42.48 ± 3.63
	Right	25	41.98	3.632	
Foveal Pit Depth (mm)	Left	25	2.56	1.027	2.50 ± 0.99
	Right	25	2.43	0.949	
Foveal Longitudinal Diameter (mm)	Left	25	14.05	2.282	13.99 ± 2.42
	Right	25	13.92	2.557	
Foveal Transverse Diameter (mm)	Left	25	15.65	2.333	15.76 ± 2.56
	Right	25	15.86	2.782	
Femoral Neck Length (mm)	Left	25	37.46	6.533	39.11 ± 6.64
	Right	25	40.75	6.743	
Femoral Neck Thickness (mm)	Left	25	32.63	3.657	32.15 ± 3.62
	Right	25	31.66	3.588	
Femoral Neck–Shaft Angle (°)	Left	25	125.76	10.872	122.78 ± 10.81
	Right	25	119.80	10.751	
Intertrochanteric Line (mm)	Left	25	52.96	6.302	52.53 ± 6.02
	Right	25	52.09	5.736	
Femoral Length (cm)	Left	25	43.24	2.354	42.73 ± 2.73
	Right	25	42.21	3.084	

Result

A total of 50 dry adult femora (25 right and 25 left) were included in the study. The mean femoral neck diameter was 33.00 ± 4.01 mm on the left side and 32.88 ± 3.52 mm on the right side, with a combined mean of 32.94 ± 3.77 mm. The femoral head diameter measured 42.97 ± 3.62 mm on the left and 41.98 ± 3.63 mm on the right, resulting in a combined mean of 42.48 ± 3.63 mm. The mean foveal pit depth was 2.56 ± 1.03 mm on the left and 2.43 ± 0.95 mm on the right, yielding an overall mean of 2.50 ± 0.99 mm. The foveal longitudinal diameter was 14.05 ± 2.28 mm on the left side and 13.92 ± 2.56 mm on the right, with a combined mean of 13.99 ± 2.42 mm. The foveal transverse diameter was 15.65 ± 2.33 mm on the left and 15.86 ± 2.78 mm on the right, resulting in a combined mean of 15.76 ± 2.56 mm.

Regarding femoral neck length, the mean length was greater on the right side (40.75 ± 6.74 mm) compared to the left (37.46 ± 6.53 mm), with a total mean of 39.11 ± 6.64 mm.

The mean femoral neck thickness was slightly higher on the left side (32.63 ± 3.66 mm) than on the right (31.66 ± 3.59 mm), yielding an overall mean of 32.15 ± 3.62 mm. The femoral neck-shaft angle was 125.76 ± 10.87° on the left and 119.80 ± 10.75° on the right, with a combined mean of 122.78 ± 10.81°. The intertrochanteric line length was 52.96 ± 6.30 mm on the left side and 52.09 ± 5.74 mm on the right, resulting in a combined mean of 52.53 ± 6.02 mm. The total femoral length was 43.24 ± 2.35 cm on the left and 42.21 ± 3.08 cm on the right, with a total mean of 42.73 ± 2.73 cm.

Discussion

In the present study, the mean femoral length was 42.73 ± 2.73 cm, which is comparable to the findings of Gupta et al. (42.11 ± 2.91 cm)[10] and consistent with the data from Kulkarni et al. (41.95 ± 2.85 cm) and Verma et al. (42.21 ± 3.12 cm)[11,12], suggesting similar femoral dimensions across different regions of India. This consistency in femoral length is important for understanding the general anatomical characteristics of the Indian population. The femoral neck length was found to be greater on the right side (40.75 ± 6.74 mm) compared to the left (37.46 ± 6.53 mm), which aligns with regional studies that have reported variations in neck length, such as those by Chaudhary et al. (28.8 ± 2.85 mm on the right and 28.8 ± 4.0 mm on the left) in Karnataka and Sundar et al. (28.8 mm and 31.8 mm) in Tamil Nadu[11,12]. This variation in femoral neck length may reflect regional anatomical differences.

The femoral neck–shaft angle in our study averaged 125.76° ± 10.87° on the left and 119.80° ± 10.75° on the right, which is slightly lower than the values reported by Skaria et al. (128.55° ± 6.99°)[13]. The difference in neck–shaft angle could be due to population-specific variations, which may influence hip biomechanics, particularly in terms of joint stability and movement. Such variations are crucial to consider when designing orthopedic implants and prostheses.

The femoral head diameter in this study was 42.48 ± 3.63 mm (combined mean), which is similar to findings by Prasath RA and Ismail BM in South Indian populations (41.98 ± 1.98 mm)[14]. This demonstrates that there is minimal regional difference in femoral head size, which is significant for ensuring that prosthetic components, such as femoral heads in hip replacements, match native anatomy to ensure better functional outcomes.

The femoral neck diameter was measured at 33.00 ± 4.01 mm on the left and 32.88 ± 3.52 mm on the right, while the femoral neck thickness was 32.63 ± 3.66 mm on the left and 31.66 ± 3.59 mm on the right. These values indicate that there is a slight asymmetry between the left and right sides, particularly with respect to neck thickness. These measurements are essential for the design of orthopedic implants, as a precise fit for the femoral neck is crucial in hip replacement surgery. The femoral neck–shaft angle, which averaged 122.78 ± 10.81°, is another important parameter in determining the correct alignment of the implant.

The intertrochanteric line length, measured at 52.96 ± 6.30 mm on the left and 52.09 ± 5.74 mm on the right, was similar on both sides, confirming the relative symmetry of this anatomical feature. This parameter plays a critical role in the alignment of hip prostheses and can be a useful reference in reconstructive surgeries.

These findings demonstrate significant morphometric variations in the proximal femur of the population in Western Rajasthan. The findings are crucial for orthopedic implant design, hip arthroplasty, and anthropometric studies, especially given that femoral parameters such as neck length, head diameter, and neck-shaft angle can directly impact the success of surgical interventions. Additionally, understanding these variations can aid in forensic identification and anthropological research, providing a valuable reference for reconstructing femoral morphology from fragmentary skeletal remains.

Strength and Limitations: The strengths lie in its comprehensive morphometric analysis of both right and left femora, covering key parameters such as femoral head diameter, neck dimensions, neck length, foveal features, and total femoral length.

However, the study's limitations include its single-center design, small sample size, and the absence of demographic data (age, sex, body size), which may affect generalizability. Additionally, functional or radiological correlations were not explored due to the cadaveric nature of the specimens. Future studies with larger, multicentric samples and inclusion of demographic and clinical data are warranted to validate and expand upon these findings.

Conclusion

This study demonstrates significant variability in proximal femoral morphometry among adults from Western Rajasthan. Parameters such as femoral neck diameter, head diameter, neck length, neck–shaft angle, and intertrochanteric line length exhibit bilateral differences. These findings provide important reference data for orthopedic surgeons, anatomists, prosthesis designers, and forensic experts, emphasizing the need to consider population-specific anatomical variations in surgical planning, implant design, and anthropological or forensic reconstructions.

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