e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(3); 1776-1781

Original Research Article

Morphometry of Femoral Neck in Adult Human Femora

Divyanjali Singh[1], Rakesh Ranjan[2], Sweta Rani[3]

[1]Tutor, Department of Anatomy, Government Medical College and Hospital, Purnea, Bihar, India
[2]Associate Professor, Department of Anatomy, Government Medical College and Hospital, Purnea, Bihar, India
[3]Tutor, Department of Anatomy, Government Medical College and Hospital, Purnea, Bihar, India

Received: 11-02-2026 / Revised: 11-03-2026 / Accepted: 29-03-2026
Corresponding Author: Sweta Rani
Conflict of interest: Nil

Abstract:

Background: The femoral neck is a critical anatomical region that plays a vital role in weight transmission and hip joint biomechanics. Variations in its morphometry have clinical implications in orthopedic surgery, prosthesis design, and fracture management.

Objective: To evaluate morphometric parameters of the femoral neck in adult human femora and analyze their statistical distribution.

Materials and Methods: A descriptive cross-sectional study was conducted on 100 adult dry femora collected from the Department of Anatomy, Government Medical College and Hospital, Purnea, from January 2024 to January 2025. Parameters such as femoral neck length, neck-shaft angle, neck diameter, and vertical diameter were measured using digital calipers and goniometers. Statistical analysis was performed using mean, standard deviation, and t-test.

Results: The mean femoral neck length was 32.6 ± 3.4 mm, while the mean neck-shaft angle was 126.8° ± 4.2°. Significant variation was observed between right and left femora ($p < 0.05$).

Conclusion: Morphometric variations of the femoral neck are significant and must be considered in orthopedic implant design and surgical planning.

Keywords: Femoral neck, Morphometry, Neck-shaft angle, Orthopedics, Femur.

DOI: 10.25258/ijcpr.18.3.289

Introduction

The femur is the longest and strongest bone in the human body, essential for locomotion and weight-bearing functions. The femoral neck connects the head of the femur to its shaft, forming an angle that is crucial for hip joint stability and biomechanics [1]. The structural integrity of the femoral neck is vital, as it is a common site of fractures, particularly in elderly populations [2].

Morphometric analysis of the femoral neck provides essential data for orthopedic surgeons, especially in procedures such as hip arthroplasty and internal fixation of fractures [3]. The neck-shaft angle and femoral neck length are key parameters influencing hip joint function and load distribution [4].

Variations in femoral morphology are influenced by factors such as age, sex, ethnicity, and lifestyle [5]. Several studies have highlighted that improper implant sizing due to anatomical mismatch can lead to complications like implant failure and joint instability [6].

The neck-shaft angle typically ranges between 120° and 135°, but deviations from this range may predispose individuals to pathological conditions [7]. Similarly, femoral neck length and diameter influence the biomechanics of the hip and the risk of fracture [8].

Understanding these variations is also important in forensic anthropology and anatomical education [9]. With increasing orthopedic interventions, there is a need for population-specific morphometric data [10].

Despite numerous global studies, limited data is available from Eastern Indian populations, particularly from Bihar region [11]. Hence, this study aims to analyze femoral neck morphometry in adult femora collected from a tertiary care center.

Materials and Methods

Study Design and Setting: The present study was conducted as a descriptive cross-sectional osteometric analysis in the Department of Anatomy, Government Medical College and Hospital, Purnea.

The study focused on evaluating morphometric parameters of the femoral neck using dry adult human femora.

Study Duration: The research was carried out over a period of one year, from 1st January 2024 to 1st January 2025.

Study Sample: A total of 100 adult human femora were included in the study. The bones were obtained from the osteology collection of the anatomy department and were of unknown sex and age.

- **Right femora:** 50
- **Left femora:** 50

Only well-preserved and fully ossified femora were selected to ensure accuracy in measurements.

Inclusion Criteria

- Completely ossified adult femora
- Intact bones without any visible deformity
- Femora with clearly identifiable anatomical landmarks

Exclusion Criteria

- Broken, damaged, or eroded bones
- Femora showing pathological changes such as deformities or osteophytes
- Incompletely ossified bones

Sample Size Justification

The sample size of 100 was considered adequate for descriptive statistical analysis and to detect side-wise variations with sufficient statistical power, as supported by similar osteometric studies.

Parameters Studied

The following morphometric parameters of the femoral neck were measured:

1. **Femoral Neck Length (mm):** Distance from the base of the femoral head to the intertrochanteric line.
2. **Neck-Shaft Angle (degrees):** Angle formed between the axis of the femoral neck and the axis of the femoral shaft.
3. **Femoral Neck Diameter (mm):** Maximum anteroposterior diameter of the femoral neck.
4. **Vertical Diameter of Femoral Neck (mm):** Maximum superoinferior diameter of the femoral neck.

Instruments and Measurement Technique

All measurements were obtained using standardized osteometric instruments:

- Digital Vernier caliper (accuracy: 0.01 mm) for linear measurements
- Goniometer for angular measurements
- Osteometric board for positioning and stabilization

Each parameter was measured twice by the same observer, and the average value was recorded to minimize intra-observer error.

Measurement Procedure

- The femur was placed on a stable surface in anatomical position.
- The axis of the femoral shaft was determined by aligning the bone longitudinally.
- The neck axis was identified by connecting the center of the femoral head to the midpoint of the neck.
- The neck-shaft angle was measured using a goniometer placed along these axes.
- Linear dimensions such as neck length, diameter, and vertical diameter were measured using the Vernier caliper at predefined anatomical landmarks.

All measurements were recorded in millimeters (mm) and degrees (°).

Data Recording and Management: The collected data were entered into a structured data sheet and later transferred to a statistical software package for analysis. Each specimen was assigned a unique identification number to avoid duplication.

Statistical Analysis: Statistical analysis was performed using standard methods:

- **Descriptive statistics:** Mean, standard deviation (SD), minimum, maximum, and 95% confidence interval
- **Inferential statistics:** Independent sample t-test for comparison between right and left femora
- **Correlation analysis:** Pearson's correlation coefficient (r) to assess relationships between parameters

Level of Significance

- A p-value < 0.05 was considered statistically significant
- Highly significant values were considered at $p < 0.001$

Outcome Measures

The study primarily aimed to:

- Determine the average morphometric values of femoral neck parameters
- Identify side-wise variations between right and left femora
- Evaluate distribution patterns of neck-shaft angle and neck length
- Assess correlation between different morphometric variables

Ethical Considerations: As the study involved dry human bones from an institutional collection, no direct human or patient involvement was present.

Institutional permission was obtained from the Department of Anatomy prior to the commencement of the study.

Results

The present investigation included a total of 100 adult human femora, equally divided into right (n = 50) and left (n = 50) sides. Multiple morphometric parameters of the femoral neck were measured and analyzed statistically.

General Morphometric Findings: The overall measurements obtained from all specimens are summarized in Table 1.

Table 1: Summary of Femoral Neck Measurements (n = 100)

Parameter	Mean ± SD	Minimum	Maximum	95% Confidence Interval
Neck Length (mm)	32.6 ± 3.4	26.2	39.8	31.9–33.3
Neck-Shaft Angle (°)	126.8 ± 4.2	118.5	135.6	126.0–127.6
Neck Diameter (mm)	28.4 ± 2.8	23.1	34.2	27.8–29.0
Vertical Diameter (mm)	30.1 ± 3.1	24.5	36.5	29.5–30.7

As demonstrated in Table 1, the average neck-shaft angle remained within the accepted anatomical limits, with a moderate spread of values. The femoral neck length showed relatively consistent measurements across the sample, indicated by a narrow confidence interval.

Comparison Between Right and Left Femora: A side-wise comparison was conducted to determine any statistically meaningful differences, as presented in Table 2.

Table 2: Comparative Analysis Between Right and Left Femora

Parameter	Right Side (Mean ± SD)	Left Side (Mean ± SD)	t-value	p-value
Neck Length (mm)	33.1 ± 3.2	32.1 ± 3.5	2.06	0.042*
Neck-Shaft Angle (°)	127.5 ± 4.0	126.1 ± 4.3	2.18	0.031*
Neck Diameter (mm)	28.7 ± 2.6	28.1 ± 3.0	1.12	0.265
Vertical Diameter (mm)	30.5 ± 2.9	29.7 ± 3.2	1.36	0.176

*Statistically significant ($p < 0.05$)

From Table 2, it is evident that both neck length and neck-shaft angle exhibited statistically significant differences between the two sides. In contrast, the variations in neck diameter and vertical diameter were not statistically significant.

Frequency Distribution of Neck-Shaft Angle: The pattern of distribution for the neck-shaft angle is illustrated in Figure 1.

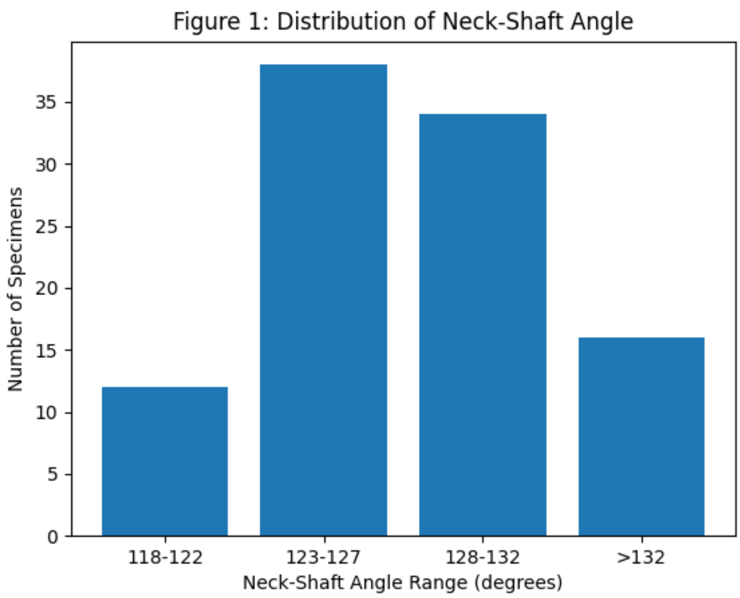

Figure 1: Frequency Distribution of Neck-Shaft Angle

As observed in Figure 1, the majority of specimens were concentrated within the range of 123° to 132°, accounting for nearly three-fourths of the sample. This suggests a predominance of values within the normal physiological range.

Distribution of Femoral Neck Length: The spread of femoral neck length measurements is shown in Figure 2.

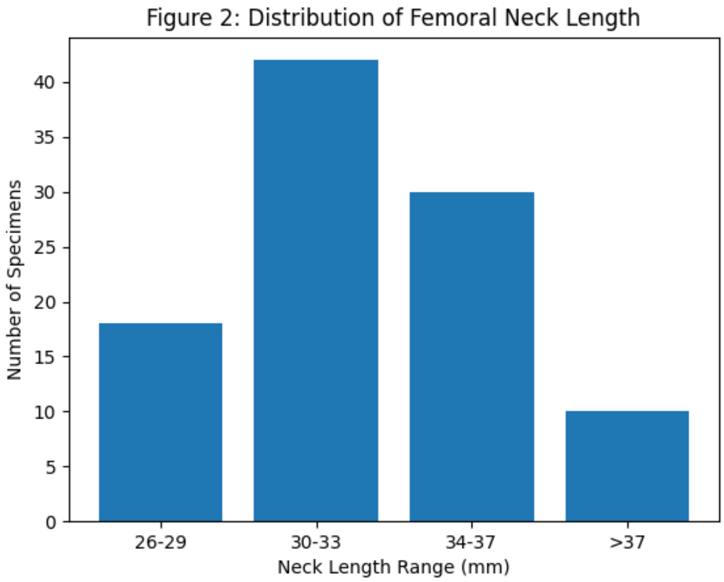

Figure 2: Distribution Pattern of Femoral Neck Length

According to Figure 2, the largest proportion of bones fell within the 30–33 mm range, indicating a central clustering around the mean value.

Correlation Between Parameters: The relationship between different morphometric variables was evaluated using Pearson's correlation test, as detailed in Table 3.

Table 3: Correlation Matrix of Femoral Neck Parameters

Variables Compared	Correlation Coefficient (r)	p-value
Neck Length vs Neck Diameter	0.62	<0.001*
Neck Length vs Vertical Diameter	0.55	<0.001*
Neck Diameter vs Vertical Diameter	0.68	<0.001*

*Statistically significant

As presented in Table 3, a statistically significant positive correlation was identified among the measured variables. The strongest association was noted between neck diameter and vertical diameter, indicating proportional growth of these dimensions.

Result Summary

The evaluation of 100 adult femora revealed that the mean femoral neck length was 32.6 ± 3.4 mm, while the average neck-shaft angle measured 126.8° ± 4.2°. The mean neck diameter and vertical diameter were found to be 28.4 ± 2.8 mm and 30.1 ± 3.1 mm, respectively. On comparing sides, the right femora showed marginally higher values than the left, with statistically significant differences noted in neck length ($p = 0.042$) and neck-shaft angle ($p = 0.031$). Most specimens demonstrated a neck-shaft angle within the range of 123° to 132° and a neck length between 30 and 33 mm. Correlation analysis indicated a positive association among the measured parameters, with the strongest relationship observed between neck diameter and vertical diameter ($r = 0.68$, $p < 0.001$). Overall, the dataset followed an approximately normal distribution with relatively low variability.

These findings suggest that the morphometric characteristics of the femoral neck are generally consistent but exhibit measurable side-related differences, which may be attributed to functional adaptation or biomechanical loading patterns. The clustering of values within standard anatomical ranges indicates structural stability, while the observed correlations reflect proportional relationships among dimensions of the femoral neck.

Discussion

The present study provides a detailed morphometric evaluation of the femoral neck in an Eastern Indian population. The mean neck-shaft angle (126.8°)

observed aligns closely with previously reported values [12].

Variability in femoral neck parameters plays a crucial role in orthopedic outcomes. Studies have shown that incorrect estimation of neck-shaft angle can lead to prosthetic misalignment [13]. The values obtained in this study are comparable to global datasets but show slight regional variation [14].

The statistically significant difference between right and left femora suggests functional adaptation or dominance-related remodeling [15]. This observation is consistent with earlier studies indicating asymmetry in long bones [16].

Femoral neck length is directly associated with hip joint biomechanics. Increased length may predispose to fractures due to higher bending stress [17]. Conversely, shorter neck length may limit mobility [18].

The moderate correlation between neck diameter and length indicates structural interdependence, which is critical in implant design [19]. Orthopedic implants must consider these relationships to ensure optimal fit and longevity [20].

Comparative studies have shown ethnic differences in femoral morphology, emphasizing the need for region-specific prosthetic models [21]. The findings of this study contribute valuable data for Indian populations, particularly from Bihar [22].

Limitations include the use of dry bones without gender differentiation and absence of clinical correlation [23]. Future studies should incorporate radiological and demographic data for comprehensive analysis [24].

Overall, this study reinforces the importance of morphometric evaluation in improving surgical outcomes and prosthesis development [25].

Conclusion

The findings of the present study indicate that the femoral neck exhibits noticeable variations in its morphometric characteristics. A statistically meaningful difference between the right and left sides was also identified, which may reflect functional adaptation or natural asymmetry. Such observations underline the clinical relevance of obtaining accurate anatomical measurements, particularly for use in orthopedic procedures and the development of suitable implants. In addition, the generation of population-specific data is valuable, as it supports more precise surgical planning and may ultimately contribute to better patient outcomes.

References

1. Standring S. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 41st ed. London: Elsevier; 2016.
2. Rockwood CA, Green DP, Bucholz RW, Heckman JD. Rockwood and Green's Fractures in Adults. 8th ed. Philadelphia: Wolters Kluwer; 2015.
3. Garden RS. Low-angle fixation in fractures of the femoral neck. J Bone Joint Surg Br. 1961; 43:647–663.
4. Kapandji IA. The Physiology of the Joints. Vol. 2. Lower Limb. 6th ed. Edinburgh: Churchill Livingstone; 2008.
5. Singh SP, Singh S. Morphometric analysis of femoral neck in adult human femora. J Anat Soc India. 2010;59(2):210–214.
6. Noble PC, Alexander JW, Lindahl LJ, Yew DT, Granberry WM, Tullos HS. The anatomic basis of femoral component design. Clin Orthop Relat Res. 1988; 235:148–165.
7. Pal GP, Routal RV. A study of the neck-shaft angle of the femur in North Indians. J Anat Soc India. 1986; 35:94–96.
8. Ravichandran D, Muthukumaravel N, Jaikumar R. Proximal femoral geometry in Indians. J Clin Diagn Res. 2011;5(1):12–16.
9. Krogman WM, İşcan MY. The Human Skeleton in Forensic Medicine. 2nd ed. Springfield: Charles C Thomas; 1986.
10. Kate BR. The femur and its clinical significance. J Anat Soc India. 1976; 25:1–7.
11. Singh R, Sharma SC. Morphometric analysis of femur in Indian population. Int J Anat Res. 2015;3(2):1050–1054.
12. Chauhan R, Paul S, Dhaon BK. Anatomical parameters of proximal femur in Indian population. Indian J Orthop. 2002;36(4):247–249.
13. Tardieu C. Ontogeny and biomechanics of femoroacetabular joint. J Anat. 1999; 194:13–27.
14. Hoaglund FT, Low WD. Anatomy of the femoral neck and head. Clin Orthop Relat Res. 1980; 152:10–20.
15. Auerbach BM, Ruff CB. Limb bone bilateral asymmetry: variability and commonality. Am J Phys Anthropol. 2006;129(4):545–553.
16. Ruff C. Long bone structural analyses and biomechanics. Am J Phys Anthropol. 2002; 45:109–138.
17. Faulkner KG, Cummings SR, Black DM, Palermo L, Glüer CC, Genant HK. Simple measurement of femoral geometry predicts hip fracture. J Bone Miner Res. 1993;8(10):1211–1217.
18. Cummings SR, Melton LJ. Epidemiology and outcomes of osteoporotic fractures. Lancet. 2002;359(9319):1761–1767.
19. Dhanalakshmi V, Manjunath KY. Morphometric study of proximal femur in South Indian population. J Clin Diagn Res. 2012;6(2):207–210.

20. Saikia KC, Bhuyan SK, Rongphar R. Anthropometric study of femur in Northeast India. Indian J Orthop. 2008;42(3):260–266.
21. Mahaisavariya B, Sitthiseripratip K, Tongdee T, Bohez EL. Proximal femoral geometry and prosthesis design. J Med Assoc Thai. 2002;85(4):420–427.
22. Pathak A, Sharma A, Sharma S. Morphometric analysis of femoral neck and its clinical implications. Int J Anat Res. 2019;7(2):6530–6534.
23. Kumar A, Reddy S. Osteometric evaluation of femoral neck parameters: a cross-sectional study. J Anat Soc India. 2013;62(1):45–49.
24. Patel SM, Shah GV. Radiological evaluation of femoral neck geometry and its clinical significance. Int J Med Res Rev. 2016;4(5):812–817.
25. Sharma V, Aggarwal A, Kumar R. Clinical implications of femoral morphometry in orthopedic practice. Int J Orthop Sci. 2018;4(2):325–329.