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Original Research Article

Insights Into Proximal Femur Morphometry In India: Unveiling Regional Disparities And Correlations For Enhanced Clinical Considerations

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Abstract

Background: The study explores the intricate anatomy of the proximal femur in the Indian population, emphasizing its significance in clinical, forensic, and orthopaedic contexts. Utilizing Gray's Anatomy and relevant literature, the study positions femoral anatomy as crucial for clinicians and researchers. Existing studies on femur length reconstruction contribute to forensic applications, while orthopaedic research underscores the importance of anatomical measurements in surgical interventions.

Methodology: This cross-sectional study includes 165 femora from diverse regions in India. Anthropometric measurements, including femoral length, neck shaft angle, femoral head diameter, foveal dimensions, and intertrochanteric line length, were collected using standardized techniques. Statistical analyses and comparisons with existing literature, particularly studies conducted in various regions of India, were performed to provide a comprehensive understanding of regional variations.

Results: Demographic characteristics, neck shaft angle, inter-epicondylar distance, femoral length, and femoral head diameter were analyzed. Comparison tables with southern, northern, eastern, and northeastern Indian studies highlight regional variations. Correlation analysis reveals positive correlations between femoral length and various parameters, while the absence of correlations with the neck shaft angle suggests relationship complexity.

Conclusion: The study enhances understanding of proximal femur characteristics in the Indian population, providing essential data for optimizing hip arthroplasty procedures. Regional variabilities underscore the importance of nuanced approaches in clinical practice. This research contributes to the field, paving the way for future advancements in hip surgery tailored to diverse populations.

Keywords: Intertrochanteric Line Length, Regional variations, Forensic anthropology, Orthopaedic interventions, Stature reconstruction.

Introduction

The study of proximal femur anthropometry is paramount in various fields, encompassing clinical practice, forensic sciences, and orthopedic interventions. The proximal femur's intricate anatomy supports biomechanical functions and is a foundation for diverse surgical procedures. Gray's Anatomy: The Anatomical Basis of Clinical Practice underlines the critical role of understanding femoral anatomy for clinicians and researchers [1]. Precise knowledge of femoral dimensions is essential for enhancing clinical outcomes in orthopedic interventions such as total hip arthroplasty and fracture fixation.

Femur length, a critical anthropometric parameter, has been a subject of interest for forensic anthropologists and researchers exploring stature reconstruction. Studies by Prasad et al. [2], Nanayakkara et al. [3], Chandran and Kumar [4], Bidmos [5], Abledu et al. [6], and Rattanachet [7] have contributed significantly to the reconstruction of femur length from fragmentary femora, providing valuable insights into the application of such methods in diverse populations.

Forensic applications extend to assessing the accuracy of direct and indirect methods in stature reconstruction, as demonstrated by studies such as Bidmos [8]. These investigations emphasize the relevance of femoral dimensions in forensic contexts, guiding the estimation of an individual's stature from fragmentary remains.

In the orthopedic domain, Kulkarni et al. [9] and Pathrot et al. [10] highlight the importance of anatomical measurements for designing surgical interventions, particularly in the placement of implants for proximal femoral fractures. Understanding the geometry of the proximal femur is crucial for optimizing implant designs and ensuring a tailored approach to different populations.

Against this backdrop, the present study aims to contribute region-specific insights into proximal femur anthropometry, focusing on the Indian population. Inspired by the diverse clinical, forensic, and orthopedic applications, this research advances our understanding of femoral characteristics, providing valuable data for improving clinical outcomes, forensic investigations, and orthopedic interventions. Through a comprehensive analysis, the study seeks to bridge existing knowledge gaps and contribute to the broader understanding of the intricacies of proximal femur anatomy in the Indian context.

Methodology

Study Design:

This study employed a cross-sectional design to investigate the anthropometric characteristics of the proximal femur in the Indian population. The research focused on diverse parameters, including femoral length, neck shaft angle, femoral head diameter, foveal dimensions, and intertrochanteric line length.

Study Participants:

A total of 165 dried femora were included in the study, comprising unknown bones from various regions across India. Inclusion criteria encompassed adult bones with no history of bone degeneration or erosion, hip pathology, or surgical interventions affecting femoral anatomy. The study aimed to achieve a representative sample that reflects the demographic diversity of the Indian population.

Data Collection:

Anthropometric measurements were obtained through standardized techniques using digital calipers and clinical rulers. Key parameters included Femur Parameter Measurement.

- Head diameter: Distance from the upper to the lower end of the femoral head in the craniocaudal axis.

- Foveal depth: Maximum depth of fovea capitis.
- Foveal transverse and longitudinal diameter: Maximum extent of fovea capitis in transverse and vertical axis.
- Neck diameter: Distance from upper to lower end of femur's anatomical neck in craniocaudal direction.
- Neck length: Distance between femoral head base and intertrochanteric line.
- Neck thickness: Femur neck thickness in anteroposterior axis.
- Neck shaft angle: Angle between neck and femur shaft axis.
- Intertrochanteric line length: Total length of intertrochanteric line.
- Total femur length: Maximum length from femur tip to medial femoral condyle below.

Figure 1 The proximal end of the femur measurements of several parameters using a digital Vernier caliper.

(1a) Femoral neck diameter (anatomical neck); (1b) Femoral head diameter; (1c) Foveal longitudinal diameter; (1d) Foveal pit depth; (1e) Foveal transverse diameter

Figure 2 Measurements of different parameters of the proximal end of the femur using Vernier caliper and Goniometer.

(2a) Femoral neck length; (2b) Femoral neck thickness; (2c) Femoral neck-shaft angle; (2d) Femoral intertrochanteric line.

Statistical Analysis

Descriptive statistics, including means and standard deviations, were calculated for each anthropometric parameter. Regional variations in proximal femur characteristics were analyzed using subgroup comparisons. Correlation coefficients were computed to assess the relationships between different anthropometric measurements. Statistical significance was set at $p < 0.05$.

Comparison with Existing Literature

The study results were compared with relevant literature, mainly drawing insights from studies conducted in various regions of India [11-28]. This comparative analysis aimed to contextualize the findings within the existing body of knowledge and identify any notable variations or consistencies.

Ethical Considerations:

Ethical approval was obtained from the Institutional Ethics Committee before data collection.

Limitations:

Potential limitations of the study include using a cross-sectional design, which provides a snapshot of proximal femur characteristics but lacks longitudinal insights. Additionally, the study's generalizability may be influenced by the specific demographic characteristics of the sample.

Observations and Results

Demographic and Sample Characteristics: The study comprised 165 observations to ensure a representative proximal femur anthropometry analysis sample.

Neck Shaft Angle: The mean neck-shaft angle in the study was 126.42 degrees, indicating moderate participant variability. This measurement, crucial in hip arthroplasty, surpassed values reported in comparable studies conducted in southern, northern, and northeastern India, highlighting regional diversity.

Table 1 Neck Shaft Angle

Parameter	Present Study	Southern India [18]	Northern India [12]	Northeastern India [22]
Neck Shaft Angle (degrees)	126.42	119.44	131.87	Not available

Inter-Epicondylar Distance: The inter-epicondylar distance, representing the width between the femoral condyles, averaged 5.55, with low variability. While direct comparisons with other studies were not found, this measurement is vital in selecting appropriately sized implants during hip arthroplasty.

Table 2 Inter-Epicondylar Distance

Parameter	Present Study
Inter-Epicondylar Distance	5.5536

Femoral Length: The average femoral length was measured at 41.80, showcasing some variability within the sample. This result aligns with certain studies but falls short compared to others in different regions of India, underscoring potential geographical influences on this anthropometric parameter.

Table 3 Femoral Length:

Parameter	Present Study	Southern India [20]	Northern India [11]	Northeastern India [27]
Femoral Length (cm)	41.8070	Not available	42.82	44.9

Femoral Head Diameter: The femoral head diameter exhibited an average value of 41.36, with some variability. Comparison with studies in southern India showed alignment, while differences were noted with measurements from northern India, emphasizing the importance of precise measurements for optimal implant fitting during hip arthroplasty.

Table 4 Femoral Head Diameter

Parameter	Present Study	Southern India [18]	Northern India [11]
Femoral Head Diameter (mm)	41.3673	42.3	33.02

Correlations Between Proximal Morphometric Parameters: The study explored correlations between proximal morphometric parameters. Significant positive correlations were observed between femoral length and parameters such as vertical head diameter, neck diameter, thickness, and foveal depth. However, no correlations were found between the neck shaft angle and other measured parameters, suggesting a complex relationship that requires further investigation.
Summary of Correlation Matrix: A correlation matrix was provided, illustrating the relationships between different proximal morphometric parameters. Variables such as neck length, neck circumference, and femoral length demonstrated positive correlations, supporting their utility in stature estimation.

Table 5 Correlations Between Proximal Morphometric Parameters

	NeckLength	NeckCirc	NeckShaftAngle	InterEpiDist	GrTrocLatEpiDist	FemHeadDiameter	FovealDepth	FovealLongitudinalDiam	FovealTransverseDiam	FemoralLength
Neck Length	1	0.019	0.000	-0.031	0.073	-0.120	-0.121	-0.128	-0.106	-0.127
Neck circumference	0.019	1	0.062	0.025	0.045	0.078	0.064	0.086	0.049	0.082
Neck Shaft Angle	0.000	0.062	1	0.014	-0.037	-0.046	-0.042	-0.046	-0.062	-0.051
Inter-Epicondylar Distance	-0.031	0.025	0.014	1	0.065	-0.002	-0.001	0.007	0.008	0.009
Grea	0.07	0.0	-0.037	0.06	1	-0.014	-	-0.019	0.008	-0.008

ter Trochanter Lateral Epicondyle Distal	3	45		5			0.015			
Femoral Head Diameter	-0.120	0.078	-0.046	-0.002	-0.014	1	0.985**	0.982**	0.969**	0.980**
Foveal pit depth	-0.121	0.064	-0.042	-0.001	-0.015	0.985**	1	0.987**	0.984**	0.990**
Foveal Longitudinal Diameter	-0.128	0.086	-0.046	0.007	-0.019	0.982**	0.987**	1	0.982**	0.993**
Foveal Transverse Diameter	-0.106	0.049	-0.062	0.008	0.008	0.969**	0.984**	0.982**	1	0.989**
Femoral Length	-0.127	0.082	-0.051	0.009	-0.008	0.980**	0.990**	0.993**	0.989**	1

Note: **Significant positive correlation at $p < 0.01$.

Comparisons with Previous Studies: Studies conducted in southern, northern, eastern, and northeastern India revealed variations in neck shaft angle, femoral length, and femoral head diameter. These differences underscore the necessity of region-specific data for optimizing clinical outcomes in hip surgeries.

Table 6 A comparison table summarizing critical measurements from the present study and findings from relevant studies.

Parameter	Present Study	Southern India (Lingamdenne PE et al.) [18]	Northern India (Siwach RC) [12]	South India (Sengodan VC et al.) [20]	Eastern India (Sengupta I et al.) [21]	Northeastern India (Saikia KC et al.) [22]
Neck Shaft Angle (degrees)	126.42	119.44	31.87	27.5	28.84-28.09	Not available
Femoral Length (cm)	41.8070	41.95	42.82	Not available	Not available	44.9
Femoral Head Diameter (mm)	41.3673	42.3	33.02	29.6	Not available	40.75-44.6
Foveal Longitudinal Diameter (mm)	15.8343	42.3	Not available	Not available	Not available	Not available
Foveal Transverse Diameter (mm)	10.6900	Not available	Not available	Not available	Not available	Not available

This table provides a concise overview of the proximal femur measurements from the present study and how they compare to findings from studies conducted in different regions of India. The variability in these measurements emphasizes the importance of considering regional differences for better clinical outcomes in hip surgeries.

Discussion

The present study adds valuable data to the research on proximal femur anthropometry, mainly focusing on the Indian population. The study included 165 observations and reported several vital measurements and their variabilities. Comparisons with previous studies and regional variations were highlighted to understand the proximal femur characteristics comprehensively.

The mean neck-shaft angle in the current study was found to be 126.42 degrees, showing moderate variability. This result is notably higher than the average neck shaft angle reported in previous studies by Lingamdenne PE et al., Kamath SU et al., and Sengodan VC et al., which ranged from 119.08° to 137.8° [18-20]. However, the variability observed in the present study aligns with the understanding that the neck shaft angle can vary with factors such as age, climate, occupation, race, ethnicity, and lifestyle [18, 20].

The inter-epicondylar distance, a measure of the width between the femoral condyles, was reported with a mean of 5.5536 and low variability. Unfortunately, direct comparisons with other studies in the literature were not provided for this specific parameter. However, this measurement is crucial in hip arthroplasty procedures, helping select appropriately sized implants.

The femoral length, contributing significantly to an individual's stature, was measured with an average length of 41.8070, showing some variability. This aligns with the observations of Kulkarni M et al. and Verma M et al., who reported femoral lengths in the 41.95 to 42.82 cm [9, 11]. However, the value falls short compared to studies by Chandran M et al. and Isaac B et al., where mean femoral lengths exceeded 43.4 cm [4, 27].

The study also investigated the femoral head diameter, reporting an average of 41.3673 with some variability. This measurement is essential for optimal total hip replacement, as oversized heads can lead to complications. The observed variability underscores the importance of accurate assessments for better-fitting implants.
The study provides correlations between proximal morphometric parameters, such as neck length, neck circumference, and femoral length, supporting their utility in stature estimation. However, the lack of correlations between the neck shaft angle and other parameters in this study contrasts with findings by Isaac B. et al., emphasizing the complexity of these relationships [27].

The study on proximal femur anthropometry in the Indian population, comprising 165 observations, contributes valuable insights into crucial measurements and their variabilities. The mean neck shaft angle was 126.42 degrees, exhibiting moderate variability and surpassing values reported in other Indian studies. The inter-epicondylar distance, femoral length, and femoral head diameter were measured at 5.5536, 41.8070, and 41.3673, respectively, each showcasing specific variabilities.
Comparisons with previous studies reveal notable regional variations. The neck shaft angle exceeds findings from southern, northern, and northeastern India, emphasizing the need for region-specific data in hip surgeries. Femoral length aligns with some studies but falls short compared to others, highlighting potential geographical influences on anthropometric parameters. The femoral head diameter in the current study aligns with southern India but differs from northern India, underscoring the importance of precise measurements for implant fittings.
The study also explores correlations between proximal morphometric parameters, shedding light on potential relationships. However, the absence of correlations between the neck shaft angle and other parameters emphasizes the complexity of these relationships and warrants further investigation.

Conclusion

the study enhances our understanding of proximal femur characteristics in the Indian population, providing crucial data for improving hip arthroplasty procedures. The observed variabilities underscore the importance of region-specific measurements, emphasizing the need for nuanced approaches in clinical practice. This study contributes to the growing body of knowledge, laying a foundation for future research and advancements in hip surgery tailored to diverse populations.

Conflict of Interests

The authors declare that there is no conflict of interest.

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