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Original Article

Anatomy Section

Morphometric Analysis of Proximal End of Femur: A Cross-sectional Study at a Tertiary Care Center in Southern India

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ABSTRACT

Introduction: Fractures in the upper end of the femur are very common. The use of implants for fixation is crucial for the rehabilitation and early mobilisation of patients. Proximal femur parameters play a significant role in the design and development of orthopaedic implants for total hip replacement. Currently, there is a need for orthopaedic surgeons to have a clear understanding of implant sizes that are suitable for the Indian population.

Aim: To determine the dimensions of the proximal end of the femur for the purpose of modeling orthopaedic implants.

Materials and Methods: A cross-sectional observational study was conducted using 140 dry adult femur bones from both sides, obtained from the Department of Anatomy at Sree Mookambika Institute of Medical Sciences, Kulasekharam, Tamil Nadu, between December 2020 and December 2022. The head and neck transverse diameter, as well as the proximal breadth of the femur, were measured using a sliding caliper. Data were collected and the mean and standard deviation were calculated. A t-test was used to compare the measurements between both sides. All statistical analyses were performed using SPSS version 10.0 for Windows.

Results: The mean head transverse diameter was 33.88±2.46 mm on the right side and 33.31±3.79 mm on the left side (p-value=0.399). The neck transverse diameter was 18.11±2.00 mm on the right side and 17.49±2.09 mm on the left side (p-value=0.157), and the proximal breadth was 79.04±7.21 mm on the right side and 78.03±5.71 on the left side (p-value=0.465).

Conclusion: There was no significant difference in the head transverse diameter, neck transverse diameter, and proximal breadth of the femur between the right and left side.

Keywords: Fractures, Implants, Morphometry

INTRODUCTION

The femur is the principal weight-bearing bone of the body. Proximally, it forms the hip joint, and distally, it forms the knee joint [1]. Fractures involving the neck and trochanter of the proximal end of the femur are very common. Internal fixation with implants for these fractures is important for the rehabilitation and early mobilisation of patients. Depending on the dimensions of the upper end of the femur, implants are designed. Currently, most orthopaedic surgeons require information on the dimensions of implants that meet Indian standards [2]. Standardising the morphology of the femur for a population helps determine the risk of femoral fractures, preoperative planning, implant design, and forensic diagnosis [3].

Femoral neck fractures are mostly intracapsular and can result in disruption of the cervical vessels formed from the intra-articular part. This can lead to necrosis of the femoral head, requiring total hip replacement or hemiarthroplasty. Intertrochanteric fractures are another common type of fracture around the hip joint. In these cases, the femoral neck is not involved, and the fracture line typically extends from the greater trochanter to the lesser trochanter [1].

The blood supply to the femoral neck is preserved in intertrochanteric fractures. These fractures are usually corrected surgically using a femoral plate and pin to align the central portion of the neck of the femur. Early mobilisation promotes proper healing of the fractures [1]. Morphometry of the proximal femur aids in the design of implants used in orthopaedic surgery, helping to identify the correct-sized implant and reduce complications related to the surgeries [4]. Anthropometric studies of the femur have shown regional differences across different populations [5]. A study on changes in the proximal femoral shape during foetal development revealed that the angle of ante-version of the femur increases with age, while the neck shaft angle reduces with age [6]. The three-dimensional geometry of the proximal femur determines the design of the cementless femoral stem in total hip arthroplasty [7]. Elderly individuals are at a higher risk of falling due to age-related changes such as gait abnormalities, cognitive diseases, degenerative joint diseases, and visual impairment [8]. Having a good understanding of the normal range of femoral torsion is necessary for hip prosthesis manufacturers [9]. The morphology of the proximal femur is an important parameter for developing and designing implants used in total hip replacement surgery. Using incorrect implant sizes can lead to serious complications such as stress shielding, loosening, and micromotion. Implant designs in North America and Europe are based on the morphology of their populations, which may not be applicable to the Indian population due to dimensional variations [10].

This study aims to provide insights to implant designers to consider altering the designs of implants that suit the specific needs of the Indian population.

MATERIALS AND METHODS

A cross-sectional study was conducted on 140 dry femurs, consisting of 70 right femurs and 70 left femurs, obtained from the Department of Anatomy at Sree Mookambika Institute of Medical Sciences, Kulasekharam, Tamil Nadu, India, between December 2020 and December 2022. The study received approval from the Institutional Research Committee and Institutional Human Ethics Committee (ref no: SMIMS/IHEC/2013/C/02).

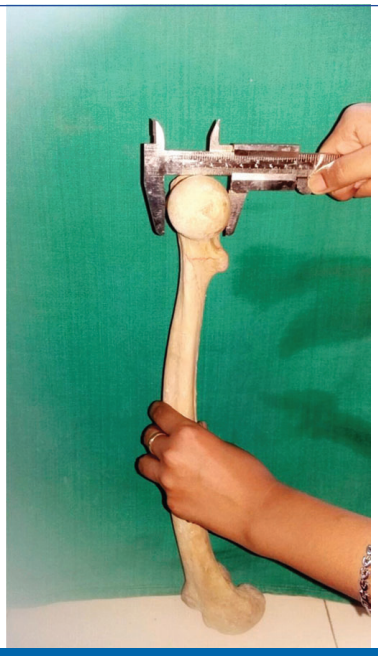
Sample size calculation: The sample size was calculated based on a literature reference by Ziylan T and Murshid KA, using a standard deviation of 2.7 mm for the neck transverse diameter in the left femur and an expected difference (d) of 1.2 [11]. The minimum sample size obtained was 76.38. Therefore, a sample size of 140 was chosen.

Inclusion criteria: Bones from both sides and either sex were included in the study.

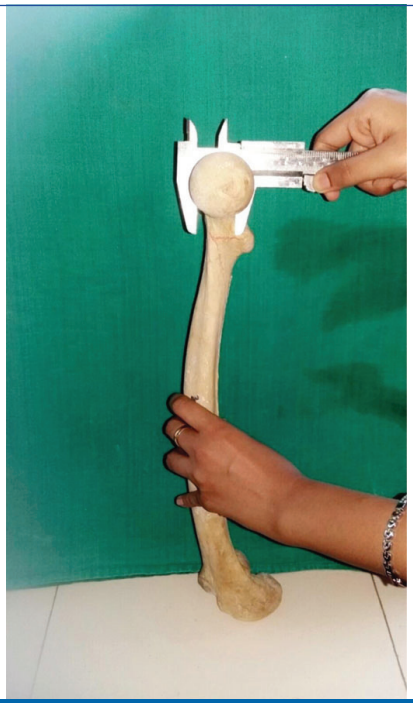
Exclusion criteria: Any femur showing significant malformation or abnormality that could affect its form and structure was excluded.

Procedure

The transverse diameter of the head was measured as the straight-line distance between the anterior and posterior ends of the femoral head using a sliding caliper, representing the maximum diameter of the head in the transverse plane [Table/Fig-1]. The neck transverse diameter was measured as the straight-line distance between the anterior and posterior ends of the femoral neck using a sliding caliper, representing the maximum diameter of the neck of the femur [Table/Fig-2]. The maximum width between the anterior end of the femoral head and the posterior end of the greater trochanter was measured using a sliding caliper [Table/Fig-3] [12].



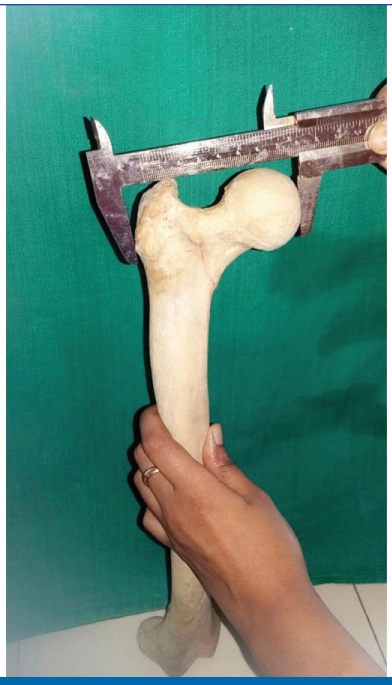
[Table/Fig-1]: Measuring transverse diameter of head of femur using sliding caliper.



[Table/Fig-2]: Measuring transverse diameter of neck of femur using sliding caliper.

STATISTICAL ANALYSIS

The data were collected, and the mean value and standard deviation were calculated. To compare the measurements between both sides, a t-test was performed on the means. All statistical calculations were conducted using Statistical Presentation System Software (SPSS) version 10.0 for Windows. A p-value of <0.05 was considered statistically significant.



[Table/Fig-3]: Measuring proximal breadth of femur using sliding caliper.

RESULTS

The mean head transverse diameter on the left side was 33.31±3.79 mm, and on the right side, it was 33.88±2.46 mm [Table/Fig-4].

	Left-side	Right-side		
	Mean±SD	Mean±SD	t-value	p-value
Head transverse diameter	33.31±3.79	33.88±2.46	-1.847	0.399

[Table/Fig-4]: Transverse diameter of head on left and right-side.

The neck transverse diameter on the left side was observed as 17.49±2.09 mm, and on the right side, it was 18.11±2.00 mm [Table/Fig-5].

	Left-side	Right-side		
	Mean±SD	Mean±SD	t-value	p-value
Neck transverse diameter (mm)	17.49±2.09	18.11±2.00	-1.42	0.157

[Table/Fig-5]: Transverse diameter of neck on right and left-side.

The mean proximal breadth on the left side was found to be 78.03±5.71 mm, and on the right side, it was 79.04±7.21 mm [Table/Fig-6].

	Left-side	Right-side		
	Mean±SD	Mean±SD	t-value	p-value
Proximal breadth (mm)	78.03±5.71	79.04±7.21	-0.734	0.465

[Table/Fig-6]: Proximal breadth of right and left-side.

DISCUSSION

In the past few decades, researchers have used various methods to measure the dimensions of the proximal end of the femur. These methods include measurements on cadaveric bones and in patients using ultrasound, computerised tomography, magnetic resonance imaging, and radiography. Previous studies have shown that the dimensions may vary among populations and depending on the measurement methods used [12,13].

Nidugala H et al., conducted a study on the morphometry of the femur in the South Indian population and concluded that the head transverse diameter on the right side was 35.31±2.90 mm, and on the left side, it was 36.81±3.79 mm, which is similar to present study findings [14]. Siwach R analysed the distance between the

two extreme points of the femoral head manually and radiologically and concluded that the average femoral head diameter is 43.53 mm, and the neck diameter is 29.5 mm [15].

Ziylan T and Murshid KA, conducted an analysis of Anatolian femurs and reported that the values of the neck transverse diameter on the right side were 26.3±3.1 mm, and on the left side, it was 25.5±2.7 mm. These results obtained by Ziyal T et al., was contrast with present study findings, which may be due to population variations [11]. Nidugala H et al., conducted a metric assessment of the femur in the South Indian population and concluded that the proximal breadth on the right side was 76.74±5.73, and on the left side, it was 79.78±6.71. The values obtained in their study were similar to present study findings [14].

Skaria S et al., conducted a morphometric study of the proximal femur and its applications in prosthesis designing, as a cross-sectional study from Western India. They concluded that the mean radiographs showing the anteroposterior view in the East Indian population. They concluded that the femoral head diameter is 45.30±4.7 mm, the femur head offset was 36.93±5.2 mm, and the femoral neck diameter was 130.57±3.0 mm [21].

Nowadays, total hip replacement surgery is performed on many individuals. Due to variations in racial and regional stature, there is a need for population-based data to design the best-fit prosthesis [12]. Gupta M et al., studied the geometrical analysis of the femur in the Uttar Pradesh region using 96 femora and concluded that the mean diameter of the head is 41.59±3.25 mm, and the neck diameter is 29.45±3.33 mm [Table/Fig-7] [1,4,5,13,15,22].

Katchy AU et al., analysed the geometry of the proximal femur in Southeast Nigeria and found that the transverse diameter of the femoral head is 44.55±3.37 mm, the neck diameter of the femur is 32.72±3.31 mm, and the proximal femoral width of the femoral head is 89±10.33 mm [23].

Author of publication	Year	Sample size	Population	Morphometry of head	Morphometry of neck	Proximal breadth
Present study	2023	140	South India	Head transverse diameter Rt: 33.88 mm Lt: 33.31 mm	Neck transverse diameter Rt: 18.11 mm Lt: 17.49 mm	Rt: 79.04 mm Lt: 78.03 mm
Nayak G [1]	2021	60	Odisha	Diameter of craniocaudal axis of head Rt: 39.55 mm Lt: 39.05 mm	Diameter of craniocaudal axis of Neck Rt: 28.48 mm Lt: 29.58 mm	-
Sengupta I et al., [4]	2020	50	Kolkatta	Head vertical diameter Rt: 28.84 mm Lt: 28.09 mm	Neck width Rt: 28.84 mm Lt: 28.09 mm	-
Vinay G et al., [5]	2020	180	Telungana	-	Anterior neck length Rt: 2.69 cm Lt: 2.61 cm	-
Verma M et al., [13]	2017	91	New Delhi	Head diameter Rt: 42.11 mm Lt: 42.51 mm	Neck diameter Rt: 44.66 mm Lt: 44.83 mm	-
Siwach R et al., [15]	2018	150	Western India	Head diameter 43.95 mm	Neck diameter 29.55 mm	-
Gupta M [22]	2022	96	Uttar Pradesh	Head diameter 41.59 mm	Neck diameter 29.45 mm	-

[Table/Fig-7]: Comparison of the present study with other studies [1,4,5,13,15,22].

value of the neck shaft angle was 130.70±6.03 mm on the right side and 126.41±7.22 mm on the left side, with a statistically significant difference [16].

Roy T et al., conducted a study on the regional variation of morphometric measurements of the proximal end of the femur and its clinical implications in coastal Andhra Pradesh. They identified the diameter of the head as 43.1 mm and the diameter of the neck as 31.6 mm [17].

Kamdi A et al., proposed osteometric parameters of the femur in the Telangana region. Their study revealed that the mean length of the femur was 43.26 cm (right side: 43.19 cm, left side: 43.28 cm). The maximum length was 48.2 cm, and the minimum length was 37.8 cm. The mean antero-posterior diameter at the upper segment of the shaft was 24.67 mm, the mean antero-posterior diameter at the middle segment of the shaft was 25.1 mm, and the mean antero-posterior diameter of the lower segment of the shaft was 25.77 mm. The study also specified that there was no significant difference identified between the right and left sides [12]. However, Ziylan T and Murshid KA, found a significant difference in the head vertical diameter of the femur between the right and left sides [11].

Cho HJ et al., identified anatomical morphometric differences in femora among Korean, Japanese, and American subjects. They revealed that the femoral head diameter was 48.50±2.23 mm in males and 43.25±2.12 mm in females [18]. A study on the Chinese population concluded that the mean femoral head diameter is 45.4 mm, and the mean narrowest neck width is 31.91 mm [19]. Prasath RA and Ismail BM obtained a result that the diameter of the femoral head was 41.98±1.98 mm [20]. Roy S et al., conducted a study on the evaluation of proximal femoral morphometry in plain

Limitation(s)

In the present study, the sample size was small (70 right femurs and 70 left femurs), and only a few parameters were analysed.

CONCLUSION(S)

The study revealed that there was no statistically significant difference found between the head transverse diameter, neck transverse diameter, and proximal breadth of the femur on the right and left sides. Therefore, the mean values of these parameters will provide valuable insights for biomechanical engineers to make necessary modifications in implant designs to better suit clinicians needs.

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