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ORIGINAL RESEARCH

Morphometric analysis of the proximal end of a desiccated human femur and its clinical implications

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ABSTRACT

Background: The longest and strongest bone in the human body, the femur, is essential for weight transfer and bipedal movement. Its size and form vary widely according on the environment, gender, and ethnicity. **Aim:** In order to comprehend the clinical consequences in orthopedic treatment, the study intends to investigate the morphometric characteristics of dehydrated human femora, including the head, neck, and trochanters. The information will be used to forecast fracture risk, implant fit, and surgical results, as well as to help design and choose orthopedic implants, especially for hip joint replacement procedures. **Materials & methods:** A total of 50 dry human femora were included in the study. Only complete, undamaged adult femora with clearly identifiable anatomical landmarks were selected. Bones with signs of deformity, pathology, or damage at the proximal end were excluded from the analysis. Femur measures such as neck diameter, length, thickness, shaft angle, intertrochanteric line length, maximum femur length, vertical head diameter, foveal diameter, fovea transverse diameter, and foveal longitudinal diameter were examined in the study. Measurements were taken using the following tools: Digital Vernier Caliper (accuracy: 0.01 mm), Measuring tape, Osteometric board, and Goniometer. **Results:** Femur measures such as neck diameter, length, thickness, shaft angle, intertrochanteric line length, and maximum femur length were examined in the study. 29.47 ± 3.43, 38.06 ± 4.04, 29.61 ± 1.93, 121.28 ± 5.38, 43.14 ± 3.22, and 44.11 ± 2.91 were the mean values. In these parameters, there was no discernible variation between gender and age. Measurements of the femur, such as the vertical head diameter, foveal diameter, fovea transverse diameter, and foveal longitudinal diameter, were also examined in the study. The mean foveal depth was 2.87 ± 1.24 mm, and the vertical head diameter was 41.51 ± 4.27 mm. The longitudinal and transverse dimensions of the fovea were 17.16 ± 5.37 mm and 13.58 ± 1.97 mm, respectively. There were no discernible gender or age disparities. **Conclusion:** In order to guide implant design and selection, this study examined morphometric characteristics in dehydrated human femora and demonstrated their importance in orthopedic health and surgical procedures.

Key words: Neck diameter, neck length, neck thickness, neck shaft angle, maximum length of the femur, foveal diameter, and fovea transverse diameter.

INTRODUCTION

Bipedal movement and the transfer of weight from the axial skeleton to the lower extremities depend on the human femur, the longest and strongest bone in the body. The environment, gender, place of residence, and ethnic heritage may all have a significant impact on the size and form of the femur's upper portion, which comprises the femoral head, neck, greater trochanter, and lesser trochanter. Understanding these differences is essential for anthropological research, prosthetic design, forensic identification, and orthopedic procedures.

Numerous morphometric investigations have been conducted on the proximal femur in India, revealing regional and ethnic differences [1]. According to a research [2], femoral head diameter and neck-shaft angles differed from Western norms, highlighting the necessity for region-specific data. Similarly, studies in central India [3] found significant differences in the size of the proximal femur between boys and girls.

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This emphasizes how important gender-specific anatomical databases are for therapeutic use.

Globally, morphometric investigations have revealed notable differences amongst populations. According to research from Europe, Africa, and East Asia, the observable disparities in femur sizes among races have a significant impact on the design of orthopedic implants and forensic estimations. For example, a study [4] showed a wider femoral head and a greater neck-shaft angle compared to Caucasians, which may affect hip arthroplasty outcomes. Neck lengths were shorter and femoral head diameters were smaller, according to studies like those by [4-6]. Custom prosthetic models were therefore necessary to provide the best possible fit and performance.

Furthermore, comparative studies have emphasized that information gathered from Western populations cannot be used directly to Indian patients without running the risk of surgical problems and implant mismatch. According to a comparative investigation, Indian patients often experience worse than ideal results from traditional prosthetic designs that are based on Western anthropometry [7]. They advocated for the use of domestic data-driven implant design methodologies. Furthermore, clinical consequences such as fracture risk assessment, surgical planning for total hip replacements (THR), and exact forensic profiling depend on precise morphometric information of the proximal femur [2,3]. The morphometry of dehydrated femora is particularly important in forensic anthropology and bioarchaeology since dried bone specimens are commonly used as the main source material for studies. The measurements taken from dried bones are crucial for determining age and sex, reconstructing stature, and identifying unknown people. Forensic investigations have benefited from the formulae developed by Indian research, such as those by [7,8], to estimate height using measurements taken from the top section of the thigh bone. Meanwhile, worldwide studies, including the one by [10–12], have improved sex determination techniques based on femoral head measures, highlighting the diagnostic utility of the bone. In order to comprehend the clinical consequences in orthopedic treatment, the study intends to investigate the morphometric characteristics of dehydrated human femora, including the head, neck, and trochanters. The information will be used to forecast fracture risk, implant fit, and surgical results, as well as to help design and choose orthopedic implants, especially for hip joint replacement procedures.

MATERIALS & METHODS

This was a cross-sectional, observational study conducted on Morphometric analysis of the proximal end of a desiccated human femuravailable in the Department of Anatomy, College of Medicine and JNM Hospital, Kalyani, Nadia, West Bengal,Pin 741235 between January - March, 2023

A total of 50 dry human femora were included in the study. Only complete, undamaged adult femora with clearly identifiable anatomical landmarks were selected. Bones with signs of deformity, pathology, or damage at the proximal end were excluded from the analysis. Femur measures such as neck diameter, length, thickness, shaft angle, intertrochanteric line length, maximum femur length, vertical head diameter, foveal diameter, fovea transverse diameter, and foveal longitudinal diameter were examined in the study. Measurements were taken using the following tools: Digital Vernier Caliper (accuracy: 0.01 mm), Measuring tape, Osteometric board, and Goniometer.

Statistical significance

We ran the data and calculated descriptive statistics for factors like mean and standard deviation using SPSS for statistical analysis. By following the right techniques to compare cohorts by age and gender, we ensured that the p-value remained below 0.05.

RESULTS & OBSERVATIONS

Table 1: Specific statistical information regarding femur dimensions, including femur diameter, femur length, femur thickness, femur shaft angle, femur interval, and femur maximum length.

Variable	Mean ± S.D	Minimum	Maximum
Neck diameter (mm)	29.47 ± 3.43	25.13	37.92
Neck length (mm)	38.06 ± 4.04	27.01	46.29
Neck thickness (mm)	29.61 ± 1.93	24.23	35.38
Neck shaft angle (mm)	121.28 ± 5.38	109.20	137.12
Intertrochanteric line length (mm)	43.14 ± 3.22	36.28	53.52
Maximum femur length (cm)	44.11 ± 2.91	35.42	54.42

Neck diameter, neck length, neck thickness, neck shaft angle, intertrochanteric line length, and maximum femur length are among the descriptive statistical data of femur measures displayed in Table 1. Femur measures such as neck diameter, length, thickness, shaft angle, intertrochanteric line length, and maximum femur length were examined in the study. 29.47 ± 3.43, 38.06 ± 4.04, 29.61 ± 1.93, 121.28 ± 5.38, 43.14 ± 3.22, and 44.11 ± 2.91 were the mean values. In these parameters, there was no discernible variation between gender and age.

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Table 2: Measurements of the femur, including its longitudinal diameter, vertical head diameter, and foveal diameter, as well as its transverse and transverse dimensions as described statistically.

Variable	Mean ± S.D	Minimum	Maximum
Head diameter (mm)	41.51 ±4.27	32.27	47.35
Foveal depth (mm)	2.87 ± 1.24	1.52	5.85
Foveal transverse diameter (mm)	13.58 ± 1.97	8.05	19.34
Foveal longitudinal diameter (mm)	17.16 ± 5.37	7.75	16.61

All femur measures, including vertical head diameter, foveal diameter, fovea transverse diameter, and foveal longitudinal diameter, are descriptively statistically summarized in Table 2. The mean foveal depth was 2.87 ± 1.24 mm, and the vertical head diameter was 41.51 ± 4.27 mm. The longitudinal and transverse dimensions of the fovea were 17.16 ± 5.37 mm and 13.58 ± 1.97 mm, respectively. There were no discernible gender or age disparities.

DISCUSSION

Specific femur parameters, such as neck diameter, femur length, shaft angle, intertrochanteric line length, and femoral head and fovea diameters, were the focus of the current investigation. The findings demonstrated that the mean values mostly agreed with the data from other populations that had already been published. Additionally, we found no discernible variations in any of the age or gender-related factors.

Our research's average femoral neck diameter (29.47 ± 3.43 mm) is comparable to Mahato's [4] findings, who discovered an average neck diameter of around 30 mm in a study of Indian femurs. According to this data, there might not be many geographical differences among central Indians. This suggests that these demographic factors may not have an impact on these anatomical characteristics because the femur measures are constant across genders and age groups. The results can thus be regarded as generally relevant to the community under study. The observed femoral length (44.11 ± 2.91 cm) is consistent with the findings of Patel et al. [5], who discovered that a group from central India had femur lengths ranging from 42 to 46 cm. This finding highlights a certain level of anatomical homogeneity among research conducted on comparable ethnic groupings. According to Pathak et al. [7], the average neck-shaft angle measured (121.28 ± 5.38°) is within the usual range of 120°–135° reported in the literature. Although the neck-shaft angle is known to influence biomechanical efficiency and fracture risk, several recent research [7] have not shown a significant link between it and factors like age or gender in healthy persons. Although intertrochanteric line measures are seldom discussed in research, our study's average length of 43.14 ± 3.22 mm is comparable to certain individual findings [8] that emphasize the significance of this measurement when developing implants for hip procedures. The femoral head measures, particularly the vertical head diameter (41.51 ± 4.27 mm), are in good agreement with the findings of a research [9] that discovered that samples from northern India had typical sizes of about 40–42 mm. Though certain studies, like one [10], have noted some age-related decreases in head dimensions, most likely as a result of degenerative alterations, our data did not show any significant correlation between femoral head dimensions and either gender or age. These results might be explained by the sample's very young and healthy makeup.

The fovea's average measurements (width: 13.58 ± 1.97 mm; length: 17.16 ± 5.37 mm; depth: 2.87 ± 1.24 mm) are consistent with a research [11] that indicated that adults' foveas exhibit very little size variation. Furthermore, a research [12] indicated that while fovea size typically doesn't change significantly with age or gender, it may have an impact on specific orthopedic techniques, which is consistent with our findings. Furthermore, according to a research [13], the size of the fovea may influence particular orthopedic techniques; nonetheless, our results are in agreement with the idea that it does not usually change much with age or sex.

Unlike some earlier research, such a study [14], which found minor sexual dimorphism in femoral measures, our cohort found no statistically significant differences between males and females in any of the examined parameters. However, the disparity might be explained by differences in sample numbers, ethnic origins, or age group distributions among the several studies [15]. Recent meta-analyses [16] support our findings, demonstrating that more mixed genetics and improved diet are reducing the typical gender disparities in bone structure in some communities.

All things considered, our research offers the Central Indian population current femur size and shape data, demonstrating that these measures are largely consistent among people of both sexes and ages. In the context of population-specific anatomical compatibility, this result has important ramifications for forensic anthropology, orthopaedic surgery, and prosthetic design.

The importance of femoral neck diameter, neck length, and neck thickness in prosthetic implant design is highlighted by this study. Proper neck dimensions help to increase stability and load transfer, avoiding problems such periprosthetic fractures or aseptic loosening [17, 18]. Optimizing prosthesis angulation, preventing limping, and reducing revision rates all depend on the average neck-shaft angle, which falls within the known physiological range [19]. When choosing prosthetic heads for complete hip replacement, evaluations of the foveal features and vertical head diameter are crucial [20]. There

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were no notable differences in age or gender, suggesting that the population under study was quite homogeneous in terms of appearance. Given the strong correlation between bone strength and load-bearing capacity and variables such neck diameter, neck-shaft angle, and cortical thickness, it is imperative to predict fracture risk [21]. Implant selection is made easier by morphometric profiles, which also enable proactive fracture risk assessment and targeted preventative actions. The findings highlight how crucial it is to use region-specific morphometric information when designing and choosing orthopedic implants in order to maximize surgical outcomes, improve patient quality of life, and increase implant longevity.

CONCLUSION

Important facets of orthopedic health and surgical procedures are clarified by this thorough examination of morphometric data in dehydrated human femora. This work improves our knowledge of anatomical differences and highlights their clinical importance in predicting fracture risk and surgical outcomes by analyzing the size and connections of the femoral head, neck, and trochanters. Furthermore, by helping to guide implant design and selection, these insights guarantee that implants are customized to fit the wide range of patient demands. In the end, our discovery opens the door to better patient care and more effective therapies by bridging the gap between anatomical knowledge and real-world orthopedic application.

Conflict of interest

There is no conflict of interest among the present study authors.

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