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Original Research Article

MORPHOMETRIC STUDY OF ADULT DRY FEMUR AND ITS FORENSIC IMPORTANCE

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Abstract

Background: Prevalence of hip osteoarthritis, fracture neck femur and other hip joint ailments are increasing day by day. Arthroplasty is the definite treatment for these patients. The femur forms the skeleton of the thigh, carries body weight, supports the movements of leg and provides attachment to the muscles. All the long bones in the human body have a linear and positive relationship with stature. This principle has been used by forensic scientists and anthropologists to estimate stature in many kinds of medico-legal and forensic examinations. **Materials and Methods:** The present study was conducted with 346 adult dry femur, out of it 182 were belongs to right and 164 were belongs to left. In present study we have measured, Femur Length, Femur Neck Length, Neck shaft angle, Femur neck thickness, Femur neck diameter and Femur head diameter. Instruments Used for this study are Sliding Calliper, Osteometric Board and measurements measured according to standard anthropometrical method. **Result:** The results of present study are the neck length of femur was 35.05+5.4mm. The length of femur 446.1+30.04mm. The neck shaft angle of femur was 137.4o. The Femur neck thickness of femur was 24.18+3.4mm. The Femur neck diameter of femur was 33.41+4.9mm. The Femur neck diameter of femur was 41.48+5.2mm. **Conclusion:** The results may be helpful to forensic practice, orthopaedic practice. The present study results further may be extended to formulate opinion in person's gait, biomechanics, movement, and posture analysis.

INTRODUCTION

The thigh bone femur is the largest, longest and strongest bone of the human body providing attachment to powerful muscles for locomotion and maintenance of erect posture. The expanded condyles of femur articulate inferiorly with the corresponding condyles of tibia and anteriorly with patella to form the complex and compound variety of modified hinge joint known as knee joint providing stability during locomotion and in long standing erect posture.[1,2] The transition from quadrupedal to bipedal gait is a biomechanical landmark in the evolution of Homo Sapiens. The most important feature that makes humans different is the bipedal locomotion and prehensile use of hands. The legs and hands are quietly modified from that of other primates in their unique architecture and built. The femoral neck in humans is an important functional modification after man attained erect bipedal posture. The neck of the femur is approximately 5 cm long which connects the head to the shaft usually at an angle of 125°. Neck-shaft angle facilitates movements at the hip joint and also acts as a lever for the muscles acting around the hip joint. The angles at the proximal femur facilitates biomechanical advantageous erect postures during motion by reducing the horizontal bending forces experienced at the pelvic girdle and thereby reducing bony tensile stress. Neck-Shaft Angle or the Inclination angle and angle of torsion are important anatomic indicators in clinical orthopaedics. Neck shaft angle or inclination angle is an angle between the femoral neck axis and diaphyseal axis.[3-6]

Grossly mutilated skeletal remains are a big challenge for forensic pathologist and physical anthropologist in the identification of the deceased. The application of osteometry is most important in medico legal investigation for estimating the height which is part of achieving the goal of estimating age at the time of death, sex, race, ancestry, ethnicity, stature, body weight and body build. The details of individualizing characteristics that are amputation, fractures, ankylosis, deformities and bone pathologies and to some extent the cause of death if reflected in the skeletal remains are also essential in the identification of the individual. The objective is to enable the law enforcement agencies to achieve the ultimate goal of personal identification. Long bones

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that make up greatest proportion of stature, femur and tibia are more accurate than humerus and ulna. Intact long bones of upper and lower extremities have been used in derivation of regression equations for estimation of stature in different population groups. These bodies are sometimes presented to forensic anthropologists in different states of fragmentation, thereby making derived equations unstable. This has necessitated the need to assess the usefulness of measurement of fragments of long bones in estimation of stature.[2] It is also helpful for the clinicians in the treatment of proximal and distal femur fractures. Femoral neck fractures involve the narrow neck between the round head of the femur and the shaft.[3] The angle of the femur formed by the longitudinal axis of the neck and the longitudinal axis of the shaft of femur bone is termed as neck shaft or collodiaphysial angle. This angle varies with age, sex, race, dominant and non-dominant leg or development of femur. The neck shaft generally ranges from the angle of 115o to 140 o at an average of 126 o in adults. The proximal femur acts as a brace, and its biomechanical properties depend on the width and length of the femoral neck. It also helps the limbs to swing clear of pelvis. Different aspects of clinical disease conditions and fracture, congenital anomalies and changes in osteoporosis as well as medico-legal cases can be understood by the study of femur bone. Femur bone has almost cylindrical shaft and a proximal rounded articular head projecting medially from its neck. The femoral neck is about 5 cm long and connects the head to shaft at about an angle of 135 o. The mobility of hip joints is facilitated by the angle and it allows the obliquity of the femur within the thigh, which helps the knees to be adjacent and inferior to trunk. It enables to swing clear of the pelvis.[7,8] Prevalence of hip osteoarthritis, fracture neck femur and other hip joint ailments are increasing day by day. Arthroplasty is the definite treatment for these patients. The femur forms the skeleton of the thigh, carries body weight, supports the movements of leg and provides attachment to the muscles. Morphology of bones is very much affected by race, sex, environmental factors and life style.[9] The present study is focused on find out the measurements of neck shaft angle, femoral Length and neck Length of femur, femur neck thickness, femur neck diameter and femur head diameter which helps in forensic and orthopaedic practice.

MATERIALS AND METHODS

In present study have used 346 femurs from different colleges in karnataka. The following measurements were measured Neck shaft angle, Femoral Length and Neck Length of femur, femur neck thickness, femur neck diameter and femur head diameter. Instruments used for this study are Sliding Calliper, Osteometric Board and measurements measured according to standard anthropometrical method.[8] We measured femur manually by using Anthropometric instruments like osteometric board, goniometer and digital calliper. Parameters measured were Femur Length for which femur was placed in a position parallel to the surface of Osteometric board by rotating the femur shaft internally then the distance between the highest point of the femur head to the lowest point of the medial condyle was measured as the femur length. Femoral head diameter was the distance in a straight line between the upper end to the lower end of the femoral head in cranio caudal axis. Femoral neck length was the distance between the inferior region of base of femoral head and the lower end of intertrochanteric line. Femoral neck thickness was thickness of neck of femur in antero posterior axis. Femoral neck diameter was the distance in a straight line from upper end to the lower end of the anatomical neck of femur in craniocaudal direction. Aim of the study was to provide the morphometric data of proximal femur for Indian population and to analyse the relation among the parameters of proximal femur, hence groups were not formed as the male and female. Literature has various studies that were done on dry femur without differentiating the sex.[8,10]

RESULTS

The present study was conducted in different medical colleges in Karnataka with 346 femurs, out of 346, right were 182 and left were 164. The results of present study are the neck length of femur was 35.05+5.4mm, right femur was 34.9+6.2mm and left femur was 35.2+4.6mm. The length of femur 446.1+30.04mm, right femur was 446.8+31.44mm and left femur was 445.4+28.62mm. The neck shaft angle of femur was 137.4o, right femur was 137.6o and left was 137.2 o. The Femur neck thickness of femur was 24.18+3.4mm, right femur was 24.22+3.8mm and left was 25.18+2.6mm. The Femur neck diameter of femur was 33.41+4.9mm, right femur was 34.76+4.6mm and left was 32.16+5.2mm. The Femur neck diameter of femur was 41.48+5.2mm, right femur was 41.12+5.6mm and left was 41.84+4.8mm.

Table 1:

Parameter		Number of femurs	Mean+SDmm
Femur Length	Total	346	446.1+30.4
	Right	182	448.8+31.4
	Left	164	444.4+28.6
Femur Neck Length	Total	346	35.1+1

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	Right	182	34.9+6
	Left	164	35.2+4
Neck shaft angle	Total	346	137.4o+3.5o
	Right	182	137.6o+3.2o
	Left	164	137.2o+3.8o
Femur neck thickness	Total	346	24.18+3.4
	Right	182	24.22+3.8
	Left	164	25.18+2.6
Femur neck diameter	Total	346	33.41+4.9
	Right	182	34.76+4.6
	Left	164	32.16+5.2
Femur head diameter	Total	346	41.48+5.2
	Right	182	41.12+5.6
	Left	164	41.84+4.8

DISCUSSION

In present study, the mean length of femur was 446.1+30.4 mm, right femur was 448.8+31.4mm and left femur was 444.4+28.6mm. Our results are in agreement with Bhosale and Zambare.[20] In their study the mean length of left male femur was 45.23 cm that of left female was 42.04cm, the mean length of right male femur was 45.08 cm that of right female was 41.64 cm.[10] Our study results also near to Ravi G study.[8] The present study results in agreement with Pandya A M et al study,[11] in this study mean value of maximum length was higher in male as compared to female. For right male bone calculated range was 379.99-523.63mm and for right female bone it was 358.26-476.70mm. Comparisons were drawn separately formale left and right femora, because individual end to favor one limb over other. It also has been observed that the female femur is shorter than male and in male the left longer than right and vice versa in female. Maximum length of femur was the best parameter for sexing the unknown femora. Maximumlength was measured following the standard techniques recommended by Martin and Selle. Discriminate analysis confirmed that the malefemur is usually larger than the female femur sex differences in long bones is that typically malebones are longer and more massive than typically female bones.[12-14]

In present study the mean neck length of femur was 35.1+1mm and in right it was 34.9+6, and in left it was 35.2+4mm. The mean neck length in study of Meenakshi Verma was calculated to be 36.06±4.94 mm.[15] Present study comparable with the maximum neck length of 37.23 ±4.65 mm found by Siwach RC,[16] lesser than 44.75±8.097 mm found by Verma M et al,[17] but greater than that of South Indian population by Isaac B et al., i.e., 28.4 mm.[18] Present study results are in agreement with Ravichandran et al study, in their study the mean femur neck length was 31.88mm.[19] In study of S Dhivya,[20] the mean femur neck length was 3.09 cm, right femur neck length was 2.98 cm and left femur neck length was 3.16 cm. Present study is similar to that of De Sousa et al,[21] in their study right femur neck length was 3.01 cm, left femur neck length was 3.05 cm.

The neck shaft angle, which helps the acetabulum to align with the femoral head, is of great structural and diagnostic value in hip joint mechanics. The angle is a beneficial structural adaptation that increases hip rotation and helps the lower limb to swing away from the pelvis, increasing freedom of movement.[15,18] Out study result shows that the mean neck-shaft angle of femur was 37.4o+3.5o , in right femur it was recorded as 137.6o+3.2o and in left it was 137.2o+3.8o. In Ravi G study,[8] it is observed that, the mean neck-shaft angle of dry femur was 136.80+4.4 o, the right femur was 136.90+4.4o and left was 136.70+4.4 o , these readings which falls under the range 115 o to 140 o given by Moore et al.[22] Our results are in correlation with study of Gujar et al,[23] which has presented the mean value of 136.6o of right and 136o of left respectively. Another study reported the values lower than our study as the angle of 122.5o to the right and 125.6o to the left femur.[24] The average neck shaft angle in the Meenakshi Verma et al,[15] study was found to be 119.08°±5.18°. Our results also consistent with the findings of Lingam Denne PE et al., who measured it to be 119.44°±4.13°.[25] The neck shaft angle varies with age and is influenced by several factors, including climate, occupation, race, ethnicity, and sedentary lifestyle.[15,25]

With increase in age, neck thickness is also increased, which contribute to the development of osteoarthritis by increasing cam impingement.[15,26] Our study reported mean Femur neck thickness was 24.18+3.4mm, right femurs show 24.22+3.8mm, and left femur was25.18+2.6mm. In study of Meenakshi Verma,[15] mean femur neck thickness was 24.01+3.05mm, right was 23.86+3.09mm and left was 24.15+3.04mm. The neck thickness values in our study are comparable with those found by Sengodan VC et al. in the South Indian population, i.e., 27.5 mm,[27] and findings by Sengupta I et al. in eastern India (28.84 mm-28.09 mm).[28] In present study mean femur neck diameter was 33.41+4.9mm, right femur was 34.76+4.6mm and left was 32.16+5.2mm. In study of Prasath RA and Ismail BM observed that femur head diameter in south Indian population was 41.98±1.98mm.[29] In study of Meenakshi Verma,[15] mean femur neck diameter was 33.02+4.22mm, right was 31.73+3.66mm and left was 34.23+4.39mm.

A major component of successful total hip arthroplasty is the design of the femoral head prosthesis. Currently, though oversized heads are preferred due to decreased chances of dislocation, they can lead to numerous other complications like

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wear, imperfect biomechanics, and groin pain.[15] In present study it is observed that mean Femur head diameter 41.48+5.2mm, right was 41.12+5.6mm and left femur was 41.84+4.8mm. In study of Meenakshi Verma,[30] mean femur head diameter was 42.32+4.11mm, right was 42.21+4.53mm and left was 42.51+3.72mm. In study Mayank gupta,[30] the vertical head diameter was observed to be 41.59±3.25 mm. This tallies with studies done in southern India by Lingamdenne PE et al,[25] and Sengodan VC et al,[27] where the average head diameter was 42.3±0.54 mm, and 42.6 mm, respectively. In study of Siwach RC show an average head diameter of 43.95±3.06 mm.[17] A study done in eastern India by Sengupta I et al,[28] reported head diameter to be in the range of 38.56±2.5 mm to 38.07±3.43 mm.

CONCLUSION

The present study supplies the mean values of different morphometric measurements from the femur. As a result, these measurements may help to indicate the characteristic morphometric features of femoral segments in south Indian population and also help the orthopaedic surgeon to place various implants in the reconstruction of femoral fragments and forensic practice. Many investigators have found femoral morphometry to vary with age, gender, race, ethnicity, and regional customs like sitting cross-legged or squatting. The skeletal parameters of the Indian population are well known to differ from other racial groups globally. The proximal femoral morphometry shows significant regional differences among Asian, Caucasian, and African populations. Though many authors have anthropometrically studied the proximal femoral fragment from different parts of the world, there are relatively fewer studies that have been done in India. Our study data may give valuable insight into a better-customized implant and prosthesis design.

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