Original Article

Radiographic Analysis of Proximal Femur in An Adult Bangladeshi Population

Akter F[1], Johora F[2], Ara R[3], Mourin N[4], Rahman N[5], Zaman SB[6]

ABSTRACT

Morphometry of the proximal end of the femur is important to orthopaedic surgeons for the selection of appropriate size of internal fixators and implants. Similarly, prosthetists need it for designing population specific hip joint prosthesis. Besides, morphometry of the proximal end of the femur shows gender variation, which helps the forensic experts in determination of sex. Moreover, anatomists and anthropologists may use it for the purpose of comparative studies. Therefore, the present study was designed to provide a standard data of different morphometric parameters of the proximal end of the femur in an adult Bangladeshi population through radiographic analysis, and observe differences between male and female, if any. This cross-sectional, analytical study was carried out in the Department of Anatomy, Sir Salimullah Medical College, Dhaka, Bangladesh, between July 2020 and June 2021. Standardised anteroposterior pelvic radiographs of 70 apparently healthy adult Bangladeshi patients (35 male and 35 female) were taken. All were reported as normal by a specialist radiologist. Data was collected in a data sheet. The diameter of the femoral head, width and length of the femoral neck and femoral neck-shaft angle were measured unilaterally using MB ruler software after zooming in and increasing resolution of the radiographs. The mean diameter of the femoral head, length and width of the femoral neck, and femoral neck-shaft angle in our total study population were found 47.67±4.47 mm, 51.44±5.36 mm, 31.90±3.71 mm, and 131.57±3.7° respectively. Sexual dimorphism was observed in the diameter of the femoral head (51.22±2.57 mm vs. 44.13±2.84 mm), length of the femoral neck (53.86±0.97 mm vs. 49.03±4.33 mm), and width of the femoral neck (34.46±2.79 mm vs. 29.59±3.05 mm ($p<0.001$). However, no difference was found in femoral neck-shaft angle between male and female (132.11±4.04° vs. 131.16±3.69°) ($p>0.05$).

Keywords: *Femur, morphometry, radiographic analysis, Bangladeshi population*

Mugda Med Coll J. 2025; 8(2): 90-95.
DOI: https://doi.org/10.3329/mumcj.v8i2.85782

INTRODUCTION

The proximal end of the femur consists of head, neck, greater trochanter and lesser trochanter. The spheroidal femoral head articulates with acetabulum of the hipbone to form the hip joint. Femoral neck makes neck-shaft angle with the femoral shaft, which is a crucial factor for the erect posture in humans. It also ensures freedom of mobility of the hip joint by swing lower limb away from pelvis. Femoral neck-shaft angle is about to 150° at birth, but gets reduced to 115°–140° in adult age. It is comparatively smaller in female than male as female has a wider pelvis compared to male.[1]

Fracture in the proximal end of the femur specially fracture neck femur and trochanteric fracture are very common in orthopaedic practice.[2] Various implants and screws are used in the proximal part of the femur by the orthopaedic surgeons during fixation of fracture in situ. A mismatch in the size and design of those implants can lead to several complications like

1. Dr. Ferdousi Akter, Lecturer, Department of Anatomy, Tangail Medical College, Tangail-1900. Email: ferdousi.mmc@gmail.com (Corresponding author)
2. Prof. Fatema Johora, Professor and Head, Department of Anatomy, Sir Salimullah Medical College, Dhaka-1100.
3. Dr. Rawshon Ara, Assistant Professor, Department of Anatomy, Monno Medical College, Manikganj-1840.
4. Dr. Nusrath Mourin, Assistant Professor, Department of Anatomy, Dr. Sirajul Islam Medical College, Dhaka-1217.
5. Dr. Nahidur Rahman, Lecturer, Department of Anatomy, Sir Salimullah Medical College, Dhaka-1100.
6. Dr. Sadika Binta Zaman, Lecturer, Department of Anatomy, Sir Salimullah Medical College, Dhaka-1100.

anterior thigh pain, stress fracture, non-union and implant failure.[3] Morphometry of the proximal end of the femur is necessary to choose a fixator or implant of proper size in order to avoid postoperative complications. Differences in the morphometric parameters of the proximal end of the femur between male and female also help the forensic experts in determination of sex from bone fragments. It also helps the anatomists and anthropologists to study comparative anatomy.

The proximal end of the femur is prone to tensile and compressive stress during weight bearing activities.[4] It undergoes functional modification according to the level of activities. Morphometry of the proximal end of the femur varies among population as it is influenced by age, sex, profession, race, ethnicity and life-styles.[5,6] Studies were conducted by many authors in different countries to study morphometry of the proximal femur by using different materials such as dry bones, plain radiographs, and computed tomography scans. Age and sex of the dried femur bone are not well documented in our country and computed tomography scans are costly; therefore, plain radiograph remains the standard method to study morphometry of the proximal end of the femur. To our knowledge, there exists a scarcity of evidence on the morphometry of the proximal end of the femur in our country; therefore, this study aims to provide standard data on different morphometric parameters of the proximal end of the femur in an adult Bangladeshi population.

METHODS

This cross-sectional, analytical study carried out in the Department of Anatomy, Sir Salimullah Medical College, Dhaka, Bangladesh, from July 2020 to June 2021. The study population was adult Bangladeshi population aged between 25 and 45 years, who attended the Department of Radiology & Imaging of the same institution to have plain digital radiographs of the pelvis. Patients with any existing diseases or deformities in the hip joint and the proximal end of the femur, any history of operation in the hip joint or the proximal end of the femur and pregnant woman were excluded from the study. The anteroposterior radiograph of hip was taken with the patient supine on the x-ray table with both lower extremities orientated in 15° of internal rotation to maximise the length of the femoral neck. The distance between x-ray tube and film was 120 cm, while the tube was orientated perpendicular to the table. The crosshairs of the beam was centred on the point midway between the superior border of the pubic symphysis and a line drawn connecting the anterior superior iliac spines.[6] Radiographs of the pelvis (anteroposterior view or AP view), in which the hip joints were reported as normal by a specialist radiologist, were collected for measurement and data collection. The soft copy of the images were collected via a USB drive and transferred to the computer. The sample was collected by a convenient sampling method. Finally, a total of 70 participants (35 male and 35 female) included in the study.

After proper magnification by zooming in and increasing the resolution, the diameter of the femoral head, length and width of the femoral neck and femoral neck-shaft angle were measured unilaterally on the left sided pelvis using MB ruler software.

Femoral head diameter (FHD): The diameter of a perfect circle drawn around the femoral head is the femoral head diameter.[7] To measure the diameter of the femoral head, a perfect circle was drawn over the spheroidal femoral head of left hip joint on the radiograph of the pelvis (AP view). Then the center of the circle was identified and marked. The medial and lateral point of the circle were marked over the femoral head at the level of femoral head center. The distance between the two points was measured by MB ruler software and was recorded (Fig. 1).

Femoral neck length (FNL): It is the distance from the femoral head centre to the femoral shaft axis that is measured along the femoral neck axis.[8] To measure the femoral neck length of the left hip joint on the plain digital radiograph of pelvis (AP view), the femoral neck axis and femoral shaft axis were drawn and then their intersecting point was marked. The distance between the femoral head centre and the intersecting point was measured by MB ruler software and recorded (Fig. 1).

Femoral neck width (FNW): The minimum diameter of the femoral neck at the narrowest part of the neck is the femoral neck width.[9] To measure the femoral neck width of the left hip joint on the plain digital radiograph of the pelvis in its AP view, the most constricted part of the femoral neck was determined by observation, three measurements were taken by MB ruler software and the minimum measurement was recorded (Fig. 1).

Femoral neck-shaft angle (NSA): It is the angle between the femoral neck axis and the femoral shaft axis.[10] To measure the neck-shaft angle of the left hip joint on the plain digital radiograph of the pelvis in its AP view, the femoral neck axis and femoral shaft axis were drawn and their intersecting point was marked. The angle between the two axes was measured by MB ruler software and recorded (Fig. 1).

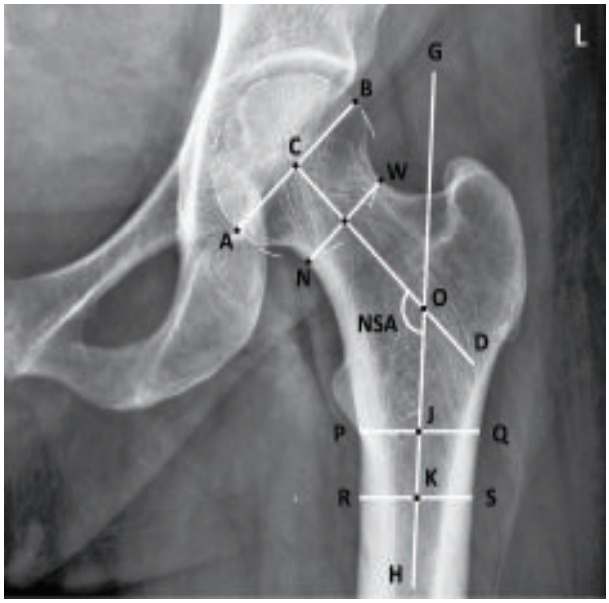

Fig. 1: *Plain digital radiograph of the pelvis (AP view) showing different reference points for femoral head diameter (AB), femoral neck width (NW), femoral neck length (CO) and neck-shaft angle (COH) of the proximal femur. Here, C: Femoral head center, CD: Femoral neck axis, GH: Femoral Shaft axis, O: intersection of CD & GH.*

Statistical analysis was done using the Statistical Package for Social Sciences (SPSS) version 23.0 for Windows (SPSS Inc., Chicago, Illinois, USA). Comparisons of different parameters of the proximal femur between adult Bangladeshi males and females were done by unpaired student's t-test. A p-value <0.05 was considered as statistically significant.

The study was approved by the Ethical Review Committee of Sir Salimullah Medical College, Dhaka, Bangladesh.

RESULTS

In present study, the mean diameter of the femoral head (FHD) in total study population was 47.67±4.47 mm (Table-I). Among males, the mean FHD was 51.22±2.57 mm **(**ranging from 44.46 mm to 55.89 mm), and among females, it was 44.13±2.84 mm (ranging from 38.78 mm to 49.61 mm). A significant difference in FHD was observed between males and females (p=0.000) (Table-II). The mean length of the femoral neck (FNL) was found 51.44±5.36 mm among our total study participants (Table-I). In males, the mean FNL was observed 53.86±0.97 mm (ranging between 42.30 mm and 65.11 mm). However, in females, it was found 49.03±4.33 mm (ranging between 40.34 mm and 59.14 mm). FNL was significantly higher among males compared to their female counterparts (p=0.000) (Table-II). The mean width of the femoral neck (FNW) of our total study population was 31.9±3.71 mm (Table-I). In males, the mean FNW was observed 34.46±2.79 mm (ranging between 29.96 mm and 40.60 mm); it was 29.59±3.05 mm (ranging between 23.44 mm and 39.13 mm) in females. FNW was also found significantly higher among males compared to their female counterparts (p=0.000) (Table-II). The mean femoral neck-shaft angle (NSA) in total study population was estimated 131.57±3.78° (Table-I). The mean angles were 132.11±4.04° **(**ranging from 124.69° to 138.81°) and 131.16±3.69° (ranging from 122.86° to 139.43°) in male and female respectively. No difference was found between male and female (p=0.308) (Table-II). Comparisons of different parameters found in the previous studies among different ethnicities are shown in the Table-III.

Table-I : *Mean of the parameters in total participants (N=70)*

Variables	Mean±SD	Range
Diameter of the femoral head (in mm)	47.67±4.47	38.78–55.89
Length of the femoral neck (in mm)	51.44±5.36	40.34–65.11
Width of the femoral neck (in mm)	31.9±3.71	23.44–40.60
Femoral neck-shaft angle (°)	131.57±3.78	122.86–139.43

Table-II: *Comparison of the parameters between genders (N=70)*

Variables	Male (n=35) Mean±SD	Female (n=35) Mean±SD	p-value
Diameter of the femoral head (in mm)	51.22±2.57 (44.46–55.89)	44.13±2.84 (38.78–49.61)	0.000[S]
Length of the femoral neck (in mm)	53.86±0.97 (42.30–65.11)	49.03±4.33 (40.34–59.14)	0.000[S]
Width of the femoral neck (mm)	34.46±2.79 (29.96–40.60)	29.59±3.05 (23.44–39.13)	0.000[S]
Femoral neck-shaft angle (°)	132.11±4.04 (124.69–138.81)	131.16±3.69 (122.86–139.43)	0.308[NS]

Figures in parentheses indicate range. Comparison between genders was done by unpaired Student's 't' test; S=significant, NS=not significant.

Table-III: *Comparison of the findings of the present study with the previous studies*[3,5,7,8,11-21]

Researchers	Population	FHD (mm)	FNL (mm)	FNW (mm)	NSA (°)
Present study	Bangladeshi (n=70)	47.67±4.47	51.44±5.36	31.9 ±3.71	131.57±3.7
Mishra et al.[3]	Nepalese	44.26±3.58	-	-	132.26±8.36
Nekkanti et al.[5]	South Indian(n=200)	40.09±3.72		28.29±3.44	130.68±5.35
Sengodan & Appusamy[7]	Indian	42.9	-	28.2	134.2
Mahaisavariya et al.[8]	Thai (n=108)	43.98±3.47	46.22±5.14	29.05±2.73	128.04±6.14
Pokharel et al.[11]	Nepalese (n=84)	-	28.29±4.18	36.10±5.67	130.35±8.67
Roy et al.[12]	Eastern Indian	45.30±4.7	-	-	130.57±3.0
Sengodan, Sinmayananthm & Kumar[13]	South Indian(n=400)	42.6		27.5	135.4
Agarwala, Paul & Daolagupu[14]	Southern Assamese, Indian(n=400)	41		28.59	132.62
Rawal et al.[15]	Indian (n=98)	45.41±3.66	48.4±5.56	-	124.42±5.49
Pathak et al.[16]	Indian				128.60
Saikia, Bhuyan & Rongphar[17]	Northeastern Indian (n=92)	-	-	-	139.5±7.5
Umer et al.[18]	Pakistani (n=136)	50.1±3.8	-	-	130.3±6.1
de Sousa et al.[19]	Brazilian (n=110)	46.56±3.6	30.96±2.94	30.4±4.18	
Ahmad et al.[20]	Egyptian	-	-	-	129.46±5.06
Jalali Kondori et al.[21]	Iranian				139.5

FHD: Femoral head diameter; FN: Femoral neck length; FNW: Femoral neck width; NSA: Femoral neck-shaft angle

DISCUSSION

The mean diameter of the femoral head (FHD) in our study population was observed 47.67±4.47 mm. Besides, the mean diameter was found significantly greater among males than that of females (p<0.001). The mean FHD of the present study is higher than that of Thai[8], Nepalese[11] and Indian population[5,13,14], but lesser than that of Pakistani population[18]. Eastern Indian population[12] had larger FHD compared to population of South India[5,7,13] and Southern Assam[14]. The mean FHD found in the present study is comparable to the studies conducted by Rawal et al.[15], Roy et al.[12], and de Sousa et al.[19] on the population India, Eastern India and Brazil respectively. Sexual dimorphism was also observed in population of South India[5,14,22], Southern Assam[15], Malaysia[9] and European Caucasian, American Caucasian, African American & Chinese population[23], which supports our study finding.

The mean length of the femoral neck in our study was 51.44±5.36 mm. Our finding of FNL was larger than that of Thai[8], Brazilian[19], and Nepalese[11] population, but almost similar to the study conducted by Rawal et al.[15] on the Indian population. We also observed that the length was significantly higher (p<0.001) in male than female. Study finding of present study correlated with the study conducted on South Indian[13], Malaysian[9], and European Caucasian, American Caucasian, African American & Chinese population[23].

In the present study, the mean of the width of the femoral neck in our study population was found 31.90±3.71 mm. The value was comparable to the studies conducted on Brazilian population[19] and Thai population[8]. However, Indian population[5,7,13,14] had narrower FNW compared to the present study.

In the present study, mean femoral head diameter and mean femoral neck width were significantly higher (p<0.001) in male than that of female. Similar finding was found in population of South India[5,13,22], Southern Assam[14], Malaysia[8], and European Caucasian, American Caucasian, African American and Chinese population[23].

In the present study, mean femoral neck length of our population was 51.44±5.36 mm. Our mean FNL was larger than that of Thai[8], Brazilian[19], and Nepalese[11] population, but almost similar to the study conducted by Rawal et al.[15] on the Indian population.

In our study, the mean femoral neck length was significantly higher (p<0.001) in male than female. Study finding of present study correlated with the study conducted on South Indian,[22] Malaysian,[9] European Caucasian, American Caucasian, African American & Chinese population.[23]

In the present study, mean NSA of our population was 131.57±3.7°. It was comparable to mean NSA of Pakistani[18], Nepalese[11], Eastern Indian population[12], and population of Southern Assam.[15] Studies conducted by Pathak et al.[16] on Indian and Ahmad et al.[20] on Egyptian population demonstrated lesser NSA as compared to our study. However, studies conducted on the population of South India[13], Northeastern region of India[17], and Iran[21] showed higher NSA than that of the present study.

In the present study, no significant difference was observed in mean neck-shaft angle between male and female. Similar finding was observed on the studies conducted in the population of Mysore, South India[5], Maharashtra, India[24], Eastern India[12], and Malaysia[9]. In contrast, gender differences were observed in several studies done on South Indian[13], Malaysian[9], and European Caucasian, American Caucasian, African American & Chinese population[23] as well as Iranian population.[21]

CONCLUSION

In the present study, the diameter of the femoral head, length and width of the femoral neck were found significantly higher in males compared to its female counterparts. However, femoral neck-shaft angles revealed no significant gender difference. Morphometry of the proximal end of the femur varies among different population as it depends on the age, sex, profession, race and ethnicity. The measurement methods may also contribute to the variation in the morphometric parameters of the proximal end of the femur.

REFERENCES

1. Moore KL, Dalley AF, Agur AMR. Bones of lower limb. In: Moore Clinically Oriented Anatomy. 8th ed. Philadelphia: Wolters Kluwer; 2018.
2. Muley M, Bhuiyan P. Morphometric study of neck of dry adult femora. Int J Anat Res. 2017;5(3.2):4317-20.
3. Mishra AK, Chalise P, Singh RP, Shah RK. The proximal femur – a second look at rational of implant design. Nepal Med Coll J. 2009;11(4):278-80.

4. Zaghloul A, Mohamed EF. Hip joint: embryology, anatomy and biomechanics. Biomed J Sci Tech Res. 2018;12(3):2267.

5. Nekkanti S, Moogali A, Mahtani A, Mruthyunjaya. A comparative analysis of morphological parameters in South Indian hip joints with review of literature. J Anat Soc India. 2020;69(2):71-80.

6. Clohisy JC, Carlisle JC, Beaulé PE, Kim YJ, Trousdale RT, Sierra RJ, et al. A systematic approach to the plain radiographic evaluation of the young adult hip. J Bone Joint Surg Am. 2008;90(Suppl 4): 47-66.

7. Sengodan VC, Appusamy N. Comparative anthropometry analysis of the digital x-rays of the right and left hip joints in an Indian population. J Nat Sci Biol Med. 2020;11(1):3-6.

8. Mahaisavariya B, Sitthiseripratip K, Tongdee T, Bohez EL, Vander Sloten J, Oris P. Morphological study of the proximal femur: a new method of geometrical assessment using 3-dimensional reverse engineering. Med Eng Phys. 2002;24(9):617-22.

9. Baharuddin MY, Kadir MRA, Zulkifly AH, Saat A, Aziz AA, Lee MH. Morphometric study of the proximal femur in Malay population. Int J Morphol. 2011;29(4):1321-5.

10. Igbigbi PS. Collo-diaphysial angle of the femur in East African subjects. Clin Anat. 2003;16(5):416-9.

11. Pokharel B, Pant AR, Chaudhary P, Khanal GP. Morphometric parameters of the proximal femur in Nepalese population: a cross-sectional study. J BP Koirala Inst Health Sci (JBPKIHS). 2020;3(2):8-12.

12. Roy S, Kundu R, Medda S, Gupta A, Nanrah BK. Evaluation of proximal femoral geometry in plain anterior-posterior radiograph in eastern-Indian population. J Clin Diagn Res. 2014;8(9):AC01-3.

13. Sengodan VC, Sinmayanantham E, Kumar JS. Anthropometric analysis of the hip joint in South Indian population using computed tomography. Indian J Orthop. 2017;51(2):155-61.

14. Agarwala V, Paul A, Daolagupu AK. Anthropometric analysis of the hip joint in Southern Assam population using computed tomography. Int J Orthop Sci. 2020;6(1):1133-9.

15. Rawal B, Ribeiro R, Malhotra R, Bhatnagar N. Anthropometric measurements to design best-fit femoral stem for the Indian population. Indian J Orthop. 2012;46(1):46-53.

16. Pathak SK, Maheshwari P, Ughareja P, Gadi D, Raj M P, Gour SK. Evaluation of femoral neck shaft angle on plain radiographs and its clinical implications. Int J Res Orthop. 2016;2(4):383-6.

17. Saikia KC, Bhuyan SK, Rongphar R. Anthropometric study of the hip joint in northeastern region population with computed tomography scan. Indian J Orthop. 2008;42(3):260-6.

18. Umer M, Sepah YJ, Khan A, Wazir A, Ahmed M, Jawad MU. Morphology of the proximal femur in a Pakistani population. J Orthop Surg (Hong Kong). 2010;18(3):279-81.

19. De Sousa EB, Fernandes RMP, Mathias MB, Rodrigues MR, Ambram AJ, Babinski MA. Morphometric study of the proximal femur extremity in Brazilians. Int J Morphol.2010;28(3):835-40.

20. Ahmad MIM, Bushra MT, Galal AT, Ouies SM. Computed tomography reference values estimation for femoral neck shaft angle in Egyptian healthy adults of both sexes. Egypt J Radiol Nucl Med. 2023;54:96.

21. Jalali Kondori B, Asadi MH, Bahadoran H, Dadseresht S. Anthropometric study of hip joint in Tehran population using computed tomography scan. Anat Sci J (ASJ). 2017;14(2):79-82.

22. Waghmode GT, Waghmode UT, Shinde PB. Evaluation of proximal femoral morphometry in plain CT scans in South-Indian population. Indian J Clin Anat Physiol. 2017;4(4):457-9.

23. Edwards K, Leyland KM, Sanchez-Santos MT, Arden CP, Spector TD, Nelson AE, et al. Differences between race and sex in measures of hip morphology: a population-based comparative study. Osteoarthritis Cartilage. 2020;28(2):189-200.

24. Bagaria V, Deshpande S, Kuthe A, Rasalkar DD, Paunipagar BK, Madhugiri TS. Radiographic study of the hip joint to determine anthropometric parameters for Indian population. Eur J Radiol. 2012;81(2):312-6.