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Original Article

Variation of Proximal Femoral Morphometry in Relation to Total Hip Replacement: A Study on Dry Femora

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Abstract

Objective: Objective: Considerable variations exist in geometry of proximal femur across populations, which play an important role in total hip replacement surgeries. However, a rigorous characterization of femoral geometry across different geographical localities in Pakistan has not been performed. We aimed to assess the variations of the proximal femoral geometry in dry human femur bones from two different regions of Pakistan.
Study type settings & duration: A descriptive study was carried out at Islamic International Medical College, Rawalpindi and at three different Medical Colleges in Peshawar from October 2018 to July 2019.
Methodology: After obtaining ethical approvals, complete, fully ossified bones without additional paint or visible pathology from Rawalpindi (N = 98) and Peshawar (N = 112) were included for measurements of neck shaft angle (NSA), vertical head diameter and femoral neck length. NSA was measured from sketches of bones by using goniometer placed parallel to the shaft axis, while regular scale was used for measuring vertical head diameter and neck length. Unpaired T test was performed to compare the variations of femoral geometry in a side- and region-specific manner from Rawalpindi and Peshawar regions of Pakistan.
Results: Means and SD values of NSA, vertical diameter of head and neck length of all bones were 125.85˚± 7.35, 42.17±4.25 mm and 54.2±6mm, respectively. Significant differences (*p* value <0.001) were observed for NSA, vertical diameter of head and neck length between bones from the two regions. The femoral geometry was similar between right and left side bones, except for NSA in Peshawar which was differed significantly.
Conclusion: Significant differences exist in the proximal femoral geometry between the Peshawar and Rawalpindi regions with higher values of NSA, femoral head diameter and femur neck length recorded in Peshawar.
Key words: Femur neck, femur head, human, Pakistan.

Introduction

Femur is the longest and strongest bone in the human body, its head articulates with tibia. It is responsible for weight transmission from vertebral column to tibia. Within the thigh, it is directed obliquely, inferomedially, to support the erect bipedal posture.[1] The oblique neck of femur, about 5cm long, ensures this oblique direction of bone when it connects the head with shaft of femur at an angle known as neck-shaft angle (NSA). This angle is smaller in females while in newborn it is equal to adults.[2,3]

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Authors Contribution

SA & SA* conceptualized the project. SA* & KUR performed the data collection. SA & KUR also did the literature search, statistical analysis, drafting, revision & writing of manuscript.

Biomechanics of hip joint are affected by many clinical conditions such as osteoarthritis and osteoporosis.[4] Fractures of femur are major contributors to morbidity and mortality among older age group[5] and femoral neck being the weakest part, NSA is a chief risk factor for hip fractures.[6] NSA measurements is important for total hip replacement(THR)[7] and is effective treatment in many clinical conditions such as osteoporosis.[6] For a successful THR design and dimension of femur must match the normal anatomy of femur.[8] Before THR the dimensions of the implant are matched with the femur during preoperative planning. On the other hand, long term success rate of surgery might be affected by inappropriate sized or inaccurately placed prosthesis due to aseptic loosening and improper weight distribution, this eventually leads to huge discomfort to the patient.[9] Although a clear kinematic advantage of larger femoral head bearings in THR has been explained in literature but the relation of the amount of increase to patient's benefit in our setup remains elusive.[10] Iliopsoas impingement has been reported in one case with prosthetic head smaller than the native femoral head.[11] Morphology of bone plays an important role in postoperative healing and regaining of normal gait. The NSA and neck length have been found to be useful as predictors for a risk of fracture of neck femur[12] and reduced neck length of implant is associated with reduced hip function.

In medico legal investigation, osteometry is a basic step to identify the deceased as mutilated skeletal remains are still a great challenge for forensic pathologist and physical anthropologist during the assessment of height for age estimation, weight, body build, sex, race and ethnicity.[13] On the other hand, sex can be predicted with a relatively high accuracy from proximal part of femur.[14]

The incidence of THR, a routine treatment for hip OA, has been on rise in Pakistan.[15] The implants used for THR are designed according to anthropometry and biomechanics data.[9] Various factors affect the proximal femoral geometry such as age, sex, genetic, ethnicity, racial, life style, diet and varying level of activity. Several studies report the regional variations in NSA[9,16,17] including the studies from Khyber Pakhtunkhwa and Sindh, which report significant variations in the geometry of proximal femur. However a conclusive investigation on comparative analysis of these parameters in a region-specific manner has not been performed in Pakistan. The aim of present study was to compare variations of anthropometric parameters of femur such as measurement of NSA, vertical diameter of head and femur neck length in dry femora of two different regions of Pakistan. These statistics will provide the baseline data for manufacturing hip implants and may decrease the intra operative and postoperative complication of THR.

Methodology

A descriptive study was carried out from October 2 018 to July 2019 at Islamic international medical college, Rawalpindi and at three different medical colleges in Peshawar. Bones were selected from bone banks including bones from right (N = 103) and left (N = 107) sides. The bones included were complete, fully ossified while painted bones, damaged head of femur or visible pathology such as healed fracture in the region of femoral neck were excluded. Total 98 (right and left) bones from Rawalpindi and 112 (right and left) femurs of unknown age from Peshawar region were observed. Although bones were observed by two researchers at two different places but to maintain inter-rator reliability single method of measurement was searched, discussed in detail (Figure-1)and then selected.

NSA was measured with Goniometer while bone length was measured with the help of wooden scale. Sketches of bones were drawn on plain paper to measure the NSA. Following parameters were measured in all femora.

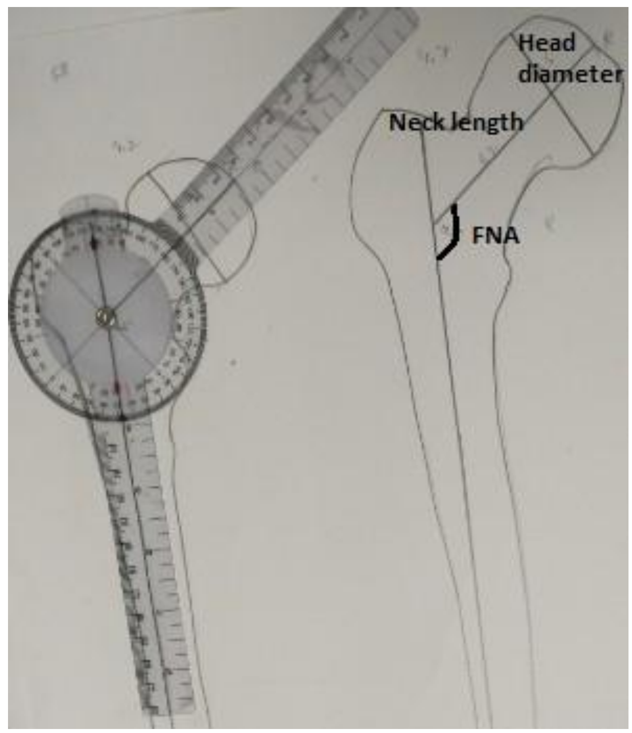

Figure 1: Using paper sketches to measure diameter of head, neck shaft angle and femoral neck length with the help of goniometer and scale.

i) Neck shaft angle[18]: Angle was measured by marking two different axis on paper sketches. Midpoint of head was determined by joining superior and inferior most point on head. Midpoint of neck was determined, and two points were joined together to find out the head neck axis. Femoral shaft axis was determined by joining midpoint of shaft near intertrochanteric line with midpoint at midway between two ends of femur. Femoral NSA was measured at point where two lines meet each other. The two axis were drawn on the sheet and angle was measured by keeping goniometer parallel to shaft axis on paper (Figure-1).

ii) Vertical diameter of head of femur: It was measured as a distance between the upper and lower end of the femoral head in a straight line.

iii) Anterior femoral neck length: The distance between the base of the femoral head and intertrochanteric line at the junction of the neck with shaft was measured by marking midpoint of head and intertrochanteric line.

iv) Ensure inter-observer reliability of results, measurements done by both investigators at each center were shared and were also checked again by co researcher. Then, data was analyzed using SPSS 21. Unpaired t-test was used to compare morphological features between right and left femur and between the two regions of Pakistan. Data was reported as proportions or mean±SD, median, maximum and minimum values.

The ethical approval was taken from Institutional Review Board of Islamic International Medical College, Rawalpindi.

Results

Mean values for NSA, diameter of head, and femur neck length in all bones were125.85˚±7.35, 42.17±4.25mm and 54.2± 6mm respectively (Figure-2). Data is represented as Mean while Error bars represent max and minimum values.

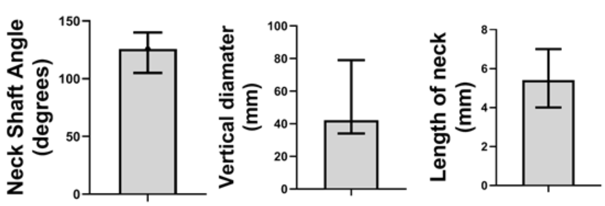

Figure-2: Femur NSA, vertical diameter of head and length of neck for all data pooled together.

A significant difference (*p* <0.001) was found between proximal femoral geometry of Rawalpindi and Peshawar region with a higher values of NSA, femur head diameter and femur neck length were observed in Peshawar (Table-1).

There were no significant differences found in variation in the right and left side bones within the region, except for NSA which differed significantly between right and left side bones in Peshawar. (Table-2).

Discussion

In summary, we report a significant variation in the proximal femoral geometry. The NSA, femoral head diameter and femur neck length lengths were higher in Peshawar than Rawalpindi, but we did not find significantly differences in left and right sides except for NSA in data from Peshawar.

Proximal femoral geometry has clinical significance for several conditions like osteoarthritis and osteoporosis where THR is required.[4] Implants must be designed according to the parameters of the native population.[9] The biomechanical properties of support provided by proximal femur depends upon width and length of neck of femur.[13] Accurate measurement of NSA may enable us to design hip implants with more accurate angle, which will further reduce the complications and increase the onset and frequency of postoperative normal walking.

Knowing the exact head size is valuable in such conditions as it will reduce the post-operative dislocation.[19] Dislocation of head, being a serious complication in THR remains a concern for surgeons as well as patients. Therefore, traditional head sizes of 22, 26, 28 and 32 mm are replaced by large diameter of 60 mm.[20] This may contribute to reduced dislocation rate along with increased range of motion before impingement.[21] Femur implants with larger femoral head size are currently in use in total THR. The most commonly used femoral head sizes for such surgeries are 32 mm and 36 mm.[22] The amount of possible motion with flexion with or without internal rotation increases with increased femoral head size,[10] therefore, an implant with more than 42 mm head size may be recommended for our population.

Table 1: Comparison of mean values of proximal femoral geometry between Peshawar and Rawalpindi regions.

Regions	Neck Shaft Angle		Vertical Diameter of Head (mm)		Length of Neck(mm)	
	Mean ± SD	*p value*	Mean ± SD	*p value*	Mean ± SD	*p value*
Peshawar N =112	130.4˚±3.86	<0.001*	43.62±2.93	<0.001*	55.7±5.9	<0.001*
Rawalpindi N = 98	120.65˚±6.94		40.52±4.89		52.4±5.6	

**p* value= < 0.001

Table 2: Comparison of proximal morphometry of left and right dry femora from Peshawar and Rawalpindi region.

Region	Parameters	Right side of Bone	Left side	*p value*
Peshawar	N=112	N=52	N=60	
	Neck shaft angle	129˚±3.5	131.5˚±3.8	0.001*
	Vertical diameter of femur head	43.6±2.9	43.5±2.9	0.799
	Femur neck length	55.6± 6	55.9±6	0.784
Rawalpindi region	n= 98	n= 51	n=47	
	Neck shaft angle	119.9˚±6.8˚	121.4˚±7.06˚	0.354
	Vertical diameter of femur head	40.56±6.2	40.5±3.06	0.853
	Femur neck length	51.8±5.56	53±5.6	0.262

**p value= < 0.001*

The NSA is based on age, stature, and width of pelvis. NSA higher than 135° is termed coxavalga. When the angle is < 120°, it is termed coxa vara.[3]

The planning of interventions for hip fractures such as THR and internal fixation necessitates proper pre and postoperative measurements of hip parameters.[23] NSA values differ across populations and are partly influenced by age, gender and ethnicity. For example, NSA values for American, British and Korean populations are ≈128-129. However, lower values of 124.95 are reported in Indian population [24] which is ethnically and geographically more relevant to our study cohort. We also performed comparative analysis between right and left side since slightly differences between both sides have been reported in the literature,[24] which have clinical significance in case of hip fracture. Comparing the mean value on right and left side, it was found that Rawalpindi region values are nearly similar to Indian population (Rt 124.78±6.9 and Lt 125.12±5.22) while mean value of Peshawar region bones are nearly similar to Chinese population(R-131.80±4.36º and L-134±4.78º in males & R-132.1±5.94º L-132.8±4.93º in females).[24,25] A study conducted in Mardan Khyber Pakhtunkhwa[8] indicated that NSA of sampled population was 135.47 ± 6.18 while study in Karachi[17] reported 130.3±6.1 respectively. Similar geographic difference also documented from the current study as the mean value of NSA for Peshawar (130.4˚± 3.86) is differed significantly from Rawalpindi (120.65˚± 6.94). Standard deviation of mentioned studies reveal data was dispersed which may be due to age of the subject which also reported by Umer et al.[17] Therefore, NSA in right and left sided hip implants can be different.

Neck length was relatively longer in our population as compare to values reported in Indians population (36mm11 and 44mm21), which explains the variation in the size of neck length. Mean value of neck length is important as shorter neck length has many postoperative complications due to further reduction in length. Postoperative femoral neck shortening has been associated with reduced hip joint function as hip abduction is affected. Limping was documented as adverse effect of neck shortening.[26]

Therefore, to avoid these complication, neck length of hip implants needs to be adjusted to mean value of our population.

Taken together, we show that the racial differences are associated with proximal femoral morphology. We report significant differences in femoral geometry between Peshawar and Rawalpindi cohorts but no difference between right and left sides for any parameter except for NSA in Peshawar. Our findings have clinical implications for planning the implant size in hip surgery. We suggest that in order to decrease the postoperative complication, measurements of the manufactured hip implants should be according to femoral geometry of respective populations.

Future studies should characterize femur morphology in a gender-specific manner, which may be helpful in further reducing postoperative complication in THR.

Conflict of interest: None declared.

References

1. Keith L. Moore, Arthur F. Dalley AMRA. Clinically Oriented Anatomy - Keith L. Moore, Arthur F. Dalley, A. M. R. Agur - Google Books [Internet]. wolter and Kluwer/ Lippin cott williams and Wilkin, 2017 (Accessed on 15th April 2019). Available at: https://books.google.com.pk/books?id=-Le5bc5F0sYC&printsec=frontcover&dq=keith+l+moore&hl=en&sa=X&ved=0ahUKEwiE2u7VrdHhAhVS_XMBHX1wDDoQ6AEILDAB#v=onepage&q=keith l moore&f=false
2. Shivashankarappa A, Nc P, Havaldar PP. A study on femur neck shaft angle and its clinical importance. Int J Orth Sci 2017; 3(4): 755-7.

3. Chaudhary PB, Shirol VS, Virupaxi RD. A morphometric study of femoral length, anterior neck length, and neck-shaft angle in dry femora: A cross-sectional study. Indian J Heal Sci Biomed Res 2017; 10(3): 330-4.
4. Wellsandt E, Zeni JA, Axe MJ, Snyder-Mackler L. Hip joint biomechanics in those with and without post-traumatic knee osteoarthritis after anterior cruciate ligament injury. Clin Biomech 2017; 50: 63-9.
5. Cornwall R, Gilbert MS, Koval KJ, Strauss E, Siu AL. Functional Outcomes and Mortality Vary among Different Types of Hip Fractures. Clin Orthop Relat Res 2004; 425(425): 64-71.
6. Mingli F, Huiliang S, Guanglei C, Zheng L, Shibao L, Limin L, et al. A clinical study on arthroplasty for failed internal fixation of hip fractures and review of literature. Pak J Med Sci 2017; 33(4): 798-803.
7. 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 Diagnostic Res 2014; 8(9): AC01-3.
8. Akbar W. A radiographic study of neck shaft angle in population of Mardan region , Khyber Pukhtonkhwa. Pakistan. Biomedica 2015; 31(2): 108-14.
9. 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 Diagnostic Res 2014; 8(9): AC01-3.
10. Cross MB, Nam D, Mayman DJ. Ideal femoral head size in total hip arthroplasty balances stability and volumetric wear. HSS J 2012 ; 8(3):270-4.
11. Hernández-Vaquero D, Delgado-Sevillano R, de la Flor-García MR. Groin pain after metal-on-metal hip resurfacing prosthesis. SAGE open Med case reports, 2014. (Accessed on 30th September 2021). Available at: http://www.ncbi.nlm.nih.gov/pubmed /27489648
12. Ghosh I, Sengupta G, Basu P, De A. Assessment of Relationship Between Neck Shaft Angle and Neck Length With Interepicondylar Distance in Femur. Int J Anat Res 2015; 3(4): 1710-5.
13. Hussain SS, Joseph RAN. A Morphometric Study of Femur and Its Clinical Importance. Int J Intg Med Sci 2016; 3(7): 341-85.
14. Mitra A, Khadijeh B, Vida AP, Ali RN, Farzaneh M, Maryam VF, et al. Sexing based on measurements of the femoral head parameters on pelvic radiographs. J Forensic Leg Med 2014; 23: 70-5.
15. Saeed UB, Ahmad KRD, Zain-Ur-Rehman M, Yasin A. Short term evaluation of total hip arthroplasty; our experience at tertiary care center. J Pak Med Assoc 2015; 65(11 Suppl 3): S190-4.
16. Pathak SK, Maheshwari P, Ughareja P, Gadi D, Prashanth RM, Gour SK. Evaluation of femoral neck shaft angle on plain radiographs and its clinical implications. Int J Res Orthop 2016; 2(4): 383.
17. Umer M, Sepah YJ, Khan A, Wazir A, Ahmed M, Jawad MU. Morphology of the proximal femur in a Pakistani population. J Orth Surg 2010; 18(3):279-81.
18. Gullapalli A, Kumar Inuganti A. Morphometric study of femoral neck shaft angle and its clinical significance. Int J Anat Res; 2017(2): 4261-4.
19. Dawson-Amoah K, Raszewski J, Duplantier N, Waddell BS. Dislocation of the hip: A review of types, causes, and treatment. Ochsner J 2018; 18(3): 242-52.
20. Lombardi AV, Skeels MD, Berend KR, Adams JB, Franchi OJ. Do Large Heads Enhance Stability and Restore Native Anatomy in Primary Total Hip Arthroplasty? Clin Orthop Relat Res 2011; 469(6): 1547-53.
21. Girard J. Femoral head diameter considerations for primary total hip arthroplasty. Orthop Traumatol Surg Res 2015; 101(1): S25–9. 22.
22. Tsikandylakis G, Mohaddes M, Cnudde P, Eskelinen A, Kärrholm J, Rolfson O. Head size in primary total hip arthroplasty. EFORT Open Rev 2018 ; 3(5): 225-31.
23. Boese CK, Frink M, Jostmeier J, Haneder S, Dargel J, Eysel P, et al. The Modified Femoral Neck-Shaft Angle: Age-and Sex-Dependent Reference Values and Reliability Analysis. Biomed Res Int, 2016. (Accessed on 10th January 2021). Available at: http://dx.doi.org/10.1155/2016/8645027
24. Verma M, Joshi S, Tuli A, Raheja S, Jain P, Srivastava P. Morphometry of proximal femur in Indian population. J Clin Diagnostic Res 2017; 11(2): AC01-4.
25. Lin KJ, Wei HW, Lin KP, Tsai CL, Lee PY. Proximal Femoral Morphology and the Relevance to Design of Anatomically Precontoured Plates: A Study of the Chinese Population. Sci World J 2014; 2014: 6-12.
26. Chen X, Zhang J, Wang X, Ren J, Liu Z. Incidence of and factors influencing femoral neck shortening in elderly patients after fracture fixation with multiple cancellous screws. Med Sci Monit 2017; 23: 1456-63.