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Indian Journal of Clinical Anatomy and Physiology

Journal homepage: https://www.ijcap.org/

Original Research Article

Morphometric analysis of proximal femur in Indian population and its implications in Total Hip Arthroplasty

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ARTICLE INFO

Article history:
Received 09-01-2024
Accepted 23-02-2024
Available online 06-05-2024

Keywords:
Hip prosthesis
Artificial implants
Femur head
Femur neck
Femur anthropometry

ABSTRACT

Background: Geometric understanding of the proximal end of femur is significant for functional bipedal erect posture and in pre-operative planning of osteotomy as well as the design and development of implants for THA. Moreover, the anthropological parameters of any bone are determined by genetic and environmental factors such as age, race, gender and lifestyle and this leads to racial variations in the morphological parameters of proximal end of femur owing to lifestyle, physique, applied force and their distribution in India population.

Materials and Methods: The current study was designed to study and compare the morphology of proximal end of femur in Indian population and was conducted on 94 dry human cadaveric bones of unknown age and sex to determine the morphology of the proximal end of femur.

Results: We observed the Femur Length as 426.6 ± 15.82 mm, Femur Neck Length as 3.455 ± 0.378 mm and Neck Shaft Angle as 125.27 ± 2.54° amongst other parameters.

Conclusion: The findings also revealed significant variations in the morphological parameters among different populations, emphasizing the importance of considering racial diversity in the design and selection of implants for THA for improving the success and longevity of hip arthroplasty procedures.

1. Introduction

Total Hip Arthroplasty (THA) is a common method of treating hip joint failure occurring due to osteoarthritis, rheumatoid arthritis, osteonecrosis, trauma and bone tumours.[1] Here the geometric understanding of the proximal end of femur is not only significant for functional bipedal erect posture but becomes an essential parameter in pre-operative planning of osteotomy as well as the design and development of implants for THA.[2] An accurate measurement is vital in selection of the implant to minimize the risk of complications like aseptic loosening, improper load distribution and discomfort resulting from mismatch as well as to ensure long term success through proper alignment of the prosthesis to be implanted.[3]

Moreover, the anthropological parameters of any bone is determined by genetic and environmental factors such as age, race, gender and lifestyle[4,5] and this leads to racial variations in the morphological parameters of proximal end of femur owing to lifestyle, physique, applied force and their distribution in India population. However, currently a range of standard sized femur implants designed from anthropometric data of western population are used for THA leading to discrepancy in regards to the measurements and this non-availability of data for Indian population can lead to complications in the long run.[6,7]

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https://doi.org/10.18231/j.ijcap.2024.005

The current study was designed to study and compare the morphology of proximal end of femur in Indian population with others.

2. Materials and Methods

The current study was conducted at the Department of Anatomy, Pramukhswami Medical College, Karamsad and the other medical colleges of Central Gujarat Region. Around 94 dry human cadaveric bones of unknown age and sex were studied to determine the morphology of the proximal end of femur. All adult dry femur bones without any visible osseous pathologies like tumours, deformities, fractures, trauma were included in the study.

All measurements of the proximal end of femur were taken using Digital sliding Vernier caliper with 0.01 mm precision, goniometer and an Osteometric board. All measurements were taken by a single author to avoid any inter-observer error and each measurement was repeated thrice to avoid any intra observer error. Arithmetic average of the three readings was considered the final reading for the study.

The morphological examination of the proximal end of femur was done in following two steps:[8,9]

The following parameters were observed:

1. **Femur length (FL):** 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.
2. **Femoral head diameter (FHD):** It was measured as the average of the diameter of the femoral head in the cranio caudal axis (distance in a straight line from the upper end to the lower end of the femoral head) and sagittal axis (distance in a straight line from the front end and behind end of the femoral head).
3. **Femoral neck length (FNL):** The length of femoral neck was measured as the distance between the inferior region of base of femoral head and the lower end of intertrochanteric line.
4. **Femoral neck width (FNW):** The diameter of the femoral neck in cranio-caudal axis (cc-axis) was measured as the distance in a straight line from the upper end to the lower end of the anatomical neck of the femur and the diameter of femoral neck in sagittal axis (s-axis) was measured as the distance in a straight line from the front end to the rear end of the femur.
5. **Neck-shaft angle (NSA):** It was measured as the angle intersected between the long axis of the shaft of femur and the long axis of the neck of femur. Femoral shaft axis was considered as a vertical line from the tip of greater trochanter and Femoral neck axis was drawn by joining the center of head of femur and the midpoint of Intertrochanteric line. NSA was measured in the frontal plane by means of goniometry.
6. **Length of intertrochanteric line (LIL):** It was measured as the distance in a straight line joining the highest and lowest point of trochanters.

The data was tabulated in Microsoft Office Excel 2016 software (Microsoft Corp.). The results were tabulated and analyzed using descriptive statistics. For the statistical analysis the Unpaired Student T-test was used to compare the morphological parameters between population of different geographic locations.

3. Results

The results obtained through morphometric analysis have been depicted in Table 1.

4. Discussion

As observed in Tables 2 and 3 we found a significant difference for the measured value when compared to those of different studies at the given degree of freedom (DF), i.e. 'p' value was < 0.05 implying that the morphometric parameters of proximal femur are significantly different across different populations.

Racial differentiation in the morphometric parameters of proximal femur across different populations have also been reported by De Sousa E et al[20] in their study evaluating the variables with Auto CAD 2000 in Brazilian population. Baharuddin MY et al[21] concuded that femur in Malaysian population were generally smaller and different than western femur in many morphological parameters. Umer et al.[22] also reported that the morphology of proximal femur in standardized antero-posterior pelvic radiographs in Pakistani population differed significantly than that from western population. These studies highlight the racial variations in parameters of proximal femur.

According to Reddy et al,[23] an implant mismatch, has been strongly correlated with increased risk of intra-operative fracture or limb lengthening as well as micro-motion leading to increased incidences of anterior thigh pain, improper load distribution, aseptic loosening as well as osteolysis. Implants and prosthesis designed for western population are larger in size as well as the angles and orientations are mismatch to other populations. It emphasizes the need to design these implants based on anthropometric and bio-mechanic data for a specific population thereby minimizing complications.

Since subdivisions of Indian population do not have specific implants designed for them, the observations of present study can be used to replicate the normal anatomy as far as possible. Improved knowledge of the morphometric parameters of proximal femur will not only aid surgeons during total hip arthroplasty but the data could also be used as a guideline to design appropriate fit implants for the

Table 1: Morphometric measurements of proximal femur in mm

	FL	FHD		FNL	FNW		NSA	LIL
		cc-axis	s-axis		cc-axis	s-axis		
Mean ± SD	426.6 ± 15.82	39.60 ± 2.28	37.69 ± 3.99	3.455 ± 0.378	31.60 ± 2.32	26.47 ± 3.20	125.27 ± 2.54	6.71 ± 0.54
Median	42.63	39.36	37.67	3.48	32.09	27.28	125.00	6.70
Range	383.7 – 465.7	35.51 – 45.27	31.16 – 46.85	2.13 – 4.47	23.76 – 41.63	19.31 – 31.51	116 – 132	5.8 – 8.8

Table 2: Comparison of morphometric parameters of femur with Indian population

S. No.	Parameters		Present Study	Ravi et al[10]	Khan SM & Saheb SH[11]	Gujar et al[12]	Siwach RC[13]	Dhivya S et al[14]
1.	Population		Western Gujarat	South Indian	South Indian	Western Gujarat	North Indian	South Indian
2.	Sample Size		94	592	250	250	150	158
3.	FL		426.62 ± 15.82	447.1 ± 28.94*	446.2 ± 26.39*	438 ± 25.64*	36.9 ± 4.11*	41.66 ± 3.03*
4.	NL		34.55 ± 3.78	36.3 ± 5.4*	36.3 ± 4.2*	34.4 ± 3.8*	37.23 ± 4.65*	
5.	NSA		125.27 ± 2.54	136.80 ± 4.45*	137	136.3 0 +6.0*	123.5 ± 4.34*	134.15 ± 5.52*
6.	FHD	CC-axis	39.60 ± 2.28	—	—	—	43.95 ± 3.06*	—
		S-axis	37.69 ± 3.99	—	—	—	—	—
7.	FNW	CC-axis	31.60 ± 2.32	—	—	—	31.87 ± 2.91	—
		S-axis	26.47 ± 3.20	—	—	—	24.90 ± 2.94*	—
8.	LIL		6.71 ± 0.54	—	—	—	—	—

*The p-value is significant when the respective study is compared with the present study. (i.e. $p < 0.05$)

Table 3: Comparison of morphometric parameters of femur with different population

S. No.	Parameters		Present Study	Menezes TM et al[15]	Zulyan T, Murshid KA[19]		Unnanuntana A et al[16]	Cho HJ et al[17]	Rubin PJ et al[18]
1	Population		Indian	Brazil	Arabian		Americans & Caucasians	Korean	French
	Type of measurement		Cadaveric bones	Cadaveric bones	Cadaveric bones		Digital Photographs	3D Reconstruction	Radiographic Reconstruction
2	Sample Size		94	29	36 (R)	36 (L)	200	202	32
3	FL		426.62 ± 15.82		416.8 ± 68.6*	428.4 ± 24.9*			443.6 ± 21.8*
4	NL		34.55 ± 3.78	2.55±0.42*					
5	NSA		125.27 ± 2.54				132.69 ± 5.91*	130.27 ± 6.25*	122.9 ± 7.6*
6	FHD	CC-axis	39.60 ± 2.28	4.42 ± 0.44*	45.2 ± 4.0*	43.4 ± 3.2*	52.09 ± 4.43*	45.50 ± 3.39*	43.4 ± 2.6*
		S-axis	37.69 ± 3.99	4.38 ± 0.47*	44.7 ± 4.1*	44.3 ± 3.3*	—	—	—
7	FNW	CC-axis	31.60 ± 2.32	3.10 ± 0.35	30.7 ± 3.6	30.6 ± 3.0	—	—	—
		S-axis	26.47 ± 3.20	2.50 ± 0.37	26.3 ± 3.1	25.5 ± 2.7	—	—	—
8	LIL		6.71 ± 0.54	4.79 ± 0.62*	—		—	—	—

*The p-value is significant when the respective study is compared with the present study. (i.e. $p < 0.05$)

population.

Since the study was done on dry cadavers it was not possible to ensure that right and left sided femurs belonged to a particular individual. Moreover, we did not observe significant difference in measurements for right and left sided femur, hence the data has been presented accordingly. We also did not categorise the data for gender, but it will be noteworthy to observe any significant difference there as well as observe the horizontal and vertical offset of the femurs for further understanding.

5. Conclusion

The findings revealed significant variations in the morphological parameters among populations, emphasizing the importance of considering racial diversity in the design and selection of implants for THA for improving the success and longevity of hip arthroplasty procedures in India.

6. Source of Funding

None.

7. Conflict of Interest

None.

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Cite this article: Contractor JB, Umraniya B, Singh P. Morphometric analysis of proximal femur in Indian population and its implications in Total Hip Arthroplasty. *Indian J Clin Anat Physiol* 2024;11(1):27-31.