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Original article

Morphometric Study of Proximal End of Dry Adult Femora: Clinical Significance

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Abstract:

Introduction: A good understanding of morphometric measurements of the proximal femur is essential in order to decrease the risk of complications associated orthopedic surgeries performed in the proximal femur due to traumatic injury, metabolic or vascular causes, and to achieve proper alignment of prosthesis to be implanted. The purpose of this study is to evaluate morphometry of neck of femur in Eastern Indian population.

Materials and Methods: The study was conducted on 50 dry adult femora [30 Right(Rt) and 20 Left(Lt)] available in the department of Anatomy of Medical College Kolkata, India. Digital Vernier Caliper and Goniometer was used for the measurements.

Observation and Results: a)Mean and Standard Deviation(SD) of Vertical length of Head of femur was Rt side: 38.56±2.50mm and Lt side: 38.07±3.43mm.

b) Mean and SD of Width of neck of femur was Rt side: 28.84±2.71mm and Lt side:28.09±2.29mm.

c) Mean and SD of length of Neck of femur on anterior aspect was Rt side:26.37±2.92mm and Lt side:26.12±3.42mm.

d) Mean and SD of length of Neck of femur on posterior aspect was Rt side:31.65±2.75mm and Lt side:26.69±3.11mm.

e) Neck-shaft angle on both sides were calculated.

Conclusion: Indian dimensions of proximal end of femur are different as compared to that of the values in other part of the world. Present study will be very useful for crafting suitable implants used for surgical correction of fracture neck femur in Eastern Indian population.

Keywords: Morphometry, Neck-shaft angle, Implant, Prosthesis, Width of neck, Vertical length of head of femur, Length of neck.

Introduction:

The femur is the longest and strongest bone in the human body[1]. It endures the mechanical load of whole body. We stand erect on our lower limbs. Body weight is transmitted from pelvis to head, neck and upper end of femur. So the resultant force is transmitted through the proximal end of femur. Here lies the importance of our study. The architecture of different parts of femur changes after child starts walking. It is very difficult to identify sex by individual femur bones. Generally male femur bones are longer, thicker and heavier than female counterparts. So gender determination is not conclusive by femoral study.

Different studies have shown that values of parameters for different races are different because of different diet, heredity, weather and other environmental factors[15]. In India malnutrition (mainly calcium and vitamin D3 deficiency) plays major role in fracture. Fracture neck femur is quite common in old age especially senile and menopausal osteoporosis. Increasing population of senior citizens is due to benefits of modern medicine. The implants used for surgical treatment of femoral fractures include dynamic hip screws, cancellous screws, blade and plates, different types of prosthesis like Austin Moor, Thompson's, Charnley's, Muller's prosthesis, unipolar and bipolar prosthesis etc[2].

In case of hip arthroplasty it is mandatory that the design and dimensions of femoral prosthesis should match with proximal femur. In case of ill-fitting prosthesis hip dislocation, implant fractures are common. But the implants available in the market are exclusively designed according to the western dimensions. The usage of these oversized implants adversely affects the functional end result of surgery[11].

Moreover not many studies are performed on morphometric analysis of proximal end of femur in Indian population. This study was thus carried out to define the morphometry of proximal end of femur in Eastern Indian population. This will help in modification of implant size for making prosthesis suitable for Eastern Indian population and in better choosing of prosthesis for better surgical outcome.

Materials and Methods:

The study was conducted on 50 dry adult femora from the anatomy department of Medical College Kolkata. Among the femurs 30 were of right side and 20 were of left side.

Exclusion Criteria:

- Grossly deformed bone
- Fragmented or damaged bone
- Bones with non prominent bony landmarks

Instruments used are as follows:

1. Digital Vernier Caliper (accuracy 0.01mm)
2. Goniometer (accuracy 1 degree)

All the lengths were measured using digital vernier caliper and neck-shaft angle was measured using goniometer.

The following parameters were recorded:

A. **Vertical length of head of femur:** It is the vertical diameter of the femoral head measuring the straight distance between the highest and lowest point of the head[15].(Figure1)

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Figure1: Image illustrating measurement of Vertical length of Head of femur

B. **Width of neck of femur:** It is measured at the narrowest part of femoral neck in supero-inferior direction[11].(Figure 2)

Figure 2 : Image illustrating measurement of width of neck of femur.

C. **Length of neck of femur on anterior aspect:** It is the distance between the base of the head and inter-trochanteric line. It is measured along a line perpendicular to the intertrochanteric crest[11].(Figure 3)

Figure 3 : Image illustrating measurement of length of neck of femur on anterior aspect.

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D. **Length of neck of femur on posterior aspect:** It is the distance between the base of the head and intertrochanteric crest. It is measured along a line perpendicular to the intertrochanteric crest[11].(Figure 4)

Figure 4 : Image illustrating measurement of length of neck of femur on posterior aspect.

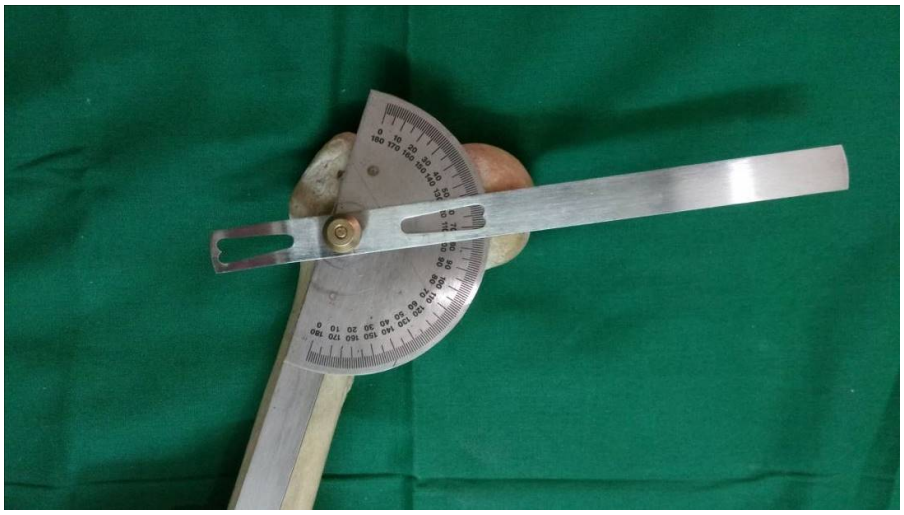
E. **Neck-Shaft angle(NSA):** It is the angle formed by neck axis and shaft axis of femur. This angle is also named as caput collum diaphysis(CCD) or cervico diaphysial angle[1,16].(Figure 5)

Neck axis: It is the line drawn from the centre of the femoral head to the centre of the femoral neck at it's narrowest part.

Shaft axis: It is the line drawn from the middle of the femoral condyles to the middle of the greater trochanter in two planes.

The mean NSA in adults ranges from 125º to 140º(on an average 135º). The NSA is widest at birth and diminishes gradually until the age of 10 years(Birkenmaier et al 2010).

Figure 5 : Image illustrating measurement of Neck-Shaft angle.



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Results:

Vertical length of head of femur: The vertical length of head of femur on right side ranged from 33.03-42.72mm with a mean of 38.56±2.50mm.

The vertical length of head of femur on left side ranged from 32.51-44.51mm with a mean of 38.07±3.43mm.

Table 1: Vertical length of Head of femur.

Side	Number of bones	Minimum (mm)	Maximum (mm)	Mean (mm)	Standard Deviation
Right	30	33.03	42.72	38.56	2.50
Left	20	32.51	44.51	38.07	3.43

Width of Neck of femur: The mean width of neck of femur on right side was estimated to be 28.84±2.71mm with a range between 22.16-34.63mm.

The mean width of neck of femur on left side was estimated to be 28.09±2.29mm with a range between 24.46-32.88mm.

Table 2: Width of Neck of femur.

Side	Number of bones	Minimum (mm)	Maximum (mm)	Mean (mm)	Standard Deviation
Right	30	22.16	34.63	28.84	2.71
Left	20	24.46	32.88	28.09	2.29

Length of neck of femur on anterior aspect: The mean length of neck of femur on anterior aspect on right side was estimated to be 26.37±2.92mm with a range between 20.55-31.02mm.

The mean length of neck of femur on anterior aspect on left side was estimated to be 26.12±3.42mm with a range between 20.35-32.88mm.

Table 3: Length of Neck of femur on anterior aspect.

Side	Number of bones	Minimum (mm)	Maximum (mm)	Mean (mm)	Standard Deviation
Right	30	20.55	31.02	26.37	2.92
Left	20	20.35	32.88	26.12	3.42

Length of neck of femur on posterior aspect: : The mean length of neck of femur on posterior aspect on right side was estimated to be 31.65±2.75mm with a range between 25.99-37.84mm.

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The mean length of neck of femur on posterior aspect on left side was estimated to be 29.69±3.11mm with a range between 23.97-35.98mm.

Table 4: Length of Neck of femur on posterior aspect.

Side	Number of bones	Minimum (mm)	Maximum (mm)	Mean (mm)	Standard Deviation
Right	30	25.99	37.84	31.65	2.75
Left	20	23.97	35.98	29.69	3.11

Neck-Shaft angle(NSA): The NSA of femur on right side ranged from 115º-138º with a mean of 124.53±6.35º.

The NSA of femur on right side ranged from 110º-140º with a mean of 126.9±7.67º.

Table 5: Neck-Shaft Angle.

Side	Number of bones	Minimum (degrees)	Maximum (degrees)	Mean (degrees)	Standard Deviation
Right	30	115	138	124.53	6.35
Left	20	110	141	126.9	7.67

DISCUSSION:

Previously many studies were performed regarding the various parameters of femur using different materials like dry bones, cadaveric specimens, plain radiographs, Computed Tomography(CT) scans and Magnetic Resonance Imaging(MRI) scans. Several quantitative anatomical studies of adult femora belonging to different races, culture and ethnic group have been carried out in different countries.

Vertical length of head of femur: The values of vertical length of head of femur in present study was less than that in most of the previous studies.

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Table 6: Comparison of Vertical length of Head of femur with previous studies.

Study	Year	Country	Material for study	Mean (in mm)
Singh & Singh[3]	1972	India	Dry bones	Male- >45.50 Female-<41.50
Anuj et al[4]	2013	India	Dry bones	Male- Right-45.21 Left-46.18 Female- Right-40.79 Left-41.55
Present study	**2018**	**India**	**Dry bones**	**Right-38.56 Left-38.07**

Width of Neck of femur: The value of width of neck of femur in present study was less than that in most of the previous studies. However the observations were comparable with the studies done by Muley Mrinal et al [10] and Baharuddin MY et al [6].

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Table 7: Comparison of Width of neck of femur with previous studies.

Study	Year	Country	Material for study	Mean(in mm)
Taner Ziylan et al[5]	2002	Turkey	Dry bones	Right-30.70 Left-30.60
AK Mishra et al[6]	2009	Nepal	Cadaves	30.52
Edurardo Branco et al	2010	Brazil	Radiographs	Right-30.96 Left-31.00
Baharuddin MY et al[7]	2011	Malaysia	CT scans	Males-28.90 Females-26.00
D Ravichandran et al[8]	2011	India	Dry bones	30.99
Muley Mrinal et al[11]	2017	India	Dry bones	Right-29.38 Left-28.86
Present study	**2018**	**India**	**Dry bones**	**Right-28.09** **Left-28.84**

Length of neck of femur on anterior aspect: The length of neck of femur on anterior aspect in present study was less than all the previous studies.

Table 8: Comparison of Length of Neck of femur on anterior aspect with other studies.

Study	Year	Country	Material for study	Mean (in mm)
Edurardo Brancho et al	2010	Brazil	Radiographs	Right-30.10 Left-30.50
D Ravichandran et al[8]	2011	India	Dry bones	30.09
Osorio H et al[9]	2012	Chile	Dry bones	35.90
Subhas Gujar et al[10]	2013	India	Dry bones	Right-34.50 Left-34.20
Muley Mrunal et al[11]	2017	India	Dry bones	Right-34.96 Left-33.42
Present study	**2018**	**India**	**Dry bones**	**Right-26.12** **Left-26.37**

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Length of neck of femur on posterior aspect: The length of neck of femur on posterior aspect in present study was less than values of the previous studies.

Table 9: Comparison of Length of Neck of femur on posterior aspect with other studies.

Study	Year	Country	Material for study	Mean (in mm)
D Ravichandran et al[8]	2011	India	Dry bones	33.68
Muley Mrunal et al[11]	2017	India	Dry bones	Right-39.55 Left-40.00
Present study	**2018**	**India**	**Dry bones**	**Right-31.65** **Left-29.69**

Neck-Shaft angle(NSA): The NSA of femur is widely variable between the populations of the two hemispheres. The value of NSA in present study was slightly more than that observed by PF Umbese [11] and Amith R et al [13] and less than PA Toogood [12] and HD Atkinson and in line with the study by Liang J.

Table 10: Comparison of NSA of femur with previous studies.

Study	Year	Country	Material for study	Mean NSA (in degrees)
M Lequesne	2004	France	X-ray	132.8
PF Umebese[12]	2005	Nigeria	X-ray	121.0
PA Toogood[13]	2008	America	Dry bones-Digital photo	129.2
Liang J	2009	China	CT	126.2
HD Atkinson	2010	England	CT	Male-129 Female-128
Amith R et al[14]	2016	India	Dry bones-Computer assisted	121.2
Present study	**2018**	**India**	**Dry bones**	**Right-124.53** **Left-126.9**

Conclusion:

In today's era, where the average life expectancy is ever increasing, we are also faced with the responsibility of caring for an increasing proportion of the elderly. And as we all know that, maintaining the mobility of such a person can improve both their physical & mental wellbeing, as desired once by the definition of HEALTH.

The present study is aimed at adding to our existing knowledge of the morphometry of proximal end of femur with their variations, which may be found relevant for:

1. Diagnosis of congenital & acquired pathologies of hip joint.
2. Designing prosthesis for hip replacement
3. Decrease the risk of complications by allowing prognosis to be judged by the morphometry & biomechanics of the pelvic girdle & allowing proper and early rehabilitation. Environmental factors, genetic factors, physical activity, nutritional status influence the size of the bones. This can explain the difference in findings from the different parts of the country (north, south, east, west or central India) or in different race or ethnic groups.

The findings of our study are vital for accurate design of side specific proximal femoral prosthesis that would prevent dislocation, infection, peri-prosthetic fracture, loosening, acetabular wear and tear, unexplained persistent pain etc. The precise knowledge about the variations in morphology and morphometry of proximal femur would help clinicians, orthopedic surgeons, prosthetic designers and radiologists for better understanding about the pathologies of hip region which aids in accurate diagnosis and in planning a suitable treatment. From this study we can conclude that we should go for smaller size proximal femoral prosthesis for Eastern Indian population. Larger study with larger sample size belonging to different ethnic groups, races, culture is required to minimize error and to acquire more accurate data.

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