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MORPHOMETRIC ANALYSIS OF PROXIMAL FEMUR AND THEIR RELATIONSHIP WITH MAXIMUM FEMUR LENGTH

Clinical Anatomy

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ABSTRACT

Incidence of proximal femoral fractures is on increasing trend owing to poor dietary habits, osteoporosis, chronic corticosteroid uses and various other hormonal or traumatic factors; hence requirement of total hip replacement and hemiarthroplasty increases. Orthopedic surgeons are facing problems with dimensions of implant which are mostly available according to western population. Use of these ill fitted implants can adversely affect the outcome. This study was done to measure the proximal femoral geometry and its correlation with maximum femur length in north Indian population. 74 normal adult femora of unknown age and gender without any gross pathology were obtained from the department of Anatomy, Motilal Nehru Medical College, Prayagraj. Morphometric parameters were measured with the help of osteometric board, vernier caliper, thread, colored marker and goniometer. The mean value of all the parameters were calculated as head height- 41.68 mm, horizontal head diameter- 42.3mm, vertical head diameter- 42.13mm, head circumference- 13.79 mm, anterior neck length - 29.64mm, posterior neck length - 37.48mm, neck width - 28.56mm, neck shaft angle-130.08, torsion angle -14.33˚and maximum length of femur - 43.41cm. Linear correlation was calculated between proximal femoral parameters and femur length by using linear regression. Pearson's correlation coefficient was also calculated. Study concluded that there is significant difference in proximal morphometric data of femora of Indian population as compared to western population. Therefore, the results may be helpful for designing implants suitable to Indian population. Furthermore, the linear regression equations derived in the study is of use in forensic sciences and anthropometric calculations.

KEYWORDS

Maximum femur length, Neck-shaft angle, Neck length, Linear regression

INTRODUCTION

Despite being the longest and strongest bone of our body, the proximal part of femur is prone to fractures as it bears maximum brunt of the body weight. Other factors such as osteoarthritis, Rheumatoid arthritis, road traffic accidents, congenital anomalies, chronic corticosteroid use and bone tumors may lead to fractures of proximal femora, thus increasing the requirement of total hip replacement or hemiarthroplasty. Orthopedic surgeons are facing problems with the size of implants. Oversized implants may lead to fracture while undersized implant would sink leading to pain and instability of joint.

The implants available in India are mainly according to the dimensions of western population. As we know that data available on the proximal femoral dimensions of cadaveric femur in India is limited, so this study may be useful for designing suitable modified implants for Indian population.

MATERIAL AND METHODS

This study was done in the department of Anatomy, Moti Lal Nehru Medical College, Prayagraj. It was a descriptive cross-sectional study conducted on maximum available samples obtained from the bone room.74 femora free from any gross deformity and of unknown age and gender were included in the study. Out of which, 38 were of right side and 36 of left side. With the help of vernier caliper accurate to 0.01mm and goniometer accurate to 1˚, osteometric board, colored maker and thread the following femoral measurements were performed- Head height, vertical and horizontal head diameter, head circumference, neck shaft angle, anterior and posterior neck length, neck width, torsion angle and maximum length of femur. The osteometric measurement criteria of femur parameters were according to the standard anthropometry handbook [1].

Head height:
distance between highest and lowest point of femoral head measured with the help of Vernier Caliper (Fig. 1a).

Vertical diameter of head:
distance between the highest and lowest point of articular surface of the head taken perpendicular to the neck (Fig.1c).

Horizontal diameter of head:
maximum anterior and posterior diameter of femur head (Fig.1b).

Circumference of head:
along its articular margin, measured with the help of thread and calipers (Fig.1d).

Neck shaft angle:
between axes of neck and shaft of femur, measured with the help of colored marker and Goniometer. Axis of neck was determined by marking the midpoint of head in terms of maximum diameter and neck in terms of least vertical diameter. While the axis of shaft was determined by marking the midtrochlear point at the lower end up to the midpoint of coronal diameter of subtrochanteric flattening (Fig. 2c).

Anterior neck length:
measured along the long axis of neck between base of the head to midpoint of intertrochanteric line (Fig. 2a).

Posterior Neck Length:
distance along the long axis of neck between base of head to midpoint of intertrochanteric crest (Fig. 2b).

Neck width:
narrowest part of neck perpendicular to the axis of neck (Fig. 2d).

Torsion of Femur:
It is an angle formed by line drawn through the center of femoral neck and head and a line representing the horizontal plane of posterior femoral condyles, measured according to guidelines given by Graeme

Scofield [2].

Maximum Femur Length:
by placing the bone on osteometric board so that the posterior surface of both condyles and greater trochanter are in same horizontal plane.

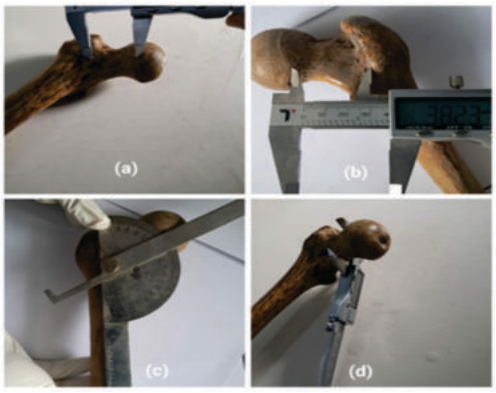

Fig 1
(a): Head height
(b):Horizontal head diameter
(c): Vertical head diameter
(d) Head circumference

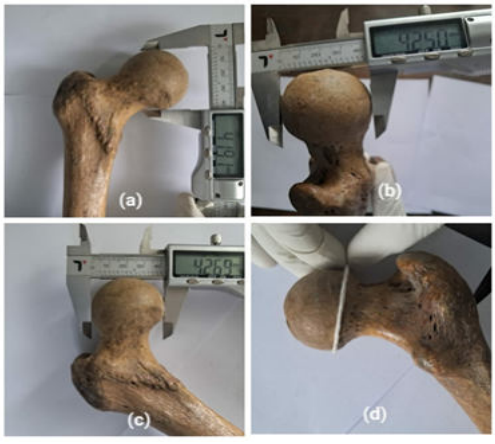

Fig 2:
(a) Anterior neck length
(b) Posterior Neck Length
(c) Neck shaft angle
(d) Neck width

After measurements the data was recorded on excel sheet and statistically analyzed using SPSS software version 26 free trial. Unpaired t test was performed where the 'p value' less than 0.05 was considered statistically significant at 5% level of significance. We also used Pearson's correlation coefficient to find the relationship between the parameters such as maximum length of femur and neck shaft angle, neck shaft angle and anterior neck length, neck shaft angle and posterior neck length.

Linear regression
was used to determine any linear correlation of head height, vertical head diameter, horizontal head diameter, head circumference, neck shaft angle, anterior neck length, posterior neck length, neck width and torsion with maximum femur length, for predicting maximum femur length with the help of any of these parameters.

RESULTS

Statistical analysis of the data gave us the descriptive statistics like frequency, range, mean, standard deviation & standard error of all the parameters (Table 1).

Maximum femur length was linearly correlated with head height, vertical head diameter, horizontal head diameter, head circumference, anterior neck length, posterior neck length and neck width. In our study we can predict maximum femur length on the basis of these parameters by using equations given in table 2.

In addition to linear correlation mentioned in table 2, head height, vertical head diameter, horizontal head diameter, head circumference, anterior neck length, posterior neck length and neck width have combined linear regression equation for maximum length of femur expressed as

Femur length = 17.61 +0.42(Head height) + 0.10(Horizontal head diameter) + 0.31(Vertical head diameter) – 0.89(Head circumference) +0.09(Neck length anterior) + 0.07(Posterior neck length) –0.084(Neck width)

Where R^2= 0.53 with P value= 0.0001 and predicted value of maximum femur length being 39.27 to 48.76cm with 95% confidence interval.

Table 1: Descriptive Statistics

Variable	Frequency	Average mean	Range	Standard Deviation	Standard Error	Mean± 2SE
Head Height	74	41.63	36.68-51	3.06	0.35	40.91-42.35
Head diameter horizontal	74	42.34	31.81-51.5	3.20	0.37	41.58-43.09
Head diameter vertical	74	42.13	36.17-51	2.96	0.34	41.44-42.82
Head circumference	74	13.79	11.4-16.5	1.14	0.13	13.52-14.05
Anterior neck length	74	29.80	18.29-41.4	4.63	0.53	28.72-30.88
Posterior neck length	74	37.44	25.22-52.5	4.58	0.53	36.38-38.51
Neck width	74	28.54	22.68-38.5	3.06	0.35	27.83-29.25
Neck shaft angle	74	130.02	115-146	7.61	.88	128.25-131.79
Torsion	74	14.39	5-30	5.82	0.67	13.04-15.74
Maximum femur length	74	43.41	38.5-49	2.6	0.30	42.80-44.02

Table 2: Linear regression

Linear regression	R2	Predicted Value	P value
Femur length = 20.40 + 0.553(Head height)	0.399	40.68-48.59	0.00001
Femur length = 23.27 + 0.476(Horizontal head diameter)	0.32	38.43-47.81	0.0001
Femur length = 19.69 + 0.563(Vertical head diameter)	0.385	40.06-48.41	0.0001
Femur length = 31.36 + 0.874(Head circumference)	0.129	41.33-45.78	0.001
Femur length = 36.52 + 0.231(Anterior neck length)	0.154	40.75-46.09	0.0001
Femur length = 34.48 + 0.239(Posterior neck length)	0.16	40.49-47.00	0.001
Femur length = 34.11 + 0.326(Neck width)	0.132	41.50-46.65	0.001

DISCUSSION:

Significant variability is seen in the anthropometric parameters of various ethnic groups and populations. Smaller build south Asian population like Indians have chances of surgical and post-surgical complications due to misfit prosthesis that suits western population. Various studies have been done on the morphometry of proximal femur in different populations using both cadaveric as well as radiographic methods.

According to Noble PC et al in total hip arthroplasty size of implant should not mismatch. Khang et al compared femoral geometric differences of Korean and Japanese population with Americans and suggested to design new modified prosthesis for Korean, Japanese and other Asian populations. Siwach et al. reported that the available implants are oversized for Indian population and their angles and orientation are mismatched [3,4,5]

Femoral head height, diameter and circumference determines the stability of hip joint. In our study we measured head height, the mean value of it was 41.63 ±3.06 mm. The result was coherent with Polguj M et al. (p=0.34). The mean head circumference in our study was 13.79±1.14 cm, which was coherent with Polguj M et at. (p=0.72) but

found to be significantly higher than the study by Tumusiime G et al. based on east African population (p= 0.0134). Studies on head diameter of femora were basically radiological considering only vertical head diameter. Here we measured both horizontal and vertical diameters of head, the mean value was 42.34±3.20 mm and 43.13±2.96 mm respectively [6,7].

Both anterior and posterior neck lengths were measured. The mean value of anterior neck length in our study was 29.80±4.63mm. which was coherent with Ravichandran D et al. (p=0.54). Similarly, posterior neck length mean value was 37.44±4.58mm but found to be significantly greater than Ravichandran D et al. (p= 0.0001) [8].

When we compare the neck width, our mean value was 28.54±3.06mm which was similar to the study by Ravichandran D et al.(p=0.23) [8].

Neck shaft angle provide range of mobility to hip joint and of clinical significance in orthopedic surgeries. In our study mean neck shaft angle was 130.2± 7.61˚. Neck-shaft angle in our study is coherent with Mahaisavariya B et al (p value= 0.54) and Husmann O et al (p value=0.414) while significantly greater than Singh G et al. (p value=0.003), Rubin PJ et al., Ravichandran D et al., Tumusiime G et al., and Rawal BR et al.(p=0.0001) studies and significantly lesser than Ravi GO et al., (p=0.0001) [7,8,9,10,11,12,13,14].

The mean value of torsion angle or angle of anteversion of femur, in our study was 14.49±5.82˚. Noble PC et al. reported mean value of torsion angle 10˚. Rawal BR et al. reported mean value 10.9±4.22˚, significantly less than our study (p=0.0001). Disturbance in this angle disturbs biomechanics of hip joint and may lead to abnormal gait [3,13].

The mean value of maximum femur length in our study was 43.41±2.6 cm significantly less than the study by Ravi GO et al. (p=0.0006) and more than the study by Polguj M. et al.(p=0.0075) [6,14].

Our study shows no significant difference in the proximal femoral parameters and maximum length of femur between right and left sides (Table-3).

We also tried to find out any relation between various parameters by using Pearson's correlation coefficient. Correlation between neck shaft angle with maximum femur length is 0.06 (P value = 0.612), with anterior neck length is 0.153(P value= 0.195) and with posterior neck length is 0.127 (P value=0.195). None of them was statistically significant.

In our study we also tried to find out linear correlation between head height, vertical head diameter, horizontal head diameter, head circumference, anterior neck length, posterior neck length and neck width individually with maximum femur length by using linear correlation coefficient formula. This can be helpful in predicting that maximum femur length (Table- 2).

In addition to the above-mentioned linear correlations, head height, vertical head diameter, horizontal head diameter, head circumference, anterior neck length, posterior neck length and neck width had combined linear correlation with maximum length of femur. So that maximum femur length can be predicted from these values in combination.

Regional variations encountered may be multifactorial owing to genetic, nutritional, environmental and lifestyle differences across the regions and differences in the amount of physical activity which affects bone mass.

Table 3: Statistical measurements of proximal femora parameters and maximum femoral length of right and left femur

Variable	Side		P value
	Right mean±SD n=38	Left mean±SD n=36	
Head Height	42.13±3.45	41.11±2.55	0.15
Head diameter horizontal	42.64±3.38	42.01±3.01	0.40
Head diameter vertical	42.53±3.18	41.72±2.69	0.24
Head circumference	13.96±1.24	13.61±1.01	0.18
Anterior neck length	29.76±5.06	29.84±4.20	0.94
Posterior neck length	37.80±5.06	37.06±3.95	0.48
Neck width	29.20±3.47	27.84±2.42	0.055
Neck shaft angle	131.05±7.96	128.94±7.18	0.23
Torsion	14.92±5.92	13.84±5.73	0.42
Maximum femur length	43.34±2.64	43.48±2.66	0.82

CONCLUSION:

From the above discussion we can conclude that there are marked differences between other studied populations and north Indian population in proximal femoral dimensions. The implants that are available in our country are mostly according to western population hip dimensions, hence, the need of an hour is to manipulate implant dimensions accordingly, thus avoiding complications like fracture of bone or malunion. The linear correlation calculated in our study for estimation of maximum femur length can be used in future for anthropometric calculations in forensic and anthropometric studies.

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Conflicts of Interest

None.

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