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A morphometric study of proximal femur geometry in northern Odisha population

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***Abstract*---**The human femoral head and neck-shaft angle measurements are important in proper femur implants and total hip replacement (THR). It can offer a guide to clinicians for the determination of risk factors for fractures (35). Proper standard sizes of diameter of the femoral head and neck shaft angle remains have always challenging for orthopaedic surgeons and anthropologist. The present study was conducted on 202 adult human femora available in Anatomy, Orthopaedic & FMT departments of V.S.S Medical College, Burla, Odisha In the present study, various measurements of the femur like circumference of head, vertical, and transverse diameter of head showed the differences in measurements of Western-Odisha femora with western counterpart. These measurements are important in surgical procedures like total hip replacement. Thus, we strongly believe that such differences need to be considered when a total hip prosthesis is designed. There is a need for the population specific prosthesis design. But a possible drawback to our method of study is the measurements were taken on dry bones and these dimensions may change during drying process. So the cadaveric studies with soft tissue in situ or intra-operative studies need to be done to delineate this issue. The result of the present study can provide a guide for future implants design to provide better fitting implants for the local population and thus change the concept of

orthopaedic surgeries in our country.

***Keywords*---**orthopaedic, implants, human femoral, intra-medullary proximal, medulla.

Introduction

Determination of metric differences in the proximal femur are essentials of implant for total hip replacement (THR). Many studies have focused on geometry, biomechanical properties, fractural type, etc. of a human femur.[1] The morphology of proximal femur is also an essential parameter in the design and development of implant for total hip replacement (THR). [2] The human femoral head and neck-shaft angle measurements are important in proper femur implants and total hip replacement (THR). [4] It can offer a guide to clinicians for the determination of risk factors for fractures [3,5] .Proper standard sizes of diameter of the femoral head and neck shaft angle remains have always challenging for orthopaedic surgeons and anthropologist. Intra-medullary proximal femoral nail (PFN) is a commonly used device for the fixation of proximal femoral fractures [6]. But there are two technical issues that need to be addressed when using this implant. First, the width of the femoral neck of the Indian population has to be sufficiently studied in relation with the differences present in genotype, racial and geographical areas.[7] Secondly, the need for fixation in certain prefixed angles as determined by the implant construct may alter the width of the neck that needs to be negotiated in order to insert the implant safely, thus making the working area narrower and increase the difficulty of the procedure. improper position of nail that may lead to secondary fracture or bursting of femur, secondly, the weakening of the bone from over reaming of the femoral cortex for accommodating the nail into the medulla[8]

The aim of these operations is to remove pathology and restore anatomy to normal as far as possible. The femur, or thigh bone is the largest, longest, and strongest bone of the human skeletons [1] .Extending from the hip to the knee, Its rounded, smooth head fits into a socket in the pelvis called the acetabulum to form the hip joint. The head of the femur is joined to the shaft by a narrow piece of bone known as the neck of the femur. The neck of the femur is a point of structural weakness and a common fracture site [2] The lower end of the femur hinges with the tibia (shinbone) to form the knee joint. The average adult male femur is 48 centimetres in length and 2.84 cm in diameter at the mid-shaft, and has the ability to support up to 30 times the weight of an adult [3]. The aim of these operations is to remove pathology and restore anatomy to normal as far as possible.

Thus the basic purpose of this study is to accumulate data on people of developing countries like ours, who's built, physique, habits, genetic makeup and personal lifestyles are different from western civilization[5] While database regarding anthropometry of femur is available for western population that for our population is lacking. Due to the importance of anthropometry for the success of hip joint replacement, and management of Femoral fractures this study analyses the morphology of the femur for the local population. The data provided in this

study will be compared with the design and size of implants available and commonly used in India. This information can then be used in the designing and development of implants suited for local population as well as assisting in decision making during clinical practices [8,9]

Materials and Methods

The instruments used for the measurement of various parameters of femora were as follows:

- Osteometric board.
- Sliding caliper.
- Flexible measuring tape.
- Goniometer.
- Protractor.
- Marker pens.

The present study was conducted on 202 adult human femora available in Anatomy, Orthopaedic & FMT departments of V.S.S Medical College, Burla, Odisha. All the femora were free of damage or deformity and fully ossified indicating adult bones. Femora with pathological changes were excluded from the study. Head vertical diameter (HVD) and head transverse diameter (HTD) of the femur was measured with the help of Sliding calliper. Head Circumference (HC) was measured at the same positions as the diameters along the four points marked by marker pen, with the help of flexible measuring tape, in millimetres [10]. Neck vertical diameter (NVD) and Neck transvers diameter (NTD) was measured in the narrowest part of the neck with the help of sliding calliper, in millimetres [11]. Neck shaft angle (NSA) Also known as collo-diaphyseal angle or inclination angle, angle that neck form with shaft of the femur [13]

Results

Several parameters mentioned in materials methods were measured from 202 femora available at the bone banks of all three departments of V.S.S Medical College, Odisha. Data thus obtained were fed to computer software and descriptive statistics performed. Minimum value, maximum value, range, mean value, standard deviation and standard error of means were calculated. Range of each parameter was extended to two standard deviations on each side of mean value to include 95% of the population. These findings have been tabulated as parameters of head and neck respectively in table No 1.

Table no. 1 Statistical analysis of parameters of head of femur (unit mm)

S. No.	Para meters	Min	Max	Range	Mean	SD	SE	Mean ±2SD
1	HVD	34.20	49.45	15.25	41.24	3.41	0.239	34.42- 48.06
2	HTD	34.00	49.00	15.00	41.21	3.44	0.242	34.33- 48.09
3	HC	108.00	153.00	45.00	128.82	10.19	0.718	108.44 -149.20
4	NVD	22.00	35.40	13.40	28.51	3.04	0.214	22.43- 34.59

5	NTD	17.30	31.19	13.89	23.66	2.79	0.197	18.08- 29.24
6	NSA	100.00	138.00	38.00	125.81	5.29	0.373	115.23- 136.39

Six parameters were studied for head and neck of femur, and are listed in the table above. The head vertical diameter (HVD), head transverse diameter (HTD), and circumference of femoral head (HC) were measured at the upper end of femur. The HVD varied from 34.20 to 49.45 mm; averaging 41.24 mm. HVD was found to have Standard deviation of 3.41 mm. on extending the range to two Standard deviations to cover 95% of the population, the HVD was found to vary from 34.42 to 48.06 mm. The dimensions of the second parameter for femoral head, HTD were similar to the HVD, with a range of 34.00 to 49.00 mm, an average of 41.21mm and standard deviation (SD) of 3.44mm. Its range for two SDs was from 34.33 to 48.09 mm.

The circumference of femoral head (HC) was found to vary from 108 to 153 mm, averaging 128.82 mm. Its SD was found to be 10.19 mm, and range for two SDs was 108.44 to 149.20 mm. The vertical diameter of neck (NVD) averaged 28.51 mm (range 22.00 to 35.40 mm). The SD for NVD was 3.04 mm and range for two SDs was 22.43 to 34.59 mm. On the other hand the transverse diameter of the femoral neck (NTD) was found to be less than the neck vertical diameter (NVD). Its range was from 17.30 to 31.19 mm with mean of 23.66 mm, its SD 2.79 mm and range for two SDs was between 18.08 to 29.24 mm. The neck shaft angle (NSA) varied from 100 to 138 degree, averaging at 125.81 degree. The SD for this parameter was found to be 5.29 degree with range for two SD being 115.23 to 136.39 degree.

Discussion

In the present study six anthropometric parameters were measured and analyzed. These results were compared with previous works on other population and ethnic groups. Unpaired t test was applied to examine whether the difference in the measurements between the two studies are statistically significant
Each dimension is discussed separately

Vertical diameter of head (HVD)

It varies from individual to individual, races and ethnic groups. The muscular forces moving across the hip joint acting between greater trochanter and pelvis has powerful effect on femur head as suggested by Hirsch, Frankel 1960[22] . Articular surface of the bone receives a portion of the force being applied across the articular surface and head of the femur will respond to such forces. The weight of axial skeletal varies from person to person and this is first borne by the head of the femur, this effect of stress and strain will be reflected by variation in its shape and size. Our results are compared with those of previous workers and summarised in the table given below.

Table no. 2 Vertical diameter of head of femur in mm. Comparison with previous studies

Sr No.	Name of worker	Sample Size	Mean	SD	P value
1.	Taner Ziylan et al. 2002, urkey(11)	72	43.4	3.2	<0.001
2.	P. J. Rubin et al. 1992, France (14).	32	43.4	2.6	<0.001
3.	V S Reddy et al. 1999, hyderabad(21).	74	45.1	3.58	<0.001
4.	Masood Umer et al.2010,pakistan(20).	136	50.1	3.8	<0.001
5.	M Y Barharuddin et al 011, Malaysia(19).	120	43.62	3.05	<0.001
6.	AK Mishra et al 2009, nepal(5).	50	42.9	3.53	<0.001
7.	R C Siwach et al 003, Rohtak(6).	150	43.95	3.06	<0.001
8.	R Chauhan et al. 2002, delhi(16).	36	45.64	3.13	<0.001
9.	T R Deshmukh et al. 2010,v idarbha(4).	77	43.30	4.19	<0.001
10.	Edie Benedito Caetano et al 2007(12).	34	41.80	3.10	>.05
11.	Present Study, 2013, Western Odisha Population.	202	41.24	3.41	<0.05

These studies suggest population specific differences in the value of mean of vertical diameter of head as shown by p value. Findings of Edie Benedito Caetano et al 2007 matches with that of present study. Study in nepalise population by AK Mishra et al 2009 having mean value 42.9 mm shows some closeness to present study (mean 41.24 mm) probably because of similar built. Study by Taner Ziylan et al. 2002, in Turkey population and P. J. Rubin et al 1992, in France people show similar value of head vertical diameter (mean 43.4 mm) but values are much more as compared to present study. Maximum difference in mean was found in study by Masood Umer et al.2010, in Pakistani population (mean 50.1). Mean value of vertical diameter of Head of femur in present study is showing significant difference with various studies on western population thereby confirming regional variation.

Transverse diameter of head of femur (HTD)

In the present study mean transverse diameter of head of femur was 41.21 mm, which was significantly higher than study on Bangladeshi population (mean 39.59 mm) by Akhtari Afroze, 2005 (p value < 0.001), and lower than various studies on western populations. The probable explanation for this lower value in Western Odisha population is the same as discussed for the vertical diameter of head; that is, different stress and strain patterns experienced by the head of femur. This is due to the difference in axial skeletal size and weight. The following table is showing summary of comparison of similar studies done by different researchers in the past in different parts of world.

Table no. 3 Transverse diameter of head of femur in mm

Sr No.	Name of worker	Sample Size	Mean	SD	P value
1.	SA Asala, 2000, Whites(23).	260	44.42	2.71	<.001
2.	SA Asala, 2000 , Blacks(23).	260	42,28	2.36	<.001
3.	PS Igbigbi, 2000, Black Malawians(24).	496	48.75	3.38	<.001
4.	Taner Ziylan et al 2002 Turkey (11).	72	44.3	3.3	<.001
5.	Kazuhiro Sakaue, 2004, Recent Japanese(25).	64	43.05	2.08	<.001
6.	Akhtari Afroze, 2005, Bangladeshi(26).	123	39.59	1.26	<.001
7.	R Purkait, H Chandra, 2004,Bhopal(27).	124	42.33	2.28	<.001
8.	Present Study, 2013, Western Odisha Population.	202	41.21	3.44	<.001

These studies suggest there are population specific differences in the value of transverse diameter of head measurement. Study conducted by SA Asala in 2000(23) shows that the mean value of transverse diameter of head for the African whites and African blacks are different. Thus racial difference also exists in the dimensions of femoral head.

Circumference of head of femur (HC)

In the present study, circumference of head of the femur (mean 128.82) is statistically lower than Brazilians femora (mean 133.96, P< 0.001) as shown by DA Silva et al. 2003(17), and study in New Zealand by AMC Murphy, 2002(28). This indicates that western populations have larger femoral head as compared to femora in the present study. The mean of the circumference of head of femur in Rohtak by Gargi Soni, 2010(29) is not showing significant difference with present study (p>0.05). The stress and strain pattern experienced by the femoral head of Indian and western population is different which makes the femoral head larger in westerns. Below mentioned table is showing comparative data of present study with various researchers in other part of world.

Table no. 4: Circumference of head of femur in mm

Sr No.	Name of worker	Sample Size	Mean	SD	P value
1.	DA Silva et al. 2003,brazilians(17).	66	133.96	10.2	<0.001
2.	Gargi Soni, 2010, Rohtak(29).	80	129.72	7.59	>.05
3.	AMC Murphy, 2002, New Zealand(28).	85	140.73	6.68	<0.001
4.	Present Study, 2013, Western Odisha Population	202	128.82	10.19	<0.001

Vertical diameter of neck of femur (NVD)

The neck of the femur in the human is a very important structure and functional specialization for man's erect posture. The mean neck vertical diameter in the present study was found 28.51 mm which is comparable with study by Edie Benedito Caetano et al 2007 having mean 28.69 mm ($p>0.05$). The following table shows the comparison of the present study with previous study done by other researchers.

Table no. 5: Vertical diameter of neck of femur in mm

Sr No.	Name of worker	Sample Size	Mean	SD	P value
1.	R C Siwach et al. Rohtak 2003(6).	150	31.87	2.91	<0.001
2.	AK Mishra et al. Nepal 2009(5).	50	33.28	3.22	<0.001
3.	Taner Ziylan et al. Turkey, 2002(11).	72	30.6	3.0	<0.001
4.	C K Chiu et al. Malasian, 2009(7).	100	34.0	3.7	<0.001
5.	Edie Benedito Caetano et al 2007,Brazil(12).	34	28.69	2.58	>.05
6.	Present Study, 2013, 202 Western Odisha Population	202	28.51	3.04	<0.001

Present study in Western Odisha population is showing significant difference with various studies by many researchers in different regions ($p<0.001$), thereby making them statistically significant. Study by Edie Benedito Caetano et al 2007 in Brazilian population(12) showing mean NVD is similar to present study, where as that by C K Chiu et al. 2009 in Malaisien population (mean 34.0)(7) and study by AK Mishra et al. 2009 in Nepalese population (mean 33.28)(5) shows maximum variation.

Neck transverse diameter (NTD):-

The proximal femoral geometry had been studied in relation to osteoporosis especially amongst postmenopausal women with hip fracture. Studies had suggested that the proximal femoral geometry influenced the risk of hip fracture. For this purpose various parameter of neck including transverse diameter of neck was assessed. NTD can also influence the prediction for the occurrence of fracture along with other factors. Table mentioned below is depicting comparative data of present study and study by other researchers.

Table no. 6 Transverse diameter of neck of femur in mm

Sr No.	Name of worker	Sample Size	Mean	SD	P value
1.	R C Siwach et al 2003, Rohtak(6).	150	24.90	2.94	<0.001
2.	C K Chiu et al. Malasian, 2009(7).	100	36.3	3.4	<0.001
3.	Taner Ziylan et al. Turkey, 2002(11)	72	25.5	2.7	<0.001
4.	Present Study, 2013, Western Odisha Population	202	23.66	2.79	<0.001

The mean transverse diameter of neck of femur in the present study was 23.66 mm, which when compared with study by R C Siwach et al is quit comparable where s measurements of C K Chiu et al. in Malasian populations and Taner Ziylan et al. in Turkey, are much higher. Thus data shows Western Odisha femora have thinner neck than the femoral neck of other population.

Neck shaft angle (NSA)

The Neck-shaft angle is important in lateral balance control, hip stability and normal walking [36]. Knowledge of this angle is important in some orthopaedic procedures such as dynamic hip screw fixation and hip replacement surgery. In addition, a narrower angle is said to predispose to stress fracture [37]. A smaller neck shaft angle implies that a DHS inserted through the classical entry portal using angled guide can go into the superior quadrant or pull the fracture in valgus both of which are undesirable. We require DHS with smaller angles.[6] Femoral neck-shaft angles show considerable variation both within and between human populations. Bone geometry is a critical factor in fracture risk for a human femoral neck, a person whose femoral neck is longer more horizontal is at a considerably higher risk for stress fracture of the unstable fracture type. [37] In the present study, mean neck shaft angle of Western Odisha population was 125.81degrees. The neck shaft angle increases with more sedentary existences and with mechanisations. Following table shows the comparative analysis of regional differences in femoral neck-shaft angles in various studies conducted previously.

Table no. 7 Neck-shaft angle of femur in degrees

Sr No.	Name of worker	Sample Size	Mean	SD	P value
1.	Macho, 1991, S African(30).	361	121.89	4.47	<0.001
2.	Trinkaus, 1993, Americans(31).	253	124.69	5.40	<0.05
3.	Kiyono & Hirai, 1928, Japanese(32).	261	125.69	3.88	>0.05
4.	Parsons, 1914, Britain(33).	134	127.14	5.11	<0.05
5.	Tague RG, 1989, France(34).	73	129.15	7.01	<0.001
6.	Yoshioka, 1987, Canadians(15).	120	131.3	6.93	<0.001
7.	Masood Umer et al.2010,pakistan(18).	136	130.3	6.1	<0.001
8.	R C Siwach et al 2003, Rohtak(6).	150	123.5	4.34	<0.001
9.	AK Mishra et al 2009, Nepal(5).	50	132.26	8.36	<0.001
10.	P A Toogood et al 2008, USA(5).	200	129.23	6.24	<0.001
11.	M Y Barharuddin et al 2011,Malaysia(19).	120	132.33	3.44	<0.001
12.	V S Reddy et al 1999, Hyderabad(21).	74	126.25	5.67	>0.05
13.	DA Silva et al 2003, Brazilians(17).	66	122	4.9	<0.001
14.	P. J. Rubin et al 1992, France(14).	32	122.9	7.6	<.05
15.	Taner Ziylan et al 2002, Turkey(11).	72	128.7	4.7	<0.001
16.	C K Chiu et al 2009, malaysia(7).	100	136.0	5.6	<.001
17.	Edie Benedito Caetano et al 2007, brazil(12).	34	128.23	4.43	<.05
18.	T.R. Deshmukh et al 2010(4).	77	131.76	3.70	<.001
19.	Y John et al 1998, USA(13).	50	126.7	4.4	>.05
20.	Present Study, 2013, Western Odisha Population	202	125.81	5.29	<0.001

Significant variation was seen in values of neck shaft angles in comparison with present study (mean 125.81) ($p<0.001$). Study by P. J. Rubin et al, France (mean122.9), DA Silva et al, Brazilians (mean 122), R C Siwach et al, Rohtak(123.5), Kiyono & Hirai, Japanese (125.69), Trinkaus, Americans (124.69), and Macho, S African (121.89), showed mean value of neck shaft angle less than present study in Western Odisha population. Study by Tague RG, 1989, France (mean 129.15), Yoshioka, 1987, Canadians (mean 131.3), Masood Umer et al.2010,Pakistan (mean 130.3), AK Mishra et al 2009, Nepal (mean 132.26), P A Toogood et al 2008, USA (mean 129.23), and C K Chiu et al 2009, malaysia (mean 136), depicted mean values of neck shaft angle more than the present study.

Conclusion

The present study provides valuable parameters which would help the forensic anthropologists, orthopaedicians and prosthetists to deliver excellent performance in their respective specialities. In the present study, various measurements of the femur like circumference of head, vertical, and transverse diameter of head showed the differences in measurements of Western-Odisha femora with western counterpart. These measurements are important in surgical procedures like total hip replacement. Thus we strongly believe that such differences need to be considered when a total hip prosthesis is designed. There is a need for the population specific prosthesis design. But a possible drawback to our method of study is the measurements were taken on dry bones and these dimensions may change during drying process. So the cadaveric studies with soft tissue in situ or intra-operative studies need to be done to delineate this issue. The result of the present study can provide a guide for future implants design to provide better fitting implants for the local population and thus change the concept of orthopaedic surgeries in our country.

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