

A GENDER AND AGE BASED MORPHOMETRIC STUDY OF HIP JOINT IN PLAIN RADIOGRAPHS OF ADULT INDIAN POPULATION

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Abstract

Background: Knowledge of various dimensions of the femoral head in both the sexes is of great help in manufacture of the prosthesis of femoral head which may be used by the orthopaedic surgeons in femoral head replacement surgery. Present study was aimed to study, gender and age based morphometric study of hip joint in plain radiographs of adult Indian population. **Material and Methods:** Present study was single-center, observational study, conducted in 264 AP plain radiographs of normal hip joints (147 males and 117 females). All linear measurements including acetabular depth, acetabular diameter, femoral head diameter, femoral neck length, femoral neck width, joint space width were measured using Dicom viewer. **Results:** The mean femoral head diameter noted on right side in males was 52.36 ± 5.34 mm & in females it was 46.68 ± 3.31 mm. The difference in mean femoral head diameter was found to be statistically significant ($P < 0.05$) when the comparison was made between left side hip joint radiographs of males and females. Higher mean value for FHD was recorded in men when the 2 genders were compared irrespective of side. Higher values of femoral neck width (FNW) were observed in males than in females, and the value was more on right side. Higher mean femoral neck width value was recorded on right side when compared to left side. The difference in mean femoral neck width was found to be statistically significant ($P < 0.01$) when the left side hip joints were considered in the 2 genders. Higher mean value of femoral neck length (FNL) was observed in males than in females and the values were higher on right side than on the left. **Conclusion:** We noted a significant difference in femoral head diameter, femoral neck length, femoral neck width, joint space width when compared according to gender.

Keywords: morphometric study, hip joint, acetabular depth, acetabular diameter, femoral head diameter, femoral neck length, femoral neck width, joint space width

Introduction

Total Hip Replacement (THR) has evolved into successful operation with an acceptable longevity for patients with incapacitating osteoarthritis, avascular necrosis of femoral head and fractures around the hip. Over the years the evolution of the design and kinematics based on anthropometric data have led to more closely replicate the patient anatomy and biomechanics. These modifications that lead to improved implant sizing have shown an impact on outcome and in reductions.¹

During surgery of the acetabular fractures or during the placement of acetabular cups in arthroplasty, placement of the screws in the acetabulum is very critical because of the neurovascular structures that surround it. Therefore, it is very important to know the anatomical landmarks as well as the average length of the screws that can be placed safely at various quadrants of the acetabulum.²

Determination of an individual's gender from the available skeleton is of great importance in forensic medicine. In medico legal cases determination of stature, sex and age from skeletal remains of the deceased person is often referred to the anatomist and other professionals in the field of anthropology. Knowledge of various dimensions of the femoral head in both the sexes is of great help in manufacture of the prosthesis of femoral head which may be used by the orthopaedic surgeons in femoral head replacement surgery,^{3,4} Present study was aimed to study, gender and age based morphometric study of hip joint in plain radiographs of adult Indian population.

Material And Methods

Present study was single-center, observational study, conducted in department of Anatomy and Department of Radiodiagnosis, Kempegowda Institute of Medical Sciences, Bangalore, Karnataka, India. Study duration was of 2 years (January 2020 to December 2022). Study approval was obtained from institutional ethical committee.

The study sample comprised of 264 AP plain radiographs of normal hip joints (147 males and 117 females). The age group ranged from 20-90 years. Those x rays with unfused acetabulum, hip joint diseases and with joint space width < 2 mm were excluded from the study. All linear measurements including acetabular depth, acetabular diameter, femoral head diameter, femoral neck length, femoral neck width, joint space width were measured using Dicom viewer.

Standardised radiographs showing AP view of normal hip joints in case of adult males and females of known age available were studied and following parameters were measured -

1. Femoral head diameter in millimeters
2. Femoral neck length in millimeters
3. Femoral neck width in millimeters
4. Hip joint space width in millimeters
5. Neck shaft angle

Statistical analysis was done by finding the mean, standard deviation and percentage and the parameters were compared between hip joints of males and females on each the two sides and also irrespective of sides. The results were correlated using paired student t test and was considered significant if p value ≤ 0.05 .

Results

The study sample comprised of 264 AP plain radiographs of normal hip joints (147 males and 117 females). The age group ranged from 20-90 years.

In the present study, the value of Femoral head diameter (FHD) when compared between males and females showed that, the diameter was higher in males than in females. However, the values were statistically significant when comparison was made between right side of males and females, left side of males and females and in both genders irrespective of side ($P < 0.001$).

The mean femoral head diameter noted on right side in males was 52.36 ± 5.34 mm & in females it was 46.68 ± 3.31 mm. The t value was 10.051 which was considered to be statistically significant ($P < 0.001$). The difference in mean femoral head diameter was found to be statistically significant ($P < 0.05$) when the comparison was made between left side hip joint radiographs of males and females

Table 1: Comparison of the left side femoral head diameter in males and females

Measurements	Gender	Mean	SD	SE of Mann	Mean difference	T	P-Value
FHD	Male	55.880	41.464	3.420	9.225	2.400	0.017
	Female	46.655	3.271	0.302			

Higher mean value for FHD was recorded in men when the 2 genders were compared irrespective of side. The difference in mean was found to be statistically significant ($P < 0.001$) with a t value of 3.835.

Table 2: Comparison of the femoral head diameter of both genders irrespective of side

Measurements	Gender	Mean	SD	SE of Mann	Mean difference	T	P-Value
FHD	Male	54.121	29.563	1,724	7,449	3.835	<0.001
	Female	46.672	3.285	0.215			

Higher values of femoral neck width (FNW) were observed in males than in females, and the value was more on right side than on the left. The values were statistically significant when comparison was made between right side of males and females, left side of males and females and in both genders irrespective of side.

The difference in mean femoral neck width was found to be statistically significant ($P < 0.05$) with a t value of 2.44. Higher mean femoral neck width value was recorded on right side when compared to left side.

Table 3: Comparison of the right side femoral neck width in males and females

Measurements	Gender	Mean	SD	SE of Mann	Mean difference	T	P-Value
FNW	Male	36.429	4.374.	0.361	5:011	2.444	0.015
	Female	31.418	24.379	2.254			

The difference in mean femoral neck width was found to be statistically significant ($P < 0.01$) when the left side hip joints were considered in the 2 genders.

Table no 4: Comparison of the FNW on the left in male and female hip joint

Measurements	Gender	Mean	SD	SE of Mann	Mean difference	T	P-Value
FNW	Male	36.756	3.508	0.289	5.374	2.638	0.009
	Female	31.382	24.398	2.256			

When FNW was compared between males and females irrespective of side, t value was found to be 3.600 which was considered to be statistically significant ($p < 0.001$).

Table 5: Comparison of the FNW in both genders irrespective of side

Measurements	Gender	Mean	SD	SE of Mann	Mean difference	T	P-Value
FNW	Male	36.593	3.961	0.231	5.193	3.600	<0.001
	Female	31,400	24.336	1.591			

Higher mean value of femoral neck length (FNL) was observed in males than in females and the values were higher on right side than on the left. The mean values were found to be statistically significant ($p < 0.001$) when right side hip joint in males were compared. with that of female, when left side hip joint in males were females and in both genders irrespective of side.

The mean femoral neck length value in men was recorded to be 30.066 ± 5.9 mm and in females it was 27.13 ± 5.2 mm. The values showed that FNL was more in men than in women. The difference in mean femoral neck length was found to be statistically significant ($P < 0.001$) with a t value of 4.204. The difference in mean femoral neck length was found to be statistically significant ($P < 0.001$) when FNL was compared between left side hip joints of males and females.

Table 6: Comparison of the femoral neck length on the left side male and female hip joint

Measurements	Gender	Mean	SD	SE of Mann	Mean difference	T	P-Value
FNL	Male	30.339	5.705	0,471	4.759	0.001	0.484
	Female	27.094	5.237	3.245			

Higher mean femoral neck length value was recorded in men when compared to women. The difference in mean femoral neck length was found to be statistically significant ($P < 0.001$) when it was compared between both genders irrespective of side.

Table 7: Comparison of the femoral neck length of both genders irrespective of side

Measurements	Gender	Mean	SD	SE of Mann	Mean difference	T	P-Value
FNL	Male	30.203	5.826	0.340	3.091	6.344	< 0.001
	Female	27.112	5.21	0.341			

The value of joint space width was more in men than in women and was found to be statistically significant ($p < 0.001$) when the hip joint of males and females were compared on the right side.

Table 8: Comparison of the right side joint space width in males and females

Measurements	Gender	Mean	SD	SE of Mann	Mean difference	T	P-Value
JSW	Male	8.062	2.411	0.199	1.370	4.907	<0.001
	Female	6.692	2.039	0.189			

The neck shaft angle was found to be higher in males than in females and the mean p value was found to be statistically significant ($p < 0.001$) when radiographs of left side hip joints were compared between males and females and also when the 2 genders were compared irrespective of side.

The mean NSA recorded was 142.10 +2.80 mm in men whereas in women it was 130.89 11.68mm. The difference in mean value was found to be statistically significant ($P < 0.001$) with a t value of 11.238. Higher mean neck shaft angle value was recorded in men when compared to women irrespective of side. The difference in mean neck shaft angle was found to be statistically significant ($P < 0.05$).

Table 9: Comparison of the neck shaft angle in both genders irrespective of side

Measurements	Gender	Mean	SD	SE of Mann	Mean difference	T	P-Value
JSW	Male	153.204	108.093	6.304	18.187	2.251	0.025
	Female	135.017	67.155	4.390			

Discussion

Awareness of the average dimensions of the acetabulum and femoral head will assist prosthetists in designing a suitable prosthesis according to the need of a particular individual. A thorough knowledge of hip joint anatomy is a prerequisite to understand its biomechanics. The normal values are needed to set the limits of significant early radiographic alteration in patients with osteoarthritis.

The common cause of hip joint failure is osteoarthritis. The hip joint failure is due to the damage of hip joint mechanism which affects range of motion and ability to bear weight on the joint. The treatment of hip joint failure is total hip arthroplasty. A mismatch in the dimensions between the femur bone and prosthesis leads to micromotion of the implanted stem during the early days of post-surgery which hinders the ingrowth of trabeculae bone.^{5,6}

Awareness of the femoral head dimensions will assist prosthetists in designing a suitable prosthesis according to the need of a particular individual. The volume of implants in the femoral head was calculated by using the formula $d/4 \cdot l$, where d is the diameter of femoral head and l is the length of the implant.



Photograph 1: X ray of the Hip Joint showing the Femoral Head Diameter indicated by the arrow

In the present study, the femoral head diameter was found to be statistically significant when right side of males was compared with right side of females ($p < 0.001$), when left side of males was compared with left side of females (< 0.05) and in case of males and females irrespective of side ($p < 0.001$). The values were found to be more in men than in women. This could be due to the fact that the diameter of the femoral head is considered to be larger in taller individuals (men).

Table 10: Comparison of femoral head diameter with that of previous studies

Author	Population	Age group	Males	Female	P value
Seikia <i>et al.</i> , ⁷	India	20-70	44.6	42.3	0.01
Rawal <i>et al.</i> , ⁸	India	40-81	48.24	42.33	0.001
Present study	India	20-90	53	36	<0.001

From the above table it can be seen that, in all the studies, the value was comparable and was more in males than in females which could be due to tall stature

Saikia *et al.*,⁷ have reported that the diameter of the femoral head was larger in taller individuals. In a study done by him on the femora of Nigerians revealed a mean diameter of 54.23 in males and 54.08 in females which was higher than the values of North Indians, which show that on an average North East people were shorter. This was true in case of Caucasians and Mongoloids, where Caucasians were found to be taller than Mongoloids and was found to have a larger diameter of femoral head.⁹

In studies done by Siwach *et al.*,⁹ and Bulent *et al.*,¹⁰ the average values of femoral head diameter was found to be 43.53 ± 3.4 mm and 45.8 ± 4.17 mm respectively. These values were comparable with that of other studies and slightly lower than the present study. In this study age, side or gender was not taken into consideration. In the study done by Bulent *et al.*,¹¹ on Turkish subjects showed a higher value for femoral head due to valgus position of femoral head-neck angle, a narrower proximal femoral metaphysis and a narrower medullary canal with a longer isthmic segment. In a study done by Eduardo *et al.*, the values on right and left were 47.1 ± 3.1 and $46.43.7$ mm respectively with a p value 0.3011. In this study age and gender were not considered.¹¹ The difference in the values among various study groups could be due to racial & environmental factors.



Photograph 2: X ray of the Hip Joint with the line indicated by the arrow shows Femoral Neck Width

In the present study, the value of the Femoral neck width (FNW) was considered to be statistically significant on right side of males and females ($p < 0.05$), on left side of males and females ($p < 0.01$) and in males and females irrespective of side ($p < 0.001$). The higher femoral neck width in men was attributed to pelvic morphology and increased height and weight.

Table 11: Comparison of FNW in the present study with the previous studies

Author	Population	Age group	Average	SD
Siwach <i>et al.</i>	India	20-60	29.5	3.19
Bulent at al	Turkey	-	19.9	4.21
Present study	India	20-90	24.9	2.9

The comparison shows that the FNW in the present study is slightly lower than the FNW in the study done by Siwach where Indians were compared with Westerners and the values were found to be similar.⁹

Table 12: The neck dimensions in the study by Siwach *et al.*,⁹

Population studied	Average neck diameter (mm)	Cross-sectional area of neck (mm)
Caucasian	31.3	778.92
Asian (Hong Kong Chinese)	29	660.12
Indians	28.39	633

The geometry of the proximal femur is determined by a large number of genetic and environmental factors including age, race, sex and lifestyle. Knowledge of the values have clinical importance in obtaining a close match between the dimension of the femur and implanted prosthesis. In a study done by Eduardo *et al.*,¹¹ the FNW on right and left sides were 31.1 ± 2.7 and 30.8 ± 3.0 mm respectively. In a few studies quoted by him in Brazilian and Malaysian population, the values were found to be similar as shown in the table below:

Table 13: Comparison of FNW on the two sides in different population by Eduardo *et al.*

Author	Population	Right	Left
Eduardo <i>et al.</i> , ¹¹	Brazil	31.1 ± 2.7	30.8 ± 3.0
Mouro <i>et al.</i> , ¹²	Brazil	26.7 ± 3.1	26.3 ± 3.3
Sharma V <i>et al.</i> , ¹³	Malaysia	26.7 ± 3.1	26.3 ± 3.3



Photograph 3: X ray of the Hip Joint with the line indicated by the arrow shows the Femoral Neck Length

In the present study, the value of the neck length was considered to be statistically significant when right side of males was compared with that of females ($p < 0.001$), between left side of males and females ($p < 0.001$) and in males and females irrespective of side ($p < 0.001$). The increased height and weight in men contributes to the higher values of femoral neck length in men than in women. Value of the femoral neck length is slightly lower in the present study when compared with that of Siwach *et al.*,⁹ and Rawal *et al.*,⁸ The differences could be attributed either to the variations in the methodology used for the studies or due to a small sample size.

Table 14: Comparison of the FNL in the present study with that of previous studies

Author	Population	Age group	Average	SD
Siwach <i>et al.</i> , ⁹	India	20-80	37.2	4.65
Rawal <i>et al.</i> , ⁸	India	40-81	48.4	5.56
Present study	India	20-90	30.33	5.8

Comparisons of skeletal geometric features that confer hip implant fitment between race and ethnic groups may yield insights about the mechanisms of hip implant fitment that could contribute to design a best fit hip implant among older Indians. In a study done by Eduardo *et al.*,¹⁰ the mean value of femoral neck length was found to be 30.1 ± 4.3 mm on the right side and 30.5 ± 4.1 mm on the left side and when the two were compared, it was not found to be significant ($p = 0.5693$).

The normal values of JSW are needed to set the limits of significant early radiographic alterations in patients with osteoarthritis. It refers to the inter bone area between

the acetabular roof and the part of the femoral head facing it. JSW is an important determinant of osteoarthritic changes. Joint space narrowing should not be expected in an elderly or obese person unless arthritic changes develop. In the present study the JSW was found to be 8.062 ± 2.411 mm in males and 6.692 ± 2.039 mm in females. The higher values in males could be attributed to the pelvic morphology.



Photograph 4: X ray of the Hip Joint with the line indicated by the arrow shows the Neck Shaft Angle

Neck shaft angle is defined as the angle formed by the neck axis and the axis of the femoral head diaphysis. When NSA 135° , it results in coxa valga, when NSA 120° , it results in coxa vara. In the present study, the value of NSA was found to be statistically significant when left side in males was compared with that of females ($p < 0.001$) and in males and females irrespective of sides ($p < 0.05$). Value of neck-shaft angle was more or less the same in all the studies as the Indian studies were all from north, east and south parts of India.

Table 15: Comparison of the NSA in the present study with the previous studies

Author	Population	Age group	Average	SD
Lequesne <i>et al.</i> , ¹⁴	France	16-88	132.83	4.37
Saikia <i>et al.</i> , ⁷	India	20-70	139.5	7.5
Rawal <i>et al.</i> , ⁸	India	40-81	124.42	5.49
Siwach <i>et al.</i> , ⁹	India	20-80	123	4.29
Present study	India	20-90	135	

Lequesne *et al.*,¹⁴ found that in their study, the age group of 61-70 years showed the highest value in the neck shaft angle. The authors could not find any valid explanation for the variations in the age groups, measurement was more towards the extreme. In a study conducted by Siwach *et al.*,⁹ it was found that the minimum value of NSA was 114 degrees and maximum of 136 degrees with a standard deviation of 4.34.

Most of the parameters in Indian femora differ markedly from other ethnic groups. A smaller neck shaft angle implies that an implant inserted through the classical entry portal using angled guide will either go into the superior quadrant or pull the fracture in valgus. Saikia *et al.*,⁷ found that in their study, the mean value of NSA was 139.5 degrees and was

several degrees more than the others. The NSA showed the highest variation when compared with the western literature. Statistically significant variation was observed among the two sides ($p < 0.0001$) in the study done by Saikia *et al.*,⁷

Conclusion

Higher mean value for FHD was recorded in men when the 2 genders were compared irrespective of side. The values were statistically significant when comparison was made between right side of males and females, left side of males and females and in both genders irrespective of side. The difference in mean femoral neck width was found to be statistically significant ($P < 0.01$) when the left side hip joints were considered in the 2 genders.

Higher mean value of femoral neck length (FNL) was observed in males than in females and the values were higher on right side than on the left. The neck shaft angle was found to be higher in males than in females and the mean p value was found to be statistically significant.

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