International Journal of Orthopaedics Sciences 2020; 6(1): 1133-1139

International Journal of Orthopaedics Sciences

E-ISSN: 2395-1958
P-ISSN: 2706-6630
IJOS 2020; 6(1): 1133-1139

www.orthopaper.com
Received: 10-11-2019
Accepted: 12-12-2019

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Anthropometric analysis of the hip joint in Southern Assam population using computed tomography

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DOI: https://doi.org/10.22271/ortho.2020.v6.i1o.1971

Abstract
Background: In bipeds, the hips have the great responsibility of transmitting the ground reaction against the body weight, while at the same time preserving mobility. Anthropometric study of hip joint has important clinical associations and the study is largely unknown for Southern Assam region of India. Since the anthropometric parameters for southern Assam population is lacking, the common implants which are designed for western are being used for the Indian patients. The goal of our study was to Compare the Anthropometry of the Hip Joint of southern Assam with other global studies using eight (8) parameters viz. Neck-shaft Angle (NSA), Head Diameter (HD), Neck Width (NW), Acetabular Angle (AA) of Sharp, Horizontal Offset (HO), Vertical Offset (VO), Medullary Canal Diameter at the level of lesser trochanter, and Acetabular version (AV) using CT scan.
Materials and Methods: It was a single hospital based observational study. Normal hip joints were analysed after ethical committee clearance. Proximal femur scanning was done with the help if computed tomography. Neck-shaft angle (NSA), neck width (NW), head diameter (HD), acetabular angle (AA) of sharp, horizontal offset (HO), vertical offset (VO), medullary canal diameter at the level of lesser trochanter (MDLT), and acetabular version (AV) were measured. SSPS software was used for data analysis. Parameters were tabulated and compared with various populations and statistically analysed.
Results: Two hundred individuals (400 hips) with a normal hip joint were included in this study to analyse. The mean values were NSA 132.6°, NW 28.59 mm, femoral HD (HD) 41.0 mm, AA of sharp 34.93°, HO 39.34 mm, VO 45.34 mm, MDLT 22.58 mm, and AV 20.60°. The values differed when compared with Western population and with other Indian studies done in South and Northeast Indian population. Significant differences were also observed in the parameters between sexes and between the sides of the hip joint.
Conclusion: The study revealed that there were significant differences exists in anthropometric parameters of hip joint among the southern Assam population when compared to that of Western literatures and also vary from region to region in other parts of India. Moreover, the data may be used as a reference data for the normal anatomical alignment during treatment. The data may provide help to perform further studies in different parts of India.

Keywords: Computed tomography, proximal femur, implants, anthropometry

Introduction

In bipeds, the hips have the great responsibility of transmitting the ground reaction against the body weight, while at the same time preserving mobility. The hip joint is one of the largest and most stable joints in the body. If it is injured or exhibits affected by any pathology, the lesion is usually immediately perceptible during walking. Because pain from the hip can be referred to the sacroiliac joint or the lumbar spine, knee, it is imperative, unless there is evidence of direct trauma to the hip, that these joints be examined along with the hip.

The hip joint is a multiaxial ball and socket joint that has a maximum stability because of the deep insertion of the head of the femur into the acetabulum. It has a strong capsule and a very strong muscles that control its actions.

Anthropometric study of the hip joint has important clinical associations and the study is largely unknown for the Southern Assam region of India. The geometry of proximal femur is determined by genetic and environmental factors such as age, race, sex, and life styles [1-4]. So, the morphology of the proximal femur, is important to understand the bio mechanics of hip as well as surgical planning. The Anthropometric parameters of proximal femur of Westerners are quite different from those encountered among Indians. Anthropometric analysis of the proximal femur will be useful in the management of the pathological conditions such as osteoarthritis of the hip, fracture neck of femur, and inter trochanteric fractures [4].

A population-based study was carried out by Nurzenski *et al*. who found that lifestyle factors influence geometric indices of bone strength in the proximal femur [5]. Siwach *et al*. compared the parameters of the femurs of Indian cadavers with those of Western, and Hong Kong Chinese populations [1, 4]. They observed that the implants were oversized, and their angles and orientations were also having a mismatch which can presumably lead to complications like splintering and fractures [1, 4]. Reddy *et al*. highlighted that a mismatch between femoral bone and stem definitely results in micro motion. These micro motions eventually lead to thigh pain, osteolysis and aseptic loosening [6, 7]. Leung *et al*. were prompted to modify the gamma nail (used for fixing a femoral neck) to suit the Asian population [8-10]. Pathrot *et al*. using cephalomedullary nails suggested design modifications for Indian population with lesser neck width (NW) [11]. Some researchers also investigated the differences in femoral bone parameters between male and female femurs [12, 13]. There has long been a belief among Indian and Asia-Pacific arthroplasty surgeons that the prosthetic components currently available on the market do not fulfil the requirements of these anthropometrically smaller ethnic groups, especially in the smaller sizes [14]. If the implant is too large, the femur can fracture as it is driven down inside the bone, so the tendency is to undersize for safety. But if the implant is highly undersized, the bone may fail to bond to it. So, the correct implant size is very important [15]. A similar study was carried out by Khang *et al*. [16] to investigate the anatomic geometric differences between femurs from Korean subjects and those of American and Japanese subjects, and they suggested to design a new hip prosthesis system for Korean, Japanese, and other Asian patients. 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 [15].

The aim of any surgical procedure in proximal femur fractures is to obtain a stable and well-functioning hip joint[4]. Since the parameters of proximal femur morphometric for southern Assam population is lacking, the common implants which are used in the proximal femur and replacement arthroplasty which are designed for Western populations are being used for Indian patients.

Sometimes, the standard commercially available prosthesis designed for western may not be the best fit to Indian patients due to anatomic variations. The complications of mismatch are aseptic loosening, improper load distribution and discomfort and per-trochanteric complications like splintering and fractures [15-17]. In uncemented hip arthroplasty secondary biologic integration of hip implant depends mainly upon quality of its primary stability [15, 18, 19]. Mismatch between bone and prosthesis will affect bone ingrowth due to its micro motion of the implants during the early post-operative period[4].It is also vital to design a prosthesis through which adequate loads can be transferred to bone to prevent stress shielding [15, 20].

The purpose of this study is to determine the anatomic variation of the normal hip joint among the people of Southern Assam using computed tomography (CT) and to statistically compare the available data worldwide.

The anthropometric measurements of the hip joint include the necessary parameters as Neck-shaft Angle (NSA), Head Diameter (HD), Neck Width (NW), Acetabular Angle (AA) of Sharp, Horizontal Offset (HO), Vertical Offset (VO), Medullary Canal Diameter at the level of lesser trochanter, and Acetabular version (AV).

Materials and Methods

It will be a single hospital based observational study. Patient's with normal hips on examination, attending orthopaedics outpatient department of Silchar Medical College and Hospital (SMCH), from 01/06/18 to 31/05/19 who voluntarily gives consent or who have to undergo abdominal CT scans for other reasons after ethical committee clearance, will be taken in the study. A standard protocol to be follow while taking CT scan. Persons with pre-existing hip pathologies after examining clinically and by plain X-rays, with those mentioned in the exclusion criteria below will be excluded from the study. Both the Hip joints to be analyse using Multi slice Philips helical CT scanner. The position of the person during imaging was supine with both lower limbs in neutral rotation. The thickness of the CT slice was 5 mm. Superimpositions and motion artefacts to be avoided. The neck-shaft angle (NSA), head diameter (HD), neck width (NW), acetabular angle (AA) of sharp, horizontal offset (HO), vertical offset (VO), medullary canal diameter at the level of lesser trochanter, and acetabular version (AV) to be measured. These parameters to be tabulated and compared with various populations and to analyse statistically.

We included two hundred patients both male and female who gives consent for CT. CT of hip joint with fused epiphysis in the age group between 20 to 70 years were taken in the study. We excluded patients not willing to give consent and patients with Skeletally immature bone Pathological conditions like osteoarthritis, rheumatoid arthritis, tuberculosis hip, old fracture or dislocations of hip, tumors of the hip and proximal femur, deformities of the lower limb and spine and any structural deformities of the hip and traumatic conditions like Fracture neck of femur, inter-trochanteric fracture, and sub-trochanteric fracture. Contraindications for CT scans like pregnancy were also excluded. We also compared the right and left side's anthropometric values of the patients.

Neck-Shaft Angle

It is the angle traverse between the long axis of the femur and the long axis of the neck of femur. Femoral shaft axis is a line drawn by extending through two equidistant points from the medio-lateral surface of femoral shaft in the center of the medullary canal. Neck axis is drawn by joining the two points equidistant from the superior and inferior surface of femoral neck [21].

Head Diameter

A perfect circle is drawn over the ideally spherical femoral head, and circle diameter is measured [4].

Neck Width

A perpendicular line to the neck axis at the narrowest part of the femoral neck is measured [11, 22].

Acetabular Angle of Sharp

The angle intersected pelvic teardrop and a line edge of the acetabulum [23]. Acetabular angle of sharp is defined as the angle formed between the horizontal line drawn through the teardrop and another line drawn from the tip of the teardrop to anterior edge of acetabulum, in coronal sections of CT scan [4].

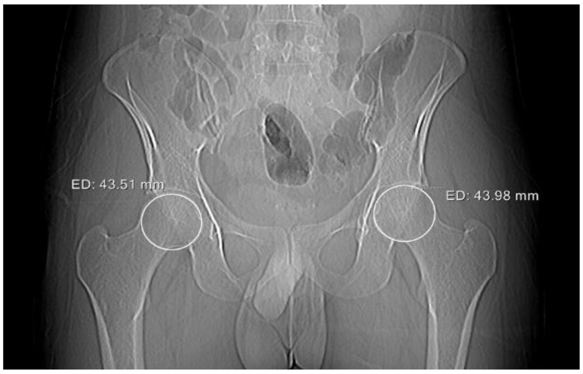
Horizontal Offset
Horizontal offset or simply femoral offset is the horizontal distance from the center of rotation of femoral head to a line bisecting the long axis of shaft of femur [24].

Vertical Offset
Vertical offset or femoral head position is the vertical distance from the center of femoral head to the tip of lesser trochanter [25].

Medullary Canal Diameter at the Level of Lesser Trochanter
Medio lateral diameter of medullary canal measured at the level of middle of the lesser trochanter [4].

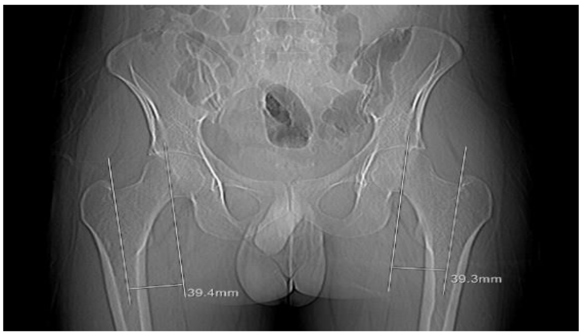
Acetabular Version
It is the angle measured between a line connecting both the posterior ischia and a line connecting the posterior lips of the acetabulum [23].

Neck – Shaft Angle



Head Diameter

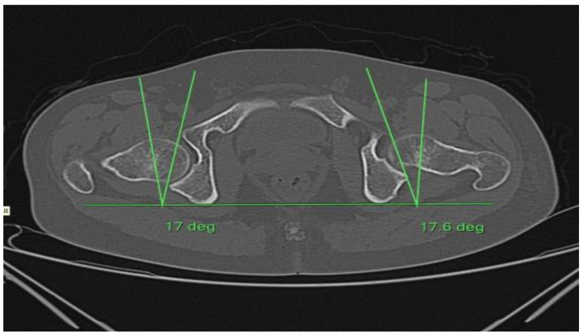
Neck Width



Horizontal Offset

Vertical Offset

Acetabular Angle Of sharp



Acetabular Version

Medullary Canal Diameter at the Level of Lesser Trochanter

Results

A total of 200 CT scans of hip joint of different patients of both right and left side were analysed in the study. There was 100(50%) males and 100 (50%) females in the study.

SPSS software used for data analysis. The mean value of femoral head diameter is 41.0 and standard deviation is 2.63 (range 30-49). The mean value of neck width is 28.59 and standard deviation is 2.90 (range 20-34). The mean value of neck shaft angle is 132.62º and the standard deviation is 5.47 (range120-142). The mean value of horizontal offset is 39.34 and the standard deviation is 2.92 (range 33-56). The mean value of vertical offset is 45.34 and standard deviation is 5.08(range 33-56). The mean value of medullary canal diameter at the level of lesser trochanter is 22.58 and standard deviation is 2.92 (range 13-28). The mean value of acetabular angle of Sharp is 34.93º and standard deviation is 3.47(range 28-42). The mean value of acetabular version is 20.60º and standard deviation is 2.96 (range 14-27). The age ranges from 20 to 70 years with a Mean age and standard deviation 42.99±12.44years in our study.

The mean femoral head diameter for males is 42.49 with standard deviation is 2.63. The mean neck width for males is 30.39 with standard deviation is 2.08. The mean neck shaft angle in males is 134.75 with standard deviation of 5.23. The mean horizontal offset in males is 40.84 with standard deviation is 3.07.The mean vertical offset for males is 46.38 with standard deviation of 4.51.The mean medullary canal diameter at the level of lesser trochanter in males is 22.58 with standard deviation of 3.06.The mean Sharp's angle in males is 35.70 with standard deviation of 3.43.The mean acetabular version in males is 18.76 with standard deviation of 2.28.

The mean femoral head diameter for females is 39.51 with standard deviation is 1.58.The mean neck width for females is 26.79 with standard deviation is 2.45.The mean neck shaft angle in females is 130.49 with standard deviation of 4.84.The mean horizontal offset in females is 37.84 with standard deviation is 1.78.The mean vertical offset for females is 44.30 with standard deviation of 5.40.The mean medullary canal diameter at the level of lesser trochanter in females is 22.23 with standard deviation of 2.92.The mean Sharp's angle in females is 34.16 with standard deviation of 3.35.The mean acetabular version in females is 22.45 with standard deviation of 2.35.

The mean femoral head diameter in right side is 40.91 with standard deviation is 2.70 and for left side is 41.09 with standard deviation of 2.56.The mean neck width for right side is 28.60 with standard deviation is 2.88 and for left side is 28.58 with standard deviation of 2.92.The mean neck shaft angle for right side is 132.64 with standard deviation of 5.45 and for left side is 132.10 with standard deviation of 5.50.The mean horizontal offset in right side is 39.29 with standard deviation is 2.92and for left side is 39.39 with standard deviation of 2.93.The mean vertical offset for right side is 45.32 with standard deviation of 5.09 and for left side is 45.35 with standard deviation of 5.08.The mean medullary canal diameter at the level of lesser trochanter in right side is 22.59 with standard deviation of 2.90 and for left side is 22.58 with standard deviation of 2.94. The mean Sharp's angle for right side is 34.83 with standard deviation of 3.27 and for left side is 35.03 with standard deviation of 3.49. The mean acetabular version in right side is 20.60 with standard deviation of 2.99 and for left side is 20.61 with standard deviation of 2.94.

Discussion

The morphometric parameters vary from country to country, race, ethnic background and built of the patient. The Indian sub-continent consists of huge collection with different morphological, genetic, cultural and linguistic characteristics [23].

Anthropometric studies can provide valuable information on different parameters of bones, joints, and their variations in different populations [26]. With regard to 3D simulation ability of multi-slice CT scanning device, its application seems very useful in anthropometric studies [26]. In this study, we measured the different parameters of hip joint in adults living in southern Assam like Cachar, Karimganj and Hailakandi using CT scan technique, so that we could quantitatively compare these parameters in other populations. In addition, the quantitative comparison was also performed between genders.

It is a cause of great distress/bane of Indian Orthopaedic surgeon to implant devices and prosthesis designed for Western skeletons [1]. Not only are these implants large in size, their angles, and orientations and thread length also mismatch Indian femora [1]. Any alteration of the normal physiology or anatomy is likely to affect the end functional result [1].

The lifestyle and social customs of the Indian population differ from that of Western population[4]. The hip joints of the Indian population would be evolutionally different from their Western counterparts since our population is more apt to floor level activities with increased external rotation of thehip[4]. Fractures around the hip and osteoarthritis of the hip joint are relatively common in elders and need ideal fixation for good functional outcome [27].

For anthropometric studies, Husmann *et al*., Roy *et al* and Noble *et al*. used plain radiographs in their study [18, 24, 28], whereas CT scan was used by Rubin *et al*. and Mahaisavariya *et al*. [29, 30]. According to Rubin *et al*., CT scan values were more accurate than plain radiographs [29].

In a study by Rubin *et al*. [29]. (Swiss population), the femoral HD was 43.4 mm. A study among the Caucasian population by Noble *et al*. [28], the femoral HD was 45.9 mm. In our study, the femoral HD was 41.0 mm (range 30–49 mm) and the p value is <0.05 and is statistically significant which is less than the Western studies. Femoral HD value in our study is also less when compared with similar study done in India by Sengodan *et al*. [4] for South Indian population which was 42.6, and by Rawal *et al*. [15] in New Delhi which was 45.41. In our study statistically significant variation is also observed between right and left side(p=0.012)

The value of neck width in our study is 28.59±2.90 and it ranges from 20-34 mm and the p value is <0.05 and is statistically significant. The value is greater when compared with similar study done in South Indian population by Sengodan *et al*. [4] and its value is 27.5. In a study conducted by Ravichandran *et al*. [31] the value of neck width is 30.99 which is greater when compared with our study.

Femoral neck forms an angle with the shaft which is usually 135° ±7° in the normal adult. Its functional significance is that the displacement of femoral shaft away from the pelvis facilitates freedom of hip joint motion[4]. Regarding the NSA, our study results were compared with that of Western studies. The NSA of our present study 132.62(range 120-142) and the p value is <0.05 and is statistically significant. The value is more than that of western population.

Our study is also compared with other Indian studies. The NSA of Southern Assam population is less when similar study conducted in Southern Indian population. The NSA among South Indian population was more than Rawal *et al.* [15] study done in New Delhi, whereas the value is less than North eastern study done by Saikia *et al.* [23].

The NSA among males is more than that of females and is statistically significant in our study, similar to Rawal *et al.* [15]. study done in New Delhi. This study revealed that there should be relative degree of difficulty in fixing the same femoral stem to a male and female patient during total hip arthroplasty to restore the natural mechanics of the joint by considering both extra and intramedullary parameters of the femur[4]. Available cephalocervical diaphyseal angles in proximal femoral nail are 130° and 135°. In our study, NSA ranges from 120° to 142°. Hence, a routine proximal femoral nail may not replicate the original NSA following surgical fixation in all patients.

The AA was first described by Sharp. AA is frequently used to determine the presence of acetabula dysplasia. In our study, the angle is 34.93° and the p value is <0.05 and is statistically significant. Stuberg and Harris [32] found mean AA of 32.2° and 32.1° in males and females, respectively. Nakamura *et al.* [33]. observed mean of 38° in the Japanese population. When comparing the AA of our study with the study done by Saikia *et al.* [23] in Northeast India, the AA is found to be less among the South Assam population compared to Northeast Indian population. The mean acetabular angle of southern Assam population is also less when compared with Southern Indian population by Sengodan *et al.* [4]. Statistically significant variation is observed between the right and left side in our study (p=0.000).

Maintaining the leg length VO and HO helps to preserve proper hip biomechanics and improves overall postsurgical patient satisfaction in total hip replacement [34, 35]. The horizontal and vertical femoral offsets in our study are 39.34 (range 33-56 mm) and 45.34 mm (33-56) respectively and the p value is <0.05 and is statistically significant., which were much lower than the values observed by Western studies of Rubin *et al.* [29]. Husmann *et al.* [18]. Our study results when compared with a similar Indian study done in New Delhi by Rawal *et al.* [15] revealed that the HO and VO are less among South Assam population. Our study when compared with southern Indian by Sengodan *et al.* [4] population found that the values of horizontal offset is more and that of vertical offset is less when compared with south Assam population.

In our study, mean value of medullary canal diameter measured at the level of lesser trochanter is 22.58(13-28) and the p value is >0.05 and is statistically insignificant. When compared with similar Indian study by Sengodan *et al.*[4] the medio lateral canal diameter at the level of lesser trochanter is less among South Indian population. The values are also found to be higher when Southern Assam population were compared with Western population done by Rubin *et al.* [29].

All these parameters measurements were done by the single independent personnel to avoid inter observer error. Data were as analysed as a whole population and as a group (right side and left side group, male and female gender group). Medullary canal diameter at the level of lesser trochanter showed no significant difference in males and females in our study. Other parameters like neck-shaft angle (NSA), head diameter (HD), neck width (NW), acetabular angle (AA) of sharp, horizontal offset (HO), vertical offset (VO) and acetabular version (AV) was statistically significant between males and females in our study. Between right and left side femoral head diameter and acetabular angle of sharp was statistically significant in our study. Other parameters do not show any significant statistically significant difference in the study.

Table 1: Gender analysis of the various parameters of the hip joint in our study

Parameters	Male (n=100)			Female (n=100)			P Values
	Mean	Range	SD	Mean	Range	SD	
Femoral head diameter (mm)	42.49	30-49	2.63	39.51	36-43	1.58	0.000
Neck Width (mm)	30.39	22-34	2.08	26.79	20-31	2.45	0.000
Neck-shaft angle (º)	134.75	124 - 142	5.23	130.49	120 - 140	4.84	0.000
Horizontal offset (mm)	40.84	35-56	3.07	37.84	33-45	1.78	0.000
Vertical offset (mm)	46.38	33-55	4.51	44.30	34-56	5.40	0.000
Medullary canal diameter at the lesser trochanter (mm)	22.58	13-28	3.06	22.23	16-27	2.92	0.293
Acetabular angle of Sharp (º)	35.70	28-42	3.43	34.16	29-41	3.35	0.000
Acetabular version (º)	18.76	14-26	2.28	22.45	17-27	2.35	0.000

SD= Standard Deviation

Table 2: The values obtained in the study

Parameters	Population mean	Male				Female			
		Low value		High value		Low value		High value	
		Right	Left	Right	Left	Right	Left	Right	Left
Femoral head diameter (mm)	41.0	30	37	49	49	36	36	43	43
Neck Width (mm)	28.59	22	22	33	34	20	21	30	31
Neck-shaft angle (º)	132.62	125	124	142	142	123	120	140	140
Horizontal offset (mm)	39.34	35	35	56	55	33	34	43	45
Vertical offset (mm)	45.34	37	33	55	55	35	34	56	56
Medullary canal diameter at the lesser trochanter (mm)	22.58	13	15	28	28	17	16	27	27
Acetabular angle of Sharp (º)	34.93	28	28	42	42	29	29	41	41
Acetabular version (º)	20.60	14	14	26	26	17	17	27	27

Table 3: Analysis of the various parameters as per the side of the hip joint

Variables	Side	Mean	Range	SD	P (Significant values underlined)
Femoral head diameter (mm)	Right	40.918	30-49	2.70	0.012
	Left	41.09	36-49	2.56	
Neck Width (mm)	Right	28.60	20-33	2.88	0.382
	Left	28.58	21-34	2.92	
Neck-shaft angle (º)	Right	132.64	123-142	5.45	0.476
	Left	132.1	120-142	5.50	
Horizontal offset (mm)	Right	39.29	33-56	2.92	0.079
	Left	39.39	34-55	2.93	
Vertical offset (mm)	Right	45.32	35-56	5.09	0.765
	Left	45.35	33-56	5.08	
Medullary canal diameter at the lesser trochanter (mm)	Right	22.59	13-28	2.90	0.943
	Left	22.58	15-28	2.94	
Acetabular angle of Sharp (º)	Right	34.83	28-42	3.27	0.000
	Left	35.03	28-42	3.49	
Acetabular version (º)	Right	20.60	14-27	2.99	0.824
	Left	20.61	14-27	2.94	

SD=Standard Deviation

Table 4: Comparative analysis of the morphometry of the hip joint reported in different studies

Parameters	Present study (India) n=400 (mean)	Sengodan *et al* [4]. (Indian), n=400 (mean)	Rawal *et al.* [15] (Indian), n=98 (mean ±SD)	Ravichandran *et al.* [31] (Indian), n=578 (mean)	Saikia *et al.* [23] (Indian), n=104 (mean± SD)	Rubin *et al.* [29] (Swi ss), n=32 (mean± SD)	Husman *et al.* [18] (France), n=310 (mean± SD)	Mahaisavariya *et al.* [30] (Thai), n=108 (mean ±SD)	Noble *et al.* [28] (Caucasian), n=80 (mean)
Femoral head diameter (mm)	41.0	42.6	45.41±3.66	Not reported	Not reported	43.4±2.6	Not reported	43.98±3.47	45.9
Neck Width (mm)	28.59	27.5	Not reported	30.99	Not reported	Not reported	Not reported	Not reported	Not reported
Neck-shaft angle (º)	132.62	135.4	124.42±5.49	126.55	139.5±7.5	122.9±7.6	129.2±7.8	128.04±6.14	125.4
Horizontal offset (mm)	39.34	37.6	40.23±4.85	Not reported	Not reported	47±7.2	40.5±7.5	Not reported	Not reported
Vertical offset (mm)	45.34	46.9	52.33±7.19	Not reported	Not reported	56.1±8.2	57.3±8.1	48.94±4.95	Not reported
Medullary canal diameter at the lesser trochanter (mm)	22.58	20.2	Not reported	Not reported	39.2±4.9	Not reported	Not reported	Not reported	Not reported
Acetabular angle of sharp (º)	34.93	35.5	Not reported	Not reported	Not reported	27.9±3.6	Not reported	Not reported	Not reported
Acetabular version (º)	20.60	18.6	Not reported	Not reported	18.2±5.6	Not reported	Not reported	Not reported	Not reported

SD= Standard Deviation

Conclusion

The study revealed that there were significant differences exists in anthropometric parameters of hip joint among the southern Assam population when compared to that of Western literatures and also vary from region to region in other parts of India. Due to wide variability of anthropometric parameters among different parts of the world, numerous investigators and manufacturers have changed their designs within a relatively short time to incorporate newer concepts, and this confuses many orthopaedic surgeons and patients. The surgeon's recommendations should be tempered by the knowledge that change does not always bring about improvement and that radical departure from proven concepts of implant design yields unpredictable long-term results. Properly selected and implanted total hip components of most designs can be expected to yield satisfactory results in a high percentage of patients. From the above discussion it is evident that anthropometry of hip joint is important for the evaluation and treatment of the injuries of the proximal femur fractures and fractures around the hip joint. Absolute knowledge of anthropometric parameters of the hip joint is important for restoration of normal biomechanics which is essential for good functional outcome of the treatment.

The neck shaft angle and the leg length (HO) and (VO) in our individuals was 8-9 degrees more than the western population. The remaining parameters were less or equal to the western literature. This data may be used as a reference data for the normal anatomical alignment during treatment. This data may provide help to perform further studies in different parts of India. Further studies over a large population, with racial consideration and comparing the radiographic and cadaveric anthropometric parameters would be better to define the normal parameters of hip joint in the Indian population.

It is suggested from this study to use anthropometric data of the healthy side as individual reference value for the treatment of fractures around the proximal femur, because there was no statistical difference between left and right side. This study may also be useful in designing total hip prosthesis and implant around the proximal femur among the Indian population.

Limitation of the Study

Every study has its own limitations. Our study is also not an exception. The limitations of the study are that it was a single center study (single observer) with a small study group and limited time period. Hence, for the homogeneity, further observational studies involving multiple examiners with a larger number of patients and long duration are needed.

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