ORIGINAL RESEARCH PAPER
Volume - 9 | Issue - 10 | October - 2020 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

A COMPARATIVE MORPHOMETRIC ANALYSIS OF PROXIMAL FEMUR GEOMETRY IN SOUTHERN-ODISHA POPULATION: A PROSPECTIVE STUDY

Anatomy

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ABSTRACT

Introduction:- The morphometric measurements of proximal femur are essential parameters in the design and development of implants for fixation of proximal femur fractures and joint replacements. Studies on these parameters help to reduce inaccurate and improper selection of implants and thus reduce serious implications for the patients in the long run.

Aim: - The present study is aimed to study the morphology of the upper end of femur in relation to its various diameters and angles and compare the geometry of proximal femur as obtained from measurements on cadaveric specimens in Southern-Odisha population and to analyze the data by using standard statistical analysis.

Materials & Methods: - Seventy-five pairs (150 bones) of cadaveric femora of unknown sex were studied morphologically using Vernier calipers, protractor and flexible measuring tape to obtain various anthropometric measurements. These values were compared with previous studies cited in the literature.

Results: - The values were compared using Unpaired Student's t-test to analyze the data of both the sides. No significant difference was observed.

KEYWORDS

Anthropometry, head of femur, neck of femur, Southern-Odisha population.

INTRODUCTION:

The femur (longest bone), the skeleton of the thigh subserves to carry the body weight, supports the lower limb locomotion and provides attachment to the muscles[1]. Morphology of a bone is very much influenced by factors such as race, sex, environment and life style. Study by Nurzenski et al in (2007), showed that life style influences geometric indices of bone strength in the proximal femur[2]. Femoral Head Offset (FHO) and Vertical Offset (VO) are significant measurements for range of motion and abductor muscle strength after total hip arthroplasty[3].

Prevalence of hip osteoarthritis, fracture neck of femur and other hip joint problems are in the increase. Arthroplasty is supposed to be the definite treatment for these conditions. Available hip prostheses of different types are commercially designed basing on European and North American data base on the morphology of their population. [4,5]. All surgical interventions aim mostly at achieving anatomical reduction with a stable fracture fixation that helps bone reunion and allows early mobilization. A better contour-fit-bone and plate is essential to establish a stronger bone plate construction[6]. Studies on the proximal femur morphometric analysis is available on different population and communities[7]. Data obtained from these works demonstrate that femoral morphometry had regional and social differences. Song.P.U et al(2009), state that initially most of the implants are designed on the basis of measurements in Caucasian population[8]. So, the use of inappropriate hip prostheses and other such implants in THA (Total Hip Arthroplasty) in Asian population may cause complications such as micromotion, loosening and stress shielding due to mismatch of implant size. In 2003, Siwach.R.C et al, stated that use of such improper implants leads to mal-union and avascular necrosis[9].

For pre-operative assessment of the size of the implants, combined use of computerised tomography and radiography is recommended to ensure an optimal biological fixation, especially in the cemented arthroplasty as stated by Sen.R.K et al(2010)[10]. Bokariya.P et al(2009) said that anthropometry gives various techniques and scientific methods for taking a number of measurements in different races and geographical regions[11].

To measure the dimensions of the femur, various methods are used by researchers. The femur dimensions on cadaveric bones are measured mechanically, but in patients, various methods such as ultrasound, roentgenography, computerised tomography (CT) and magnetic resonance imaging (MRI) are used. Srimathi.T et al(2012) stated that number of studies in femur dimensions varies according to the methods adopted and according to the populations taken into consideration[12].

Anthropometric studies on the size of femur in central Indian population reveal that they have medium sized femora as compared to the other available data[13]. In India, a few studies have been conducted on morphometry of femur which reveal that in Indian population the results of Western studies are not fully applicable because the measurements of the femora vary in these populations[14]. The present study has been taken up to enlighten the implant designers to take a step on altering the designs of the implants that suits the Indian needs.

AIM:

To measure the values of proximal femur parameters of right and left side and compare the obtained values with other researchers to observe the regional difference, if any; and conclude whether or not the commercially available prostheses can be used in Southern-Odisha population without major implications.

MATERIALS AND METHODS:

For the prospective morphometric study, 150 dry femurs from human Indian cadavers of both sexes were used from the Department of Anatomy and Department of Forensic Medicine of M.K.C.G Medical College, Berhampur, Odisha from September 2019 to May 2020. Out of 150 dry femurs, 75 were of right side and 75 were of left side.

Sample size selection was done with reference to the research paper by Ziylan.T et al(2002), on the geometry of the proximal femur in Anatolian population[15]. (N=72, α=5%, power 80%).

The bones with visible osseous pathologies like trauma, deformities, tumours, fractures, etc. were excluded as these ailments could affect the result of study. In this study, we measurements were taken manually by using Vernier calipers, protractor and flexible measuring tape.

Fig-1: Showing Collection Of Femur Bones

Parameters measured were Head Vertical Diameter(HVD) in which the maximum length between the highest and lowest point of the head of the femur in cranio-caudal axis was measured.(Fig-2).

Fig-2: Measuring Vertical Diameter of Head of Femur

Head Transverse Diameter(HTD) was measured by Vernier calipers as a distance between the most laterally projected points on equatorial plane taken at right angle to the vertical diameter of head. Head Circumference(HC) was measured by winding the flexible measuring tape around the circumference of head of femur along its articular surface. Neck Vertical Diameter(NVD) was measured using Vernier calipers as the minimum distance in supero-inferior plane (sagittal plane) in the narrowest part of femur neck between the superior and inferior surface. Neck Transverse Diameter(NTD) was also measured using Vernier calipers as the minimum distance of the narrowest part of the neck of femur in antero-posterior direction. For the Neck Shaft Angle(NSA), a thread was tied from the center of the fovea centralis, passing through midpoint of NVD to the site immediately below the greater trochanter. Another thread was tied which extends in the mid sagittal plane over the anterior surface of the bone from the superior surface of neck and the midpoint between the two condyles. The angle between the two was measured using protractor.

Statistical Analysis:

Statistical analysis comparing morphological parameters between right and left femora were performed using unpaired t-test. The level of significance was set at $p<0.05$.

RESULTS:

Table-1 shows the measured values of the anthropometric parameters studied in 75 pairs of human dried femora in Southern-Odisha population. The mean, standard deviation(SD) values between the right and left sides were compared and the p-value was obtained. There was no significant difference observed between the left and right sided parameters.

Table-1: Showing The Anthropometric Measurements Of 75 Pairs Of Femora

Measurements of Femur Bone (150 bones)							
Side	**Parameters**	**HVD (mm)**	**HTD (mm)**	**HC (mm)**	**NVD (mm)**	**NTD (mm)**	**NSA(°)**
Right (75)	Mean	42.0066	41.091	130.9	28.96	24.3824	123.14
	SD	3.77289	3.4821	10.86	4.369	4.22762	4.31
Left (75)	Mean	42.423	40.26	132	29	24.77	122.747
	SD	3.9252	3.403	10.74	4.249	4.311	4.22
	p-value	0.58	0.2257	0.75	0.9428	0.06	0.5734

In the present study, HVD on right side is 42.01±3.77 which is comparatively lower than left side 42.42±3.92. The HTD was found to be 41.09±3.48 on right side which is higher than left side femora 40.26±3.40. The HC in present study was observed to be 130.9±10.86 on right side which is comparatively lower than left side femora 132±10.74. The NVD and NTD were lower in right sided femora which are 28.96±4.36 and 24.38±4.22 respectively than on the left sided femora which are 29±4.24 and 24.77±4.31. The NSA in present study on right side was higher 123.14°±4.31 than left side 122.75°±4.22.

DISCUSSION:

The basic biomechanical goal of total hip arthroplasty is to configurate a stable anatomical articulation with an optimum range of movement, to restore a near normal biomechanics for muscular efficiency and to equalize the limb lengths. The present study was undertaken to compare differences in dimensions if any between femora of Southern-Odisha population and those of population from other regions and indicate the problem of a possible geometric mismatch thereof between a selected implant and the dimensions of the hip joint in the population concerned. Neck-shaft angle(NSA) is an important parameter of upper femur geometry used for designing as well as placing the femoral implant during total hip replacement operation.

In the present study, HVD on right side is lower than that of left sided femora, which is similar to the observation of Nidugala.H et al(2016) [16] where the study was conducted on South-Indian population and the mean obtained was 39.85±3.55 and 41.75±3.48 respectively but is in variance with the findings by Sreekumar.R et al(2016)[17] and Dwivedi.A.K et al(2019) [18]. The mean value of head vertical diameter showed on right side was 32.87±2.53 and on the left side 32.12±2.00 in the study by Sreekumar.R et al(2016) but statistically no significant differences between the data of two sides were found, as the p-value was 0.122 [17]. Dwivedi.A.K et al(2019) stated that they found the mean HVD to be 40.57±3.54 and 40.49±3.49 on right and left femora in Maharashtrian population[18].

The HTD was higher on right side femora than on left side in our study, as obtained by Ziylan.T et al (2002) [15], where the average HTD was 44.7±4.1 and 44.3±3.3 respectively on both sides that supports the findings by Sreekumar.R et al(2016) where the mean head transverse diameter on right side was 33.88±2.46 and on left side was 33.31±3.79 [17]. Similar finding was observed by Dwivedi.A.K et al(2019) i.e. HTD on right was 40.59±3.47 and on left side was 40.30±3.48 [18]. Desousa.E.B et al(2010) studied on proximal extremity of femur and found that the average head transverse diameter on right side was 31.1±2.7 and on the left side was 30.8±3.0 that corroborates our findings[19]. Nidugala.H et al(2013) concluded that the head transverse diameter on right was lower than that of left side i.e. 35.31±2.90 and 36.81±3.79 respectively which differs from that of our study[16].

The HC, in the present study, was lower in right than on left femora similar to that found by Dwivedi.A.K et al(2019), where HC was 126.50 ± 10.44 on right side and 126.80±10.83 on left side[18].

The NVD was observed to be lower on that of right than on left side similar to that of Dwivedi.A.K et al(2019)[18] where the mean were 27.78±2.78 and 27.86±2.87 respectively. Ziylan.T et al(2002) reported the morphometry of Anatolion femur and quoted the mean of neck vertical diameter on right side as 45.2±4.0 and on left side as 43.4±3.2 [15]. The contrast observed in the data of Ziylan.T et al(2002) and that in the present study probably reflects the ethnic variation in femoral morphometry. Sreekumar.R et al(2016) found the NVD was higher on the right side 25.72±3.31 than the left side 24.52±3.27[17].

In the present work, the NTD was lower on the right than on the left side, unlike that obtained by Sreekumar.R et al (2016), where mean were 18.11±2.00 and 17.49±2.09 respectively[17]. Ziylan.T et al(2002) too reported that the values of neck transverse diameter on right side was higher, 26.3±3.1 and on left side it was lower, 25.5±2.7 [15], that stand contrary to our observations. Dwivedi.A.K et al(2019) also quoted values which were contrasting to our data in which right side NTD was 23.28±2.85 and on left side was 23.13±2.83 [18].

The NSA, in our study, was found higher on right side than on left side, similar to that stated by Sreekumar R. et al (2016) on right side 127.20°±2.43 and 126.16°±4.22 on left side[17]. Golchini.E et al(2016) stated that the mean values of NSA, in different populations as reported by them, using different methods such as dry bone-mechanical, dry bone-digital photo, dry bone- X-Ray and computerized tomography(CT) are 129.57° (American), 131° (Canadian), 127.4° (British), 127.7° (Norwegian), 125.3° (French), 124.2° (Netherland), 124.85° (Turkish), 121.9° (South Africa), 121° (Nigerian), 134° (Pakistani), 127.54° (Indian), 126° (Japanese) and 130.65° (Chinese)[20]. They obtained mean NSA to be 125.9° in Iranian population [20]. Gilligan.I et al(2013), reviewed a global NSA database comprising about 8000 femora representing 100 human groups. Results from the analyses showed that the mean NSA for humans is 127°, which is markedly lower than the accepted value of 135°(range 125-140)[Ref:- Gray's Anatomy, 41st edition, 2016, Editor-Susan Standring, Elsevier,pg-1379]. There was no sex difference, no

age-related change in adults, but a small lateral difference which could be due to right leg dominance[21].

Table-2 shows the studies undertaken by various authors in different populations and their mean NSA values [20]. These values were measured manually using dry bones. The Table-2 shows that mean NSA in Chinese was observed to be 136.2°, in American 135° and in Canadian 131° which were the higher values amongst all the populations taken into consideration. The lower values of mean were 121.9°, 123.5° and 124.6°, found respectively in those of South-African, Indian and Japanese. The present study in Southern-Odisha (Indian population) shows that the NSA is similar to that stated by Siwach.R.C et al(2003) [9].

Table 2: Showing The Mean NSA Values In Different Studies By Mechanical Measurement Of Dry Bones

Sr. no.	Author	Year	Sample size	Population	Method	NSA (mean)
1	Parsons	1924	134	British	Dry bone-mechanical	126.3°
2	Kiyono	1928	46	Japanese	Dry bone-mechanical	124.6°
3	Hoagland	1980	51	Chinese	Dry bone-mechanical	136.2°
4	Hoagland	1980	55	American	Dry bone-mechanical	135°
5	Yoshioka	1987	32	Canadian	Dry bone-mechanical	131°
6	Nobel	1988	200	American	Dry bone-mechanical	124.7
7	Macho	1991	361	South-African	Dry bone-mechanical	121.9°
8	Trinkaus	1993	55	American	Dry bone-mechanical	129.4°
9	Oguzo	1996	50	Turkish	Dry bone-mechanical	124.85°
10	B Isaac	1997	171	Indian	Dry bone-mechanical	126.7°
11	Maruyama	2001	200	Japanese	Dry bone-mechanical	125°
12	RC Siwach	2003	150	Indian	Dry bone-mechanical	123.5°
13	Gilligan	2013	115	Chinese	Dry bone-mechanical	127.2°
14	Golchini	2016	159	Iranian	Dry bone-mechanical	125.9°
15	Present study	2019	150	Indian(Southern-Odisha)	Dry bone-mechanical	123.14° (R) 122.75° (L)

LIMITATION:

Sexual dimorphism in the morphometry of femur has not been taken into consideration while selecting femur for the study. Demographic characteristics such as age, sex, ethnicity, nutritional status etc. were unknown. The precision of measurements could have been increased by use of digital calipers.

CONCLUSION:

The study shows that there is no significant difference observed in the parameters like Head Vertical Diameter, Head Transverse Diameter, Head Circumference, Neck Vertical Diameter, Neck Transverse Diameter and Neck Shaft Angle between the right and the left sides of femora. So, the commercially available prostheses and implants can be used in Southern-Odisha population without serious implications in patients in the long-run. It is commonly accepted that the statistical analysis of morphometry of femur among various populations reveals a large amount of variation due to the fact that the morphometric measurements of femur from different countries are likely to be affected by variations in climate, heredity, diet and other geographical factors related to life style.

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