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Anthropometric Analysis of Femur in South Indian Population

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Most of the femoral orthopaedic implants were designed and manufactured based on western anthropometry which is different from South Indian population and causes complications like aseptic loosening. This was an observational descriptive type of study which was performed on 95 fully ossified human femur bones (48 Right sided and 47 Left sided) collected from our institute. Vernier Caliper, Goniometer and Inch tape were used for taking measurements. The parameters studied were Neck Shaft Angle, Length of femur, Vertical Head diameter, Head circumference, Mid-shaft anteroposterior diameter and Mid-shaft Circumference.The results of the present study are the mean neck shaft angle was 146.25±4.18°, the mean length of femur was 3.38±3.14cm, the mean vertical head diameter was 39.9±3.42mm, mean head circumference was 14.13±1.04cm, mean midshaft anteroposterior diameter was 25.396±2.93mm and the mean midshaft circumference was 9.086±0.69cm. The mean values are also taken separately for the right and left femora. Comparing the results of this study with the previous study for right and left sided values, the results are found to be statistically significant.The mean values of the femoral parameters should be considered during surgical fixation of femoral fractures and also for designing orthopaedic implants and hip prosthesis for South Indian population.

Keywords: Anthropometry; Arthroplasty; Diaphyses; Femur; Femoral Fractures; Hip Prosthesis.

The anatomy of proximal end of femur is essential to understand the biomechanics of hip joint[1,2]. The neck shaft angle of femur[3,4,] also known as Cervicodiaphyseal angle5 (120°-140°)[6] along with the proximal femoral geometry is of utmost importance in pre-operative planning of osteotomy, arthroplasty or fracture fixation[7] and for implants of femoral neck[8]. Use of undersized or oversized femoral implants leads to altered soft tissue tensioning and altered patella femoral stresses[9]. In case of improper selection of femur implant, postoperative complications can arise.

MATERIALS AND METHODS

The objective of the study is to measure the various parameters of femur in South Indian Population and to correlate with the previous studies. This is an observational descriptive type of study which was performed on 95 fully ossified human femur bones (48 Right sided and 47 Left sided) collected from our institute, Chennai. Instruments used for taking measurement were Goniometer, Vernier Caliper and Inch tape.

Inclusion Criteria: Normal cadaveric bones of South Indian Population

Exclusion Criteria: Bones with any pathology and damaged bones

The following are the parameters of femur studied:

- Neck Shaft Angle
- Length of femur
- Vertical Head diameter
- Head circumference
- Mid-shaft anteroposterior diameter
- Mid-shaft Circumference

Appropriate statistical tests were done after the formulation of results.

RESULTS AND DISCUSSION

The average values of the above said parameters as found in the current study are as follows:

Neck Shaft Angle (NSA)

In this study, the neck shaft angle was measured and recorded among 95 dry femurs, out of which, 48 were right sided and 47 left sided. The minimum angle measured was 138° on the right side and 137° on the left side. The maximum angle measured was 154° on the right side and 155° on the left side. The mean NSA of all the femur was 146.25±4.18°. The mean NSA on the right side was 145.46±4.62° and the mean NSA on the left side was 147.06±3.54°.

The variation in NSA between the right and left sides was found to be statistically insignificant. Comparing the results of this study with the study of Ravichandran *et al*[10] (mean NSA is 126.55°), the values are found to be higher in this study. In a study done by RC Siwach *et al*[11] in 2003 among people of Rohtak using150 dry bones, the neck shaft angle was 123.5°, as against 146.25°, which is again higher. Comparing with the results of this study with the study of Minakshi verma *et al*[12], NSA was not significant on the right side whereas on left side, the two tailed p value is less than 0.0001. By conventional criteria, this difference is considered to be extremely statistically significant.

Tilman and Tondury suggested that NSA is around 150° during fetal development and decrease to 125° by the time of skeletal maturity[14]. NSA varies with climate, clothing, age, side, lifestyle, occupation, gender and economic status of the individual[15]. Orthopaedic manufacturers use data from various studies to develop femoral prosthesis to develop new hip stem designs for treating fractures of the proximal femur especially femoral neck fractures[16]. It is an important parameter to predict the risk for a hip fracture, especially in osteoporosis and to start preventive treatment if there is an increased risk[17]. Radiography of the angle aids in the diagnosis and further management of femoral neck fractures.

Length of Femur

The minimum length measured on the right side was 37.2cm and on the left side, 38.3cm. The maximum length measured on the right side was 51.7cm and on the left side was 52.3cm. The mean length of all femurs measured was 43.38±3.14cm. The mean length of femur on the right side was 43±2.98cm and the mean length on the left side was 43.77± 3.29cm. The variation in the length of femur between the right and left side was found to be statistically insignificant.

Comparing the results of this study with the study of Zuylan and Murshid[18] (in their study left femur length was 42.84 cm, right femur length was 41.68 cm), femoral length was not significant on the right side whereas on left side, the two tailed p value is 0.0469. By conventional criteria, this difference is considered to be statistically significant.

The difference in mean femoral length in between populations is due to factors that affect bone morphology such as genetic constitution, diet, nutrition status, environment, and physical activity[19]. Femur length is important in designing intramedullary femoral implants and surgical management of femoral shaft fractures. It is used in the estimation of body stature of the person in the field of forensic medicine[20].

Femoral Head Diameter

In this study, Vertical head diameter of the femur was measured using vernier caliper. It is taken at right angle to the long axis of neck of femur. The vertical diameter is the straight distance between the most superior to the most inferior point of the femoral head in a vertical plane.The least head diameter of the femur measured was 32.45mm on the right side and 33.19mm on the left side. The highest head diameter of the femur measured was 46.83mm on the right side and 46.27mm on the

left side. The mean head diameter of all femurs was 39.9±3.42mm. The mean head diameter on the right side was 39.95±3.15mm and the mean head diameter on the left side was 39.85±3.71mm. The variation in the vertical head diameter between the right and left side was found to be statistically insignificant.

Comparing the results of this study with the study of Khaleel N *et al*, on the right side, the two tailed p value is 0.0025 and on the left side, the two tailed p value is less than 0.0001. By conventional criteria, this difference is considered to be very statistically significant on both sides.

Rumapurkait[22] found that head diameter alone could correctly determine sex to 92.5% of males and 95.5% females. In the same study they also found that vertical head diameter of right femur was significantly greater than left. Pons[23] stated that the head diameter determined the sex better than any other part of bone. It is essential for selection of the implants of the head during Hemiarthroplasty of the hip. Vernier Caliper measurements of the vertical head diameter are more reliable than X ray and CT images for measuring the head diameter for the selection of prosthesis[24].

Head Circumference

The head circumference was measured around the head of the femur using an inch tape. The minimum head circumference measured was 12cm on the right side and 11.8cm on the left side. The maximum head circumference measured was 15.8 cm on the right side and 16.2cm on the left side. The mean head circumference of all femurs was 14.13±1.04cm. The mean head circumference on the right side was 14.15±0.99cm and the mean head circumference on the left side was 14.11±1.09cm. The variation in the head circumference between the right and left side was found to be insignificant. Ranjan Bajpai *et al* studied the head circumference of femur in Nashik district, Maharashtra and found to be significantly higher in males compared to females[25]. Head circumference is important in deciding the range of movements after THA (Total Hip Arthroplasty)

Table 1. Average Values of all Parameters

Parameter	Total Value	Right Femur	Left Femur
Neck Shaft Angle	146.25±4.18°	145.46±4.62°	147.06 ±3.54°
Length of femur	43.38±3.14cm	43±2.98cm	43.77±3.29cm
Head diameter	39.9±3.42mm	39.95±3.15mm	39.85±3.71mm
Head circumference	14.13±1.04cm	14.15±0.99cm	14.11±1.09cm
Midshaft anteroposterior diameter	25.396±2.93mm	25.51±2.89mm	25.28±2.99mm
Midshaft Circumference	9.086±0.69cm	9.002±0.64cm	9.172±0.73cm

The relevant statistical tests and their significance along with p value are discussed in the respective parameters.

Table 2. Comparison of Neck Shaft Angle of Present Study with Previous Studies[13]

Author	Year	Number of bones	Geographical Distribution	Materials	Neck Shaft Angle (in degrees)
RC Siwach	2003	150	Rotak	Dry bones	123.5±4.3
K C Saikia	2008	92	Guwahati	CT Scans	139.5±7.5
T R Deshmukh	2010	77	Vidarbha	X rays	131.5
Subhas Gujar	2013	250	Central Gujarat	Dry bones	136.2±6.0
Shaik hussain Saheb	2014	250	South India	Dry bones	137.1
Vineeta Laxmi	2018	62	Bihar	Dry bones	136.55±5.23
Minakshi verma et al	2017	91	New Delhi	Dry bones	130.3±3.875
					p value with present study= 0.0001(significant)
Present Study	2019	95	South India	Dry bones	146.25±4.18

i.e hip movements increases with larger bearing sizes. Larger heads prevent dislocation after the surgery and the risk of revision surgery.

Midshaft Anteroposterior Diameter

Anteroposterior diameter of femur can be taken at three different levels:

Upper: Just below the lesser trochanter

Middle: Approximately at the middle of the shaft

Lower: Approximately 4 cm above the cartilaginous margin of condyles taken in mid sagittal plane.

In this study, midshaft anteroposterior diameter was measured and compared among 95 dry femurs, among which 48 were right and 47 left. The minimum midshaft anteroposterior diameter that measured was 21.32mm on the right

Table 3. Comparison of Femur Length in Different Population[19]

Authors	Population	Subdivision	Femur length
Zuylan *et al*	Anatolian	Right	41.68±6.86cm
		Left	42.84±2.49cm
			p value on left with present study= 0.0469 (significant)
Gujar *et al*	Indian	Right	43.99cm
		Left	43.65cm
S Dhivya, V Nandhini	South Indian	Right	41.29±3.39cm
		Left	41.88±2.82cm
Khan and Saheb	South Indian	Right	44.66±2.66cm
		Left	44.58±2.61cm
Present study	South Indian	Right	43±2.98cm
		Left	43.77±3.29cm

Table 4. Comparison of Femoral Head Diameter with Previous Study[21]

Authors	Population	Subdivision	Vertical Head diameter of femur (mm)
Khaleel N et al	SV medical College, Tirupathi, Andhra Pradesh.	Right	41.63mm±3.09mm
			p value with present study= 0.0025(significant)
		Left	42.96mm±3.92mm
			p value with present study= 0.0001(significant)
Present study	South Indian Population	Right	39.95mm±3.15mm
		Left	39.85mm±3.71mm

Table 5. Comparison of Midshaft Anteroposterior Diameter with the Previous Studies[26]

Authors	Population	Subdivision	Midshaft anteroposterior diameter
T.Jayachandra Pillai et al	Different medical institution and Anthropology department of S. V. University, Tirupati	Right	26.20±2.02mm
		Left	26.61±2.40mm
			p value with present study= 0.0075(significant)
Dr Ashish Kamdi et al	Telangana region	Right	25.14mm
		Left	25.06mm
Present study	South Indian Population	Right	25.51mm
		Left	25.28mm

Table 6. Comparison of Midshaft Circumference with Previous Study[18]

Author	Population	Subdvision	Midshaft Circumference
Zuylan et al	Anatolian Population	Right	8.62±0.65cm p value with present study= 0.0001(significant)
		Left	8.72±0.76cm p value with present study= 0.0002(significant)
Present Study	South Indian Population	Right	9.002±0.64cm
		Left	9.172±0.73cm

side and 16.99 mm on the left side. The maximum midshaft anteroposterior diameter measured was 32.96mm on the right side and 32.19mm on the left side. The mean midshaft anteroposterior diameter of all femurs was 25.396±2.93mm, on the right side was 25.51±2.89mm and on the left side was 25.28±2.99mm. On statistical analysis, the difference in the midshaft anteroposterior diameter between the right and left side was found to be statistically insignificant.

Comparing the results of this study with the study of T.Jayachandra Pillai *et al*[26], midshaft anteroposterior diameter was not significant on the right side, whereas on the left side, the two tailed p value is 0.0074. By conventional criteria, this difference is found to be very statistically significant. This value is taken into consideration while making a best fit femoral prosthesis and also for the determination of sex by the forensic anthropologist. Ashish Kamdi observed that the values are slightly higher in males compared to females[27].

Midshaft Circumference

In this study, midshaft circumference was measured with an inch tape and compared among 95 dry femurs. The least value of midshaft circumference that was measured was 7.6cm on both the sides. The highest value recorded was 10.5cm on the right and 10.7cm on the left. The mean midshaft circumference of all femurs was 9.086±0.69cm. The mean midshaft circumference on the right side was 9.002±0.64cm and the mean midshaft circumference on the left side was 9.172±0.73cm. The difference in the midshaft circumference between the right and left side was found to be statistically insignificant.

Thomas K. Black *et al* in their study observed that femoral circumference is a useful tool in the determination of sex especially when the skeletal remains are fragmentary or poorly preserved. They concluded that femur circumference greater than 81mm were classified as males and lesser than 81mm as females and those with a femoral circumference equal to 81mm were classified as indeterminate sex[28].

Comparing the results of this study with the study of Zuylan *et al*, the midshaft circumference, on the right side, the two tailed p value was 0.0001 and on the left side, the two tailed p value was 0.0002. By conventional criteria, this difference is found to be extremely statistically significant.

CONCLUSION

On studying and analysing the various parmeters of femur, this study concludes that there is no statistically significant differences between the right and left femurs. There has been studies showing significant differences in femoral sizes and shapes across gender, age, race and region. These differences are challenge for the design of well-fitting prosthesis which suits the South Indian Population. Therefore, analyses of femur parameters with statistical methods are very essential.

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