A MORPHOMETRIC STUDY OF UPPER END OF FEMUR AND ITS IMPLICATIONS IN HEMIARTHROPLASTY

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ABSTRACT

Introduction: Hemiarthroplasty of hip is very common now-a-days in fracture neck of femur. So there is always need of population specific data for making best fit prosthesis to reduce complications following the procedure.

Objectives: To measure Femoral Head Diameter, Femoral Neck Length, Femoral Neck Diameter, Femoral Neck Thickness and Cervico- Diaphyseal Angle. To find the correlation between each parameter.

Materials and method: 100 dry femur, required for the study, were collected from the Department of Anatomy, Mysore Medical College, Mysore. Measurements were obtained using a digital vernier calliper, a ruler and a protractor.

Results: Mean value of Femoral Head Diameter was similar to other Indian studies. Mean value of Cervico-Diaphyseal Angle varied as that of western studies. The values of Femoral Head Diameter show high correlation with the values of Femoral Neck Diameter, Length and Thickness.

Conclusion: The regional variations noted in this study will help designing prosthesis of appropriate head, neck and stem size, thus reducing the failure rates in hemiarthroplasty.

KEY WORDS: Upper end of Femur, Hemiarthroplasty, Morphometry of Femur.

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INTRODUCTION

The femur is the largest and strongest bone in the body and the structure of its proximal portion allows the leg to move in three dimensions relative to the torso, thus serving as a linchpin of human mobility [1].

Intertrochanteric fractures with severe displacement and comminution are common in elderly patients. These patients have a poor bone quality and the fractures are often associated with complications such as non union, metal failure and femoral head perforation [2,3]. Femoral neck fractures involve the narrow neck between the round head of the femur and the shaft [4].

To allow an earlier Post-operative weight-bearing and a rapid rehabilitation and to avoid excessive collapse at the fracture site, some surgeons have recommended prosthetic replacements for the treatment of unstable intertrochanteric fractures [5-7]. Studies by Rogmark *et al.*,[8] and Roden *et al.*,[9]showed complications of non-union, avascular necrosis and a high rate

(30-40%) of reoperation following internal fixation and superior function after primary hemiarthroplasty which eliminates these complications as the femoral head and neck is replaced by metallic implant[10]. Instability and dislocation after total hip arthroplasty are the most common causes of revisions and major complications for failure of inserted prostheses, leading to a reduction in quality of life. Because the use of artificial femoral head sizes smaller than patient's own size is the important cause for dislocation, the use of large femoral head have increased. Femoral head sizes greater than 32 mm offer multiple advantages in physical function and activity levels of patients by improving hip stability, decreasing dislocation rate and increasing range of motion. However, various concerns are encountered including wear debris generation at the trunnionbore interface and increases in frictional torque and stress over the component-bone interface when using larger head sizes[11] Variations in hip morphology are also of critical interest to surgical planning where the ability to take hip morphology into account on a patient specific basis is crucial for success in choosing designs of implants and other structures used for hip replacements and augmentations of hip stability[12]. Use of western implants in Indians increases the chance of implant failure significantly leading to malunion,non-union and avascular necrosis[13]. As the environment plays an important role in the development, the regional variation of the femur bone is influenced by geographical area, sex, stature, and heredity. The knowledge of variations in the parameters of dry femora will help the orthopedicians and also assist prosthetists to design a suitable prosthesis for restoration of normal neck shaft angle[14].

Aim: To measure the morphometric parameters of upper end of femur- Femoral Head Diameter (FHD),Femoral Neck Diameter (FND),Femoral Neck Length (FNL),Femoral Neck Thickness (FNT),Cervico-Diaphyseal Angle (CDA).To compare their values on right and left side.

MATERIALS AND METHODS

For the prospective morphometric study, 100 dry femurs from human cadavers of both sexes were obtained from the Department of Anatomy, Mysore Medical College and Research Institute,Mysore from May 2017 to December 2017. Out of 100 dry femurs, 50 were of right side and 50 were of left side. Sample size selection was done with reference to the research paper by Minakshi Verma et al., on the Morphometry of Proximal Femur in Indian Population [15]. (N=100, α=5%, power 80%).Bones with visible osseous pathologies like tumours, deformities, fractures, trauma were excluded. Morphometric parameters of upper end of femur were measured manually by using anthropometric instruments like ruler, goniometer and digital calliper.FHD(Femoral Head Diameter) was the distance in a straight line between the upper end to the lower end of the femoral head in cranio caudal axis [Figure-1].FNL(Femoral Neck Length) was the distance between the inferior region of base of femoral head and the lower end of intertrochanteric line [Figure-2]. FNT(Femoral Neck Thickness) was thickness of neck of femur in antero posterior axis [Figure-3]. FND(Femoral Neck Diameter) was the distance in a straight line from upper end to the lower end of the anatomical neck of femur in craniocaudal direction [Figure-4], and Cervico Diaphyseal Angle (CDA) was the angle between the line joining the center of head of femur and the midpoint of Intertrochantric line (Femur Neck Axis) and vertical line from the tip of greater trochanter (Femur Shaft Axis) [Figure-5].

Statistical Analysis: Data was tabulated and reported as mean $\pm$ Standard deviation. Spearmans correlation was used to analyse the relationship between all parameters[TABLE-5].

RESULTS

Mean value of the parameters are as follows: Femoral Head Diameter: 42.33 $\pm$ 3.8mm(total), 42.23 $\pm$ 3.3mm(right),42.43 $\pm$ 4.2mm(left); Femoral Neck Length: 33.9 $\pm$ 6.7mm(total), 35.69 $\pm$ 7mm(right),32.16 $\pm$ 5.9mm(left); Femoral Neck Diameter: 30.43 $\pm$ 3.7mm(total),30.22 $\pm$3.4mm(right), 30.65 $\pm$ 3.9mm(left); Femoral Neck Thickness: 25.64 $\pm$ 3.5mm(total), 25.13 $\pm$ 2.9mm(right),26.15 $\pm$ 3.9mm(left); Cervico - Diaphyseal Angle: 117.6p $\pm$ 8.5p (total) ,116.84p $\pm$ 8.07p (right) ,118.52p $\pm$ 8.9p (left) . Femoral Head Diameter values are

classified as follows: <37mm(7%); 37.1-39mm(15%);39.1- 41mm(12%); 41.1- 43mm (23%); 43.1- 45mm(17%); 45.1- 47mm (15%); 47.1- 49mm(7%); >49mm(4%). All these values were tabulated in [TABLE-1].

Table 1: Morphometric parameters of upper end of femur.

Parameters	Mean average total	Mean average right	Mean average left
Femoral head diameter	42.33 ± 3.8mm	42.23 ± 3.3mm	42.43 ± 4.2mm
Femoral neck length	33.9 ± 6.7mm	35.69 ± 7mm	32.16 ± 5.9mm
Femoral neck diameter	30.43 ± 3.7mm	30.22 ± 3.4mm	30.65 ± 3.9mm
Femoral neck thickness	25.64 ± 3.5mm	25.13 ± 2.9mm	26.15 ± 3.9mm
Cervico- diaphyseal angle	$117.6^{o} \pm 8.5^{o}$	$116.84^{o} \pm 8.07^{o}$	$118.52^{o} \pm 8.9^{o}$

DISCUSSION

Femoral head diameters were classified into various ranges and frequency in each range was noted and tabulated [TABLE- 2]. High frequency (23 %) was found in the range of 41.1- 43mm. In the present study, parameters were calculated manually using anthropometric instruments.Other methods used to measure the parameters are shown in[TABLE-3].The parameters of present study are compared with those of previous studies.The mean femoral head diameter is 42.33 ± 3.8mm which is similar to the study of Minakshi verma et al , New Delhi, India [15]. The mean Cervico-diaphyseal angle is 117.6^{o}, which is different from the values of previous studies, tabulated in[TABLE- 4].There is high correlation noted in the values of femoral head diameter with femoral neck length , diameter and thickness [TABLE- 5].

Table 2: Distribution of Femoral Head Diameters.

Range	Frequency
<37mm	7%
37.1-39mm	15%
39.1- 41mm	12%
41.1 -43mm	23%
43.1- 45mm	17%
45.1- 47mm	15%
47.1- 49mm	7%
>49mm	4%

Table 3: Various methods of measurements.

Study	Method
Minakshi verma et al –(New Delhi,India)	Digital photographs with image j software [15]
Ho jung cho et al –(Korea)	Automated geometric computation program using 3d models [26]
De sousa e et al –(Brazil)	Radiographic measurements using xrays [27]
Zaki et al (Egypt)	Radiological measurements using ct images[25]

Table 4: Comparison of parameters of present study with previous studies.

Parameters/Study	FHD	FNL	FND	FNT	CDA
Present Study	42.33mm	33.9mm	30.43mm	25.64mm	117.6^{0}
Minakshi verma et al, New Delhi [15]	42.31mm	44.75mm	32.98mm	24.01mm	128.9^{0}
Aparna gullapalli et al, Andhra Pradesh [28]	-	-	-	-	121^{0}
Ravi G.O.,et al, South India [12]	-	36.3mm	-	-	136.8^{0}
Prabha nand chaudhary et al, North Karnataka [14]	-	28.8mm	-	-	127.21^{0}
De sousa et al, Brazil [27]	-	30.3mm	46.75mm	30.95mm	131.9^{0}

Table 5: Correlation of one parameter with other parameters.

Spearman's rho Correlations		FHD	FNL	FND	FNT	CDA
FHD	Correlation Coefficient	1	.278**	.841**	.782**	-0.037
	Sig. (2-tailed)	.	0.004	0	0	0.71
	N	103	103	103	103	103
FNL	Correlation Coefficient	.278**	1	.302**	.235*	-0.004
	Sig. (2-tailed)	0.004	.	0.002	0.017	0.967
	N	103	103	103	103	103
FND	Correlation Coefficient	.841**	.302**	1	.838**	-0.103
	Sig. (2-tailed)	0	0.002	.	0	0.298
	N	103	103	103	103	103
FNT	Correlation Coefficient	.782**	.235*	.838**	1	-0.089
	Sig. (2-tailed)	0	0.017	0	.	0.371
	N	103	103	103	103	103
CDA	Correlation Coefficient	-0.037	-0.004	-0.103	-0.089	1
	Sig. (2-tailed)	0.71	0.967	0.298	0.371	.
	N	103	103	103	103	103

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Limitations: Study was done on dry bones. Hence right and left bones are not from same individual. Gender and Age could not be taken into account.

CONCLUSION

Intertrochanteric fractures with severe displacement and comminution are common in elderly patients. These patients have a poor bone quality and the fractures are often associated with complications such as non union, metal failure and femoral head perforation [16,17].

To allow an earlier Post-operative weight-bearing and a rapid rehabilitation and to avoid excessive collapse at the fracture site, surgeons have recommended prosthetic replacements for the treatment of unstable intertrochanteric fractures [18-20]. Numerous studies have also shown that there is increase in the rate of intra operativecomplication in the event of using mismatched implants especially over size

implants[21]. Commercially available hip prostheses are made based on European data [22,23]. callipers and ring gauge measurements are more reliable than the CT and X-ray methods for measurement of femoral head diameter in hemiarthroplasty[24].The values in present study shows variations with other studies from different regions. Hence region specific data of present study helps orthopedicians in selecting appropriate prosthesis, to reduce postoperative failure of prosthesis in hemiarthroplasty.

Conflicts of Interests: None

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