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Morphometric Parameters of the Proximal Femur in Nepalese Population: A Cross-sectional Study

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Abstract

Background: Most of the proximal femur fractures are managed surgically by internal fixation with a variety of implants. Improperly designed or ill-fitted implant may lead to a failure of fixation, breakage of implant and non-union, thus increasing the morbidity and the cost of treatment. This study was conducted to evaluate the radiographic morphometry of the proximal femur which may be helpful in designing the implants for the Nepalese population.

Methods: In this cross-sectional study, 84 patients aged 18 years and above with traumatic unilateral hip fracture were enrolled. Anthropometric measurements were recorded. The postoperative check X-ray in the antero-posterior view of the pelvis and bilateral hip were assessed. Various morphometric parameters of the proximal femur were measured and recorded in the radiograph of the unaffected limb using a digital caliper.

Results: Out of 84 patients, 47 were male. The mean ± SD femoral neck width, femoral neck length, femoral axis length, cervico-diaphyseal angle, acetabular tear-drop distance, and great trochanter-pubic symphysis distance were 36.10 ± 5.67 mm, 28.29 ± 4.18 mm, 104.51 ± 9.56 mm, 130.35 ± 8.67°, 32.56 ± 11.05 mm, and 163.07 ± 10.71 mm respectively. The femoral neck width was found to be significantly larger in males (39.08 ± 3.06 mm) than in females (32.32 ± 5.99 mm, $p < 0.001$).

Conclusion: This study determined the radiographic measurement of the proximal femur and found that the femoral neck width of the males was larger than that of the females.

Keywords: anatomy, measurement, proximal femur, radiography

Proximal femur fracture is common in the elderly. Each year more than 300,000 people get admitted to the hospital for treatment of the proximal femur fractures in the U.S.A.[1] According to the 9th Asian Federation of Osteoporosis Society, the number of hip fractures in Asia will increase from 1,124,060 in 2018 to 2,563,488 by 2050.[2] Hip fracture is associated with a high morbidity and mortality.[3,4] Early medical optimization and surgical stabilization facilitates quicker patient mobilization and recovery. Most of these fractures are managed surgically by internal fixation with a variety of implants ranging from partially threaded cancellous cannulated screws to arthroplasty.[5,6] The outcome depends upon the type of fractures, the skill of surgeons and most importantly the design of the implants. Improperly designed and ill-fitted implants lead to failure of fixation, breakage of implant and non-union, thus increasing the morbidity and cost of treatment.[7,8] Most of the implants used in the hospitals of Nepal are designed based on the morphometric study of the western population. Screw cutout and breakage of barrel plate in dynamic hip screw construct, dislocation and breakage of prosthesis in hemi-arthroplasty are a common phenomenon.[9,10] Similarly, it is difficult to pass hip pin and neck screw in proper place and part of the nail remains outside the tip of greater trochanter in the proximal femoral nail (PFN) construct. So, properly designed implants based on the morphometry of the local population may be helpful to overcome these difficulties. Few studies evaluated the morphometry of the proximal femur in Nepal.[11,12] Hence, the primary objective of this study was to measure the morphometry of proximal femur and the secondary objective was to determine the association of the morphometric parameters of proximal femur with gender and body mass index (BMI).

METHODS

After obtaining ethical approval from the Institutional Review Committee, B. P. Koirala Institute of Health Sciences, this cross-sectional study was conducted in

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patients with unilateral hip fracture presenting to the Department of Orthopedics between 1st Jan 2017 to 30th June 2017. All the patients aged above 18 years with traumatic unilateral hip fracture were enrolled. Patients with pathological fracture, hip deformity, metabolic or genetic diseases and bilateral hip fractures were excluded.

The sample size was calculated based a pervious study done by Iyem C et al where femoral neck width (FNW) was 35.4 ± 4.2 mm.[13] Considering 95% confidence interval and 2.5% of relative precision on mean, the sample size was determined using one sample formula as- $n = (Z^2\sigma^2)/L^2 = (1.96 \times 4.2)^2 / 0.9^2 = 83.66 \approx 84$. Thus, a total of 84 patients with a hip fracture admitted in the Department of Orthopedics, were recruited based on purposive sampling technique.

All the patients who met the inclusion criteria and gave an informed consent to participate in the study were subjected to a postoperative check X-ray pelvis and bilateral hip in the antero-posterior view with the tube at a distance of 1 meter from the chassis. The patient was positioned in supine position and the unaffected lower limb internally rotated by 20°. A radiologist measured and recorded the morphometric parameter of proximal femur in the radiograph of unaffected limb of patients using a digital caliper. Anthropometric measurements including gender, height, weight and BMI were recorded following a standard protocol. Weight was measured by placing the scale on hard, flat and even surface. Then patient was asked to stand atop the scale and remain still. The procedure was done thrice and an average value was calculated. Height was measured by asking a patient to stand erect against a wall keeping the head in Frankfurt plane. Each patient was asked to remove heavy clothes, shoes and cap before taking the measurement. Ensuring that the head, shoulder and buttock touched the wall, a ruler was gently pressed down on the top of the head. The spot was marked where the ruler touched the wall with a pencil. The patient was asked to step away from the wall and a tape was used to measure the vertical height. BMI was calculated as weight divided by the square of height [kg/m²] and categorized according to WHO classification into underweight (BMI < 18.5 kg/m²), normal (BMI 18.5 - < 25 kg/m²), overweight (BMI 25 to < 30 kg/m²) and obese (BMI > 30 kg/m²).[14]

The independent variables included age, gender, height, and BMI; the outcome variable was proximal femoral morphometry which included FNW, femoral neck length (FNL), femoral axis length (FAL), cervico-diaphyseal angle (CDA), acetabular tear-drop distance (ATD), greater trochanter-pubic symphysis distance (GTPSD). The collected data were then entered in MS excel and analyzed using the Statistical Package for Social Science (SPSS for windows) version 20. All the descriptive data were summarized using frequency distribution, figures and tables. The Student-t test was used to measure the mean difference in the gender category and one-way ANOVA was used to assess the association of BMI between and within the groups.

RESULTS

A total of 84 patients with hip fractures who underwent surgical management were included in the study. There was no missing data. The mean age of the patients was 62.79 ± 1.5 years (Fig. 1).

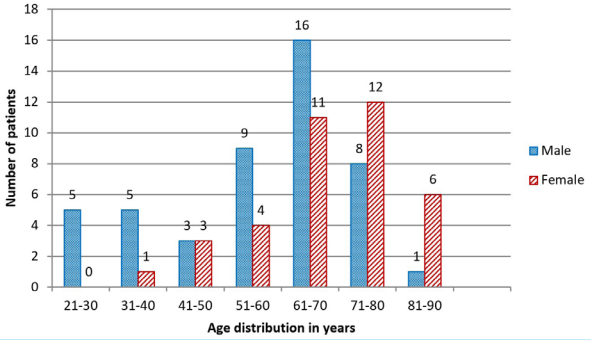

Figure 1. Age distribution of patients (n = 84)

The majority of patients were male (47, 56%) and Aryan (57, 68%). Table 1 shows the anthropometric measurements of the participants. Mean height, weight and BMI of male patients were 169 ± 4 cm, 67.5 ± 5 kg, and 23.7 ± 2 kg/m² respectively and those of female patients were 155 ± 7 cm, 55.2 ± 6 kg, and 23 ± 2 kg/m² respectively. None of the patients included were obese. The majority of the study participants (60%) had a fracture of the proximal femur on the right side.

Table 1. Anthropometric measurements of the participants (n = 84)

	Mean	SD	Minimum	Maximum
Age (y)	62.8	1.5	23	90
Height (m)	1.6	0.1	1.4	1.7
Weight (kg)	62.1	8.2	45.0	76.0
BMI (kg/m²)	23.4	1.9	18.0	28.2

The mean FNW, FNL, FAL, CDA, ATD and GTPSD were 36.10 ± 5.67 mm, 28.29 ± 4.18 mm, 104.51 ± 9.56 mm, 130.35 ± 8.67 degree, 132.56 ± 11.05 mm and 163.07 ± 10.71 mm respectively (Table 2).

Table 2: Morphometry of proximal femur (n = 84)

	Mean	SD	Min.	Max.
FNW (mm)	36.10	5.67	24	42
FNL (mm)	28.29	4.18	21	36
FAL (mm)	104.51	9.56	86	170
CDA (degree)	130.35	8.67	120	154
ATD (mm)	132.56	11.05	107	150
GTPSD (mm)	163.00	10.71	131	180

Table 3 shows the comparison of different morphometric parameters between males and females. The Independent t-test revealed that FNW (mean ± SD) was larger in males (39.08 ± 3.06 mm) than in females (32.32 ± 6 mm) ($p < 0.001$). However, no significant association was found between gender and other parameters.

One way ANOVA test showed no significant association between BMI and proximal femoral morphometry (Table 4).

DISCUSSION

Hip fracture is the most common major injury in the elderly and an important cause of morbidity and mortality.[15] An analysis of the dimensions from the local population is important as it provides a crucial information required to design a more suitable size and shape of the implant, especially when dealing with a proximal femoral fracture where the outcomes of the surgery depend upon the relative shape, size and design of the implant. The morphology of bones is very much affected by race, sex, environmental factors, and lifestyle.

In our study, the mean age of 84 patients with hip fractures was above 60 years. We found that in younger age group (age < 50 years), hip fracture was more common in males than in females while in the elderly, it was more seen in female patients. This was probably because of more outdoor activities and risk-taking behavior in young

Table 3. Morphometry of proximal femur by gender

	Male (n=47)		Female (n=37)		Test of Significance	
	Mean (Range)	SD	Mean (Range)	SD	Difference in mean	*p* value
FNW (mm)	39.08 (31 - 42)	3.06	32.32 (24 -41)	5.99	6.70	< 0.001
FNL (mm)	28.19 (31 - 33)	3.71	28.43 (21 - 36)	4.76	-0.24	0.79
FAL (mm)	104.47 (86 -119)	5.80	104.57 (86 - 170)	12.94	-0.09	0.963
CDA (degrees)	129.57 (120 - 154)	8.48	131.32 (120 - 154)	8.92	-1.75	0.362
ATD (mm)	132.40 (107 - 150)	11.76	132.76 (114 - 150)	10.22	-0.35	0.88
GTPSD (mm)	163.87 (131 - 180)	10.59	162.05 (131 - 180)	10.91	1.82	0.443

Table 4. Morphometry of proximal femur and BMI

Proximal Femoral Parameter	BMI Category			*p* value
	Underweight (n=2)	Normal (n=66)	Overweight (n=16)	
FNW (mm)	31.0 ± 9.9	35.9 ± 5.7	37.3 ± 4.9	0.31
FNL (mm)	26.5 ± 4.9	27.9 ± 4.3	29.9 ± 3.6	0.19
FAL (mm)	108.5 ± 14.8	104.4 ± 10.2	104.3 ± 5.9	0.84
CDA (degree)	126.0 ± 3.0	130.9 ± 9.0	128.7 ± 7.8	0.51
ATD (mm)	143.0 ± 4.2	132.9 ± 10.1	129.6 ± 14.3	0.23
GTPSD (mm)	161.0 ± 12.7	163.7 ± 10.8	160.5 ± 10.3	0.53

males and osteoporosis in elderly females. These findings are consistent with other studies worldwide.[16-18]

In our study, the mean FNW, FNL, FAL, CAD, ATD and GTPSD were 36.10 mm, 28.29 mm, 104.5 mm, 130.350, 132.56 mm, and 163.07 mm respectively. Most of these morphometric parameters are similar to the findings in a cross-sectional study done in a tertiary hospital in Nepal.[11] The findings are also similar to that of a study done in Turkish population by Iyam C et al.[13] However in the South Indian population, FNL and CDA were larger than in our study in an observational study done in cadaveric dry femur.[19] FNW and FNL in our study was larger than that found in a prospective study done in the Malay population while CDA was comparable.[20] CDA in our study was also comparable to that in Kenyan[21] and Brazilian[22] population while it was larger in Pakistani people[23], in whom it was 1340, which is the exact angle of the dynamic hip screw construct.

We found a significant difference in FNW between males and females, with the FNW being larger in males. Iyam C et al. reported a statistically significant difference in other parameters as well (FNL, FAL) in the Turkish population, which was not found in our study.[13] Baharuddin MY et al. also reported a statistically significant difference in various parameters (FNW, FNL, CDA) between males and females in Malay population, with all parameters being larger among males.[20]

In our study proximal femoral morphometry did not show any association with the BMI. This may be because we had no obese patients in our study. In a study conducted by Bhattacharya S et al., BMI had a strong to moderate correlation with proximal femoral morphometric indices.[24] Among the abnormal BMI cases, only FNW showed a strong correlation while CDA showed a poor correlation. Among the normal BMI patients, FNW also showed a strong correlation while all others showed a moderate correlation.

The limitations of this study include a small sample size and single centered study.

CONCLUSION

This study determined the radiographic measurement of the proximal femoral morphometry in which the femoral neck width of a male was found to be larger than that of a female. But BMI did not show any association with proximal femoral morphometry. These measurements can be used to design orthopedic implants for the Nepalese population.

DECLARATIONS

Ethics approval and consent to participate: Ethical approval obtained from the Institutional Review Committee, B. P. Koirala Institute of Health Sciences (BPKIHS). Written informed consent taken from each participant before enrollment.

Consent for publication: Not applicable

Availability of data and materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request. All relevant data are within the manuscript and its supporting information files.

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