PROXIMAL FEMORAL MORPHOMETRY OF ADULT NEPALESE POPULATION

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ABSTRACT

Background: The proximal femoral morphometry varies among different population according to age and differs in males and females. The management of many of the hip problems involves the restoration of near normal anatomy of the hip by application of prosthetic devices and implants. Currently proximal femoral implants are available in standard sizes in reference to western population and such implants therefore could have limitations when used to the diverse ethnicity of Nepalese population. A study of proximal femoral morphometry in Nepalese adult population would provide information to design implant for Nepalese population. **Aims and Objectives**: To study the dimensions of proximal femur of adult Nepalese population in radiographs. **Materials and Methods**: Cross Sectional study was carried out in Outpatient Department (OPD) and Emergency Department of Bir Hospital and National Trauma Center, Kathmandu in patient of age group 25 years and above. Patients fulfilling the inclusion criteria were ordered X-ray pelvis antero-posterior view including bilateral hip joint.

Parameters like HAL (Hip axis length), NAL (Neck axis length),HW (Head width),NW (Neck width),TW(Trochanteric-width),NSA (Neck Shaft Angle),NL(Neck Length) were considered and relationship between Height, Weight and BMI of the patients with the morphometric parameters was assessed. **Results:** The average age of the participants was 43.86 years (Range: 25 years – 80 years). Out of which 57.2% were males and 42.8% were females. There was predominance of Mongolians (24.1%) followed by Brahmins (22.8%) and chhetris (20%) in the study . The average values of proximal femoral morphometric parameters were found to be HAL:114.74 ± 10.46mm, NAL: 101.14 ± 8.95mm, HW: 49.06 ± 4.21mm, NW: 33.01± 4.44mm, TW: 59.79 ± 5.11mm , NSA: 123.58° ± 4.01° and NL 26.26 ± 3.81.These values were different from the previous studies done in cadaveric femora in Nepal and also from other population. Significant differences were found in HAL, NAL, HW, NW, and TW between male and female participants; however, there was no significant difference in NSA between the two categories. Height and weight had strong linear correlation with HAL, NAL, HW, NW, NL and TW but no significant correlation with NSA. There was statistically significant weak correlation of only HAL and NW with BMI. **Conclusion**: This study showed that the values of proximal femoral morphometric parameters differ from previous studies done in cadaveric femora in Nepal. Values also vary from the other population. NSA in particular was found to be much lower compared to the western population.

Key words: *Proximal Femoral Morphometry[1], HAL[2], NAL[3], HW[4], NW[5], TW[6], NSA[7], NL[8]*

INTRODUCTION:

Hip joint is a multiaxial ball and socket type of synovial joint. It is formed by the articulation of head of femur and the acetabulum of pelvis. It is designed for stability as well as a wide range of movement. The entire weight of the trunk is transmitted to the lower limbs through the hip joint[1]. It involves unique biomechanics an understanding of which is crucial in treatment of many pathologic conditions. Certain areas have benefited significantly from the better understanding of hip biomechanics; as for example the surgical approach and procedures of reconstructive surgeries, the design and development of total hip prostheses; and the physiotherapy programs for different hip joint problems [2].

The peculiar morphology of proximal femur has a role in hip biomechanics and any alteration or variation in this morphology therefore has a clinical significance. There are metric differences in the skeletal components in males and females within the population[3] and among different population with respect to their genetic composition and various environmental factor such as geography, diet and lifestyle[4].

An exponential rise in hip fracture risk has been observed with ageing which is not fully explained by corresponding fall in bone mineral density alone [5].

Ageing also increases risk of falls in individuals. In addition ageing causes structural changes in the proximal femur that might increase the risk of fracture should someone fall on their side. Over a decade ago, Yoshikawa and colleagues showed that bone loss occurs preferentially on the superior aspect of the femoral neck with ageing. This region of the femoral neck is under minimum mechanical stress during walking, whereas a fall on the hip reverses the stress pattern causing high compressive stress at the superior neck, this could make the bone susceptible to failure by buckling [6].

Shape of proximal femur is an important risk factor for hip fracture [4]. In addition to the morphology of proximal femur, body mass index (BMI) is also associated with hip fracture risk [7].

Studies have shown that anthropometric parameters such as BMI are associated with some of the parameters of hip geometry [8].The proximal femoral morphometry varies also according to age and differs in males and females [4].The management of many of the hip pathologies involves the restoration of normal or near normal anatomy of the hip via corrective surgeries and application of prosthetic devices and implants. Currently proximal femoral implants are available in standard sizes of femoral head and neck shaft angle designed based on western data [9]. Such implants therefore could have limitations in reference to the racial differences with Nepalese population and when the same dimension is used for males as well as females.

Our current knowledge regarding the morphology of human skeleton is based primarily on the studies performed in the population of the developed countries which is different from ours with respect to geography, race, nutrition, lifestyle etc. A study of proximal femoral morphometry in our own population therefore would be a useful piece of information to the orthopedic surgeons, anatomists, forensic scientists, anthropologists and the implant developers.

2. Aims and objectives:

2.1 General

To study the dimensions of proximal femur of adult Nepalese population in radiographs.

2.2 Specific

- To determine the normal values of dimensions of proximal femur namely:
    a. HAL (Hip axis length)
    b. NAL (Neck axis length)
    c. HW (Head width)
    d. NW (Neck width)
    e. TW(Trochanteric-width)
    f. NSA (Neck Shaft Angle)
    g. NL(Neck Length)

- To analyze age and gender wise variation in the morphometric parameters of proximal femur

- To evaluate the relationship between Height, Weight and BMI of the patient with the morphometric parameters.

3. MATERIALS AND METHODS

Following the ethical clearance from the Institutional Review Board of National Academy of Health Sciences, Cross sectional study was conducted at Bir Hospital and National Trauma Center, Kathmandu. Informed written consent was obtained in either Nepali or English language whichever they felt comfortable assuring full confidentiality. A detailed proforma of the participants including name, age, gender, weight, height, occupation, educational status were taken. The height of the partcipants was measured from vertex to the plantar surface of the foot in standing position using a measuring tape. Weight of the participants was measured using the weighing scale available in the Emergency Department. The participants then underwent Antero-posterior radiographs of pelvis with bilateral hips in recumbent position with a film focus distance of 100 cm with central beam projecting midway between the level of the ASIS and the symphysis pubis. Both the hips were maintained in 15 - 20 degrees of internal rotation and the heels kept 20 - 24 cm apart.

The measurements were taken in one of the hips in the radiograph whichever had the better alignment with regards to internal-external rotation and adduction-abduction.

The measurements were made by researcher himself on digital copy of the radiographs using standard software available in the radiology department.

The measurements of HAL, NAL, NL, HW, NW, TW and NSA were then taken on the radiograph. The definitions of the measurements along with the landmarks in X ray are as follows.

1. HAL (A-D): length of the femoral neck axis from the base of the lateral part of the greater trochanter to the inner pelvic brim.
2. NAL (A-B): length of the femoral neck axis from the base of the lateral part of the greater trochanter to the caput femoris.
3. HW (E-F): broadest cross section of the femoral head.
4. NW (G-H): narrowest cross section of the femoral neck.
5. TW (I-J): cross section from immediately above the lesser trochanter to the most lateral aspect of the greater trochanter.
6. NSA (between BKL): angle between femoral neck axis and the axis of shaft of femur.

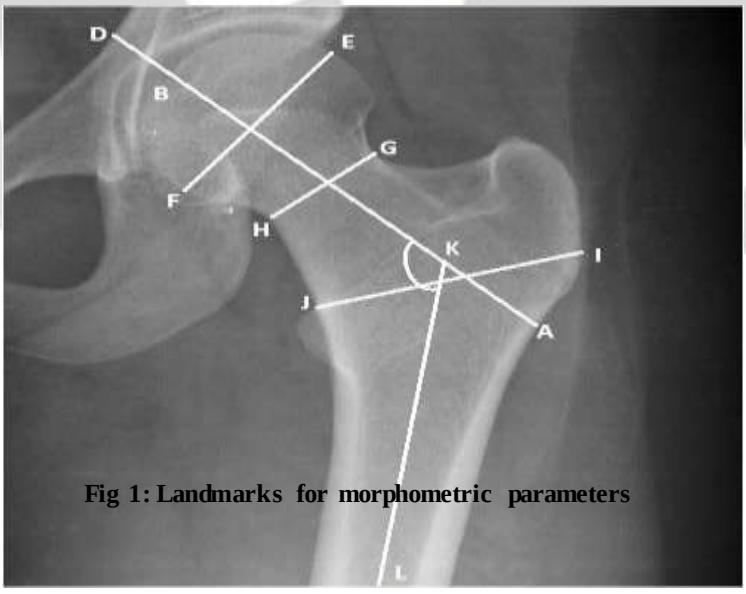

Fig 1: Landmarks for morphometric parameters

4. RESULTS

Out of 145 patients in our study, 83 (57.2%) were males and 62 (42.8%) were females with male: female ratio of 1.33 which is shown in Figure 2. The average age of the participants was 43.86 years with standard deviation of 14.61 years . Most of the participants (89%) were between age group of 25 to 65 years. The mean height, weight and BMI of the participants came out to be 1.57m, 59.85kg ,23.61 respectively which shown in Table 1. Among the participants, 26.9% were housewives, 18 % were farmers, 8.3% were students, 15.2% were engaged in some kind of business, 15.9% were engaged in government services and 15.9% had occupation other than above categories as shown in Figure 3. Majority of the participants (76.6%) had history of trauma while the remaining participants (23.4%) fall in non-trauma category as shown in Figure 4. Parameters of proximal femur had mean value as HAL (114.7 mm),NAL (101.14 mm),HW(49.06 mm),NW(33.01 mm),TW(59.79 mm),NSA(123.58 degrees),NL(26.26 mm) with only NSA being higher in male than female which is shown in Table 2. There were maximum number of participants with NSA in the group 120° - 124.9° followed by in the group 125° - 129.9°; approximately 70% cases were between 120° to 129.9°. 1.4% of the participants had neck shaft angle greater than 135°. HAL, NAL, HW, NW, TW were found to have strong positive correlation with one another which was statistically significant ($p < 0.001$) however NSA had statistically significant correlation with HAL, NAL and TW only. There was strong positive correlation of height with HAL, NAL, HW, NW, TW and NL which was statistically significant ($p<0.001$) which is shown in Table 3. HAL, NAL, HW, NW, TW and NL showed positive correlation with weight and these associations were statistically significant ($p<0.001$) which is shown in Table 3. There was no statistically significant correlation of NSA with both height as well as weight. HAL and NW had statistically significant weak correlation with BMI at 95% level of confidence. There is weak positive correlation of age with NL; however, there is no statistically significant correlation of age with HAL, NAL, HW, NW, TW, NSA at 95% level of confidence.

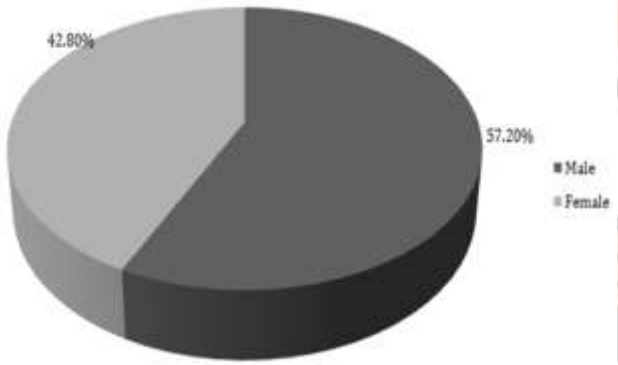

Figure 1: Pie Chart showing gender distribution

Measurements	Mean	SD	Males		Females	
			Mean	SD	Mean	SD
Height (metres)	1.57	0.09	1.63	0.07	1.50	0.059
Weight (kg)	59.85	9.7	64.67	8.32	53.39	7.29

BMI (kg/ m^2)	23.61	2.9	23.98	2.94	23.11	2.89

Table 1: Table representing anthropometric parameters

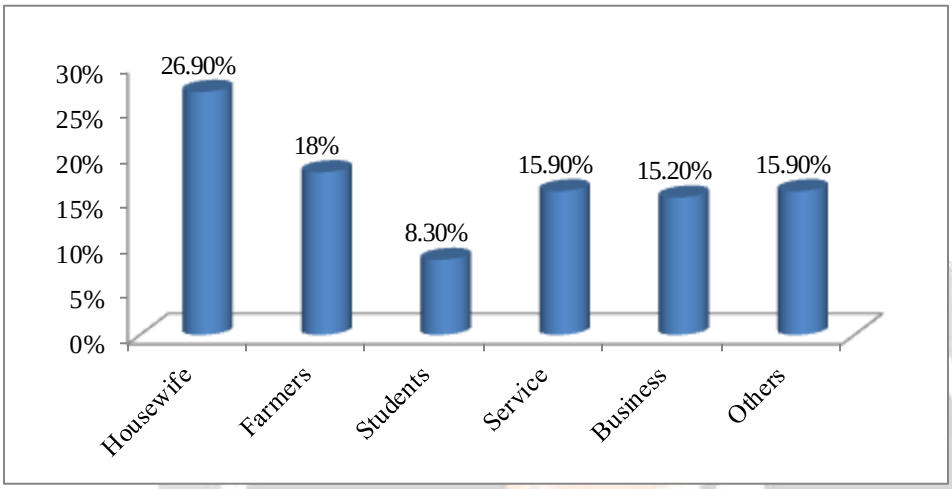

Figure 3: Bar diagram showing occupation of the patients

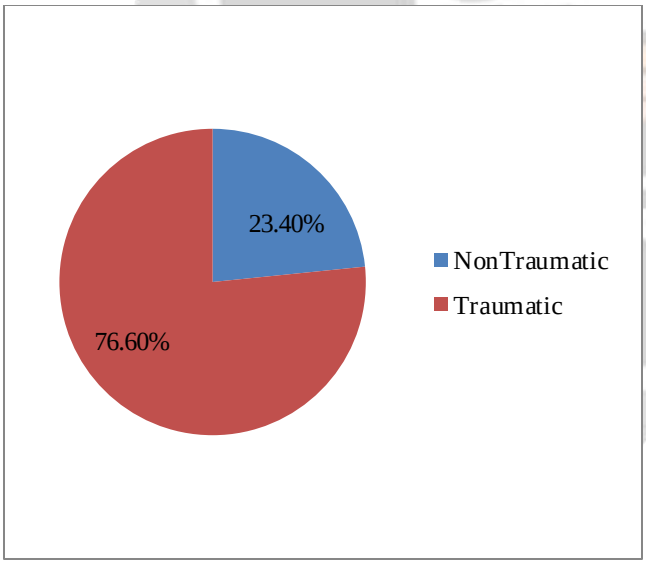

Figure 4: Pie diagram showing mode of injury

Measurements	Mean	Minimum	Maximum	SD
HAL (mm)	114.74	85	136	10.46
NAL (mm)	101.14	77	121	8.9
HW (mm)	49.06	41	63	4.2
NW (mm)	33.01	25	67	4.44
TW (mm)	59.79	39	74	5.11
NSA (degrees)	123.58	114	137	4.01
NL(mm)	26.26	16	37	3.81

Table 2: Average of the measurements of proximal femoral morphometric parameters

Variables	r and p values	Height	Weight	BMI
HAL	r	0.513**	0.488**	-0.172*
	p	<0.001	<0.001	0.039
NAL	r	0.469**	0.422**	0.127
	p	<0.001	<0.001	0.129
HW	r	0.50**	0.451**	0.126
	p	<0.001	<0.001	0.132
NW	r	0.367**	0.443**	0.229*
	p	<0.001	<0.001	0.006
TW	r	0.110**	0.268**	0.089
	p	<0.001	<0.001	0.285
NSA	r	-0.054	-0.012	0.028
	p	0.521	0.891	0.736
NL	r	0.348**	0.289**	0.736
	p	<0.001	<0.001	0.383

Table 3: Correlation of height, weight and BMI with femoral morphometric parameters

5. DISCUSSION

This study was done in 145 participants. The average age of the participants was 43.86 years with standard deviation of 14.61 years with range of 25 years to 80 years. This mean value is lower than the mean age of similar study done by Pires RE, Prata EF, Gibram A V et al. [10] in Brazilian population (n=305) where mean age was 59.2 years ± 20 years (Range of 18 years to 100 years). One reason for this observed difference is that the life expectancy of

Brazilian is higher than that of Nepal leading to higher number of elderly participants in that study.

In a study done in UK on proximal femoral morphometry in contralateral hip of subjects with fractures around hip (N=100) [11], mean age of the participants was 79 years which is also much higher compared to our study. The reason for this difference is due to the fact that hip fractures are more common in elderly population; thus, there were very little number of younger patients included in the study.

There was male predominance among the participants in the present study with 57.2% were males and 42.8% were females. This distribution is different to the study done by Pires RE, Prata EF, Gibram AV et al.[10] in Brazilian population (n=305) where there was female predominance in the participants with 61.3% females and 38.7 % males. One reason for male predominance in our studies could be because males are more likely be involved in injuries as they are exposed to risk environment more often than female and visits health facility for X-ray examination.

The mean height of the participants in the present study is 1.57 m ± 0.09 m which in contrast to the study in Malayan population by Baharuddin MY, Kadir MR, Zulkifly AH et al.[12] (n= 60) is less than that of Malayan individuals where average height of the participants was 1.65m ± 9.63m.

In the present study the average height of the female participants is 1.50m ± 0.05m which is lower than the average weight of the participants in the study done in Turkish women by Irdesel J and Ari I[8] (n=190) where the mean weight of Turkish women was 1.54m ± 0.05m. Compared to both the studies the mean height of the participants in the present study is less than that of the other two studies. This difference could have occurred due to the differences in genetic, nutritional and environmental factors between the different population.

The mean weight of the participants in the present study was 59.85 kg ± 9.7 kg which in contrast to the study in Malayan population by Baharuddin MY, Kadir MR, Zulkifly AH et al [12]. (n= 60) is less than that of Malayan individuals where average weight of the participants was 61.5 kg ± 13.8 kg. In the present study the average weight of the female participants is 53.39 kg ± 7.29kg which is lower than the average weight of the participants in the study done in Turkish women by Irdesel J and Ari I [8] (n=190) where the mean weight of Turkish women was 66.47 kg ± 0.82 kg. Compared to both the studies, the mean weight of the participants in the present study is less than that of the other two studies. This difference could have occurred due to the influence of racial and socioeconomic differences in the built and nutritional status of the individuals in two population. In the present study the mean BMI of the participants is 23.61 kg/ m^2 ± 2.9 kg/ m^2 and the average BMI in female individuals was 23.1kg/ m^2± 2.89kg/ m^2 which is lower than the average BMI of the participants in the study done in Turkish women by Irdesel J and Ari I[8] (n=190) where the mean BMI was 28.02 kg/ m^2 ± 0.32kg/ m^2. Such differences between Turkish and Nepalese women could have occurred due to the differences in built, nutritional status and lifestyle of the individual as a result of genetic and socioeconomic differences between the two population.

From a study of 50 cadaveric bones, Mishra AK, Chalise P, Singh RP et al. [13] in 2009 came up with the measurements of proximal femoral morphometric parameters. On comparing the two studies, the femoral head diameter in present study is larger and neck diameter somewhat smaller compared to the study by Mishra AK, Chalise P, Singh RP et al. In that study NSA had been measured after taking plain radiograph of the femur itself and measured in the radiograph. The mean NSA was 132.26° ± 8.36° which is much higher compared to the present study.

In a similar study done by Pires RE, Prata EF, Gibram AV et al.[10] in Brazilian population (n=305) in which the morphometric parameters of proximal femur was taken in plain digital x- ray. The mean HAL, NW as well as NSA were found to be lower in Nepalese population compared to the Brazilian population.

In a study in Malayan population in a tertiarty healthcare centre in Malaysia (n=60) performed by Baharuddin MY, Kadir MR, Zulkifly AH et al. [12] NAL, HW, NW and NSA were calculated from CT scan study. Comparing with that study the values of mean NAL, HW and NW in present study is larger however NSA is smaller than that study.

Comparing the present study to a study done by Irdesel J and Ari I [8] in Turkish women in plain radiograph (N=190), HAL was found to be comparable to that of Nepalese women in present study but the other morphometric parameters were higher. The unique observation was that lengths were similar but widths were thicker in Turkish women. NSA was also found to be lower in present study compared to the Turkish women. Femoral neck axis length and neck shaft angle are independent risk factors for femoral neck fracture. This finding therefore carries significance indicating Nepalese women may be at higher risk of femoral neck fracture by virtue of proximal femoral morphology alone with lower neck shaft angle, longer neck axis and thinner bones.

Comparing with a study by Pulkkinen P, Partanen J, Jalovaara P et al.[14] in Finnish women (n = 40), The mean HAL, NAL, HW, NW and TW were higher in Nepalese women in present study. However, NSA was lower compared to the Finnish women.

In 2012 , a large scale study was conducted in Singapore by Elbuken F, Baykara M and Ozturk C et al.[15] in 18,943 individuals between 20- 108 years of age using DEXA scan to measure NSA of proximal femur. The study revealed small differences in neck-shaft angle between males and females. The mean value for all groups was 129.171° (95% CI 129.065–129.278), while those for females and males were 129.142° (95% CI 129.032–129.252) and 129.630° (95% CI 129.157–130.104), respectively showing the difference to be insignificant at 95% level of confidence. In the present study HAL, NAL, HW, NW, TW were found to have strong positive correlation with one another which was statistically significant. Only HAL, NAL and TW had statistically significant negative correlation with NSA.

On comparing this finding with the study done in Turkish women by Irdesel J and Ari I [8] there was strong positive correlation between these five parameters with one another. NSA had negative correlation with HAL, NAL and weak positive correlation with TW. However, there was no significant correlation with NW and HW.

In the present study there was significant relation of BMI with HAL and NW. In the study by Irdesel J and Ari I[8] in Turkish women, weak positive correlation with TW, NW and HW was seen however there was no significant correlation of BMI with HAL, NAL and NSA.

Thus, there is strong correlation among the HAL, NAL, HW, NW, TW however there is strong to negligible correlation between the NSA and other five morphometric parameters. This indicates there is negligible to weak correlation of BMI with the morphometric parameters. Such comparison was not found in other literatures.

Limitations of the study

Limitations of the study was It was a hospital based study so, the analysed data may not well represent the whole nepalese population. Measurements would have been more accurate if more advanced technology such as 3D CT scan could have been used.

CONCLUSIONS

Our study shows the average values of proximal femoral morphometry in adult Nepalese to be HAL: 114.74 ± 10.46mm, NAL: 101.14 ± 8.9mm, HW: 49.06 ± 4.21mm, NW: 33.01± 4.44mm, TW: 59.79 ± 4.48mm , NSA: 123.58 ± 4.01° and NL 26.26± 3.81mm. Significant differences were found in HAL, NAL, HW, NW, TW and NL between male and female participants; however, there was no significant difference in NSA between the two categories. Height and Weight had strong linear correlation with HAL, NAL, HW, NW, TW and NL but no significant correlation with NSA. There was statistically significant correlation of HA L and NW with BMI at 95% level of confidence.

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REFERENCES

[1]. Moore K L, Dally A F. Clinically oriented anatomy. Fourth edition. Canada: Lippincott Williams and Wilkins. 1999.

[2]. Johnston JD, Callaghan J, Rosenberg AG, Rubas HE, et al. The Adult Hip. Philidalphia: Lippincott Williams & Wilkins 1998; 81-90.

[3]. Purkait R, Chandra H, A study of Sexual variation in Indian femur. Forensic Science International 2004; Vol.146 (1):25-33.

[4]. Noble PC, Box GG, Kamaric E et al. The effect of aging on the shape of the proximal Femur. Clin Orthop

1995;3163:1-44.

[5]. Marks R, Physical Activity and Hip Fracture Disability: A Review.Journal of Aging Research 2011; vol 2011:1-18

[6]. Mayhew PM, Thomas CD, Clement JG, et al. Relation between age, femoral neck cortical stability, and hip fracture risk. Lancet 2005; 366:129-35.

[7]. Baker LE, Pain JC, Luker KR et al. Active shape modeling of the hip in the prediction of incident hip fracture. J Bone Miner Res. 2011 Mar; 26(3):468-74.

[8]. Irdesel J, Ar I. The proximal femoral morphometry of Turkish women on radiographs. Eur J Anat. 2006;10(1):21-6.

[9]. Deshmukh TR, Kuthe AM, Ingole DS et al. Prediction of Femur Bone Geometry using Anthropometric Data of Indian Population: A Numerical Approach. Journal of Medical Science 2010; 10 (1): 12-18.

[10]. Pires RE, Prata EF, Gibram AV et al. Femur: Correlation with the Occurrence of Fractures. Acta Ortop Bras. 2012; 20(2): 79-83.

[11]. Patton MS SM, Duthie RA,Sutherland AG. Proximal femoral geometry and hip fractures. Acta Orthop Belg. 2006;72.

[12]. Baharuddin MY, Kadir MR, Zulkifly AH et al. Morphology study of the proximal femur in Malay population. International Journal of Morphology. 2011; 29(4):1321-25.

[13]. Mishra AK, Chalise P, Singh RP et al. The proximal femur –a second look at rational implant design. Nepal Med Coll J. 2009;11(4): 278-80.

[14]. Pulkkinen P, Partanen J, Jalovaara P et al. " Combination of bone mineral density and upper femoral geometry improves the prediction of Hip fracture." Osteoporosis Int. 2004;15: 274-80.

[15]. Elbuken F, Baykara M, Ozturk C. Standardisation of the neck-shaft angle and measurement of age-, gender- and BMI-related changes in the femoral neck using DXA. Singapore Med J. 2012; 53(9) 587 -90.