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Research Article

A STUDY OF NECK SHAFT ANGLE IN THE NORTH-WEST INDIAN POPULATION ON RADIOGRAPHS

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ABSTRACT

Geometry of proximal femur has been identified as risk factor for hip fractures. It is also suggested that proximal geometry can influence the fracture type. Neck shaft angle has been related to mechanical strength of proximal femur. Neck shaft angle shows considerable variation in human population with the mean values ranging from 122° ± 136° and in normal individuals are found from 110°- 150°. Geography, climate and race appears to have little effect on patterning the femoral neck shaft angle anthropometric skeletal measurements and shape of bones can offer a guide to the clinicians for the determination of risk factors for the fractures. The aim of the present study is to see the results for the neck shaft angle in the population of north-west India and compare it bilaterally and in both sexes. For the present study pelvic radiographs of 280 patients were studied. Measurements were performed bilaterally on PACS (Picture Archiving and Communication system) with digital calipers. Observations were taken under the guidance of radiologist. Data was collected and analysed statistically. The average neck shaft angle in the present study was 121.39°± 2.46° on right side and 121° ± 2.44° on the left side with no variability in relation to side and gender.

Key Words: *Femur, Geometry, Neck Shaft Angle, Fracture, Morphometry*

INTRODUCTION

The femur is the longest and strongest bone in the human body. Its shaft, almost cylindrical in most of its length and bowed forward, has a proximal head projecting medially on its short neck which articulates with the acetabulum. The femoral neck connects the head to the shaft at an angle of about 125 degrees which facilitates movement at the hip joint, enabling the limb to swing clear of the pelvis. This angle varies with age, stature, & width of pelvis, being less in adult, in persons with short limbs, and in women (Romanes, 1981). The proximal femur acts as a brace, and its biomechanical properties depend on the width and length of the femoral neck.

The degree of the diaphysio-femoral neck angle according to Wagner and colleagues varies from 125°3' to 132°3'. On the other hand, it was reported that the value may fluctuate from 109° to 153°, with no gender or racial predilection (Samaha, 2008). In particular, femoral neck-shaft angles are characteristically very high (150°) in neonates and then gradually decrease during development, reaching adult values during adolescence. The normal process of reduction in the angle to a more varus orientation of the femoral neck during development is dependent on the assumption of normal weight-bearing through the hip region and increasing locomotor activity levels during development. This is particularly evident in cases of reduced or absent weight-bearing during development. This is seen in infantile congenital dislocated hip, slipped femoral capital epiphysis, cerebral palsy and immature idiopathic scoliosis (Anderson, 1998). At the same time, several studies have shown that the neckshaft angle is very stable from midadolescence through most of adulthood (Humphrey, 1889; Trinkaus, 1993). Femoral neck-shaft angles show considerable variation within human populations. Mean values range from 122°±136°, and normal individuals are found from around 110° to almost 150°. Geography, climate and race appear to have little effect on patterning in femoral neck-shaft angles (Anderson, 1998). Mechanical stresses in the femoral neck of females appear to increase at three times the rate per decade of those of males. These results lend support to the hypothesis that the higher fracture rate in elderly women is due, at

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least in part, to elevated levels of mechanical stress, resulting from a combination of greater bone loss and less compensatory geometric restructuring with age (Beck, 1990). Anthropometric skeletal measurements are used to show up regional diversity between different populations or within the same population. Moreover, skeletal measurements and the shape of bones can offer a guide to clinicians for the determination of risk factors for fractures (Iredesel, 2006).

There is a system asymmetry of the proximal femur in normal condition with the predominance of the left proximal epiphysis in providing moving and support function. The right proximal femur meta-epiphysis is less adjusted to movement and severe strain (Samaha, 2008). Asymmetry in the human lower limb is assumed to be low and random with respect to side, although some authors have noted variably greater degrees of left leg robusticity in individual samples (Macho, 1991; Trinkaus, 1994).

The clinical importance of neck shaft angle of femur lies in the diagnosis, treatment and follow-up of fractures of neck of femur, trochanteric fractures, slipped upper femoral epiphysis, developmental dysplasia of the hip and neuromuscular disorders of the lower extremity. The commonly used implants for surgical treatment of proximal fractures such as dynamic hip screws, ASNIS screws, cancellous screws, blade plates etc. are designed primarily for the western population who's constitutional and biomechanical factors vary from those of Indian population (Ravichandran, 2011).

MATERIALS AND METHODS

The study was conducted in Christian Medical College and Hospital, Ludhiana from 1st March 2011 on the pelvic radiographs of 280 patients. All individuals between 20-50 years of age who would be undergoing pelvic x-ray AP view in the supine position with radiologically normal xrays were included in the study. These pelvic radiographs were obtained using the standardised protocol: in 15-30 degrees of internal rotation of the hips in the supine position with a film-focus distance of 100 cm, and the beam centered on the symphysis pubis. Morphometric measurements were performed bilaterally on PACS (Picture Archiving and Communication System) with digital callipers. The observations and measurements were made under the guidance of radiologists.

All other data like age, sex, presenting complaints were collected from available records at the Medical records department. This collected data was tabulated and analysed.

The statistical analysis was carried out using Statistical package for Social Sciences (SSPS Inc., Chicago, IL, version 15.0 for windows) for descriptive analyses. Normality of quantitative data was checked by measures of Kolmogorov Smirnov tests of normality. Data was normally distributed so t-test was applied for comparison of genders.

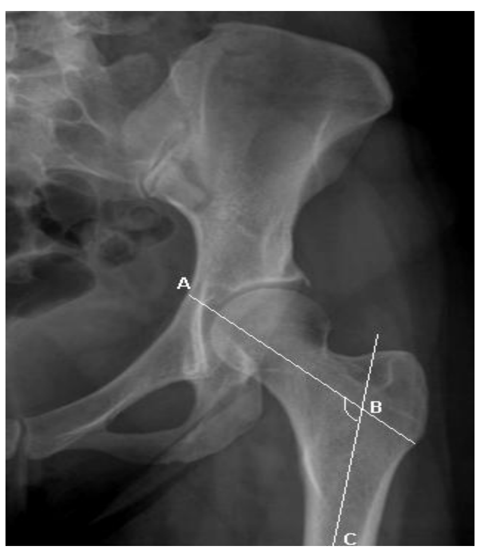

Figure 1: ABC angle- Angle between the axis of femoral neck and shaft of femur (Iredesel, 2006)

For comparison of right & left side Paired t-test was applied. Discrete categorical data were presented as *n* (%); for categorical data, comparisons were made by Pearson Chi-square test and Fisher's exact test as appropriate. All statistical tests were two-sided and performed at a significance level of α=.05.

RESULTS AND DISCUSSION

Results

The study population of 280 cases included an equal 50% male and 50% females with a mean age of 38 ± 9.547 years in males and 39 ± 9.123 years in females. The mean age of the total population was 39 ± 9.338 years (20-50)

Table 1: Mean distribution according to age

GENDER	Mean	N	SD
Male	38	140	9.547
Female	39	140	9.123
Total	39	280	9.338

The mean neck shaft angle of the right side in males was 121.63 ± 2.41 degrees (112.1-127.4). The mean neck shaft angle of the right side in females was 121.16 ± 2.50 degrees (113.3-128.1). The mean neck shaft angle of the right side in the total population was 121.39 ± 2.46 (112.1-128.1) the difference in the mean neck shaft angles of males and females on the right side was found to be statistically insignificant (p value: 0.104).

Table 2: Distribution according to Neck Shaft Angle (Right)

	Neck Shaft Angle (Right)				
	Mean	**N**	**SD**	**Min**	**Max**
Male	121.63	140	2.41	112.1	127.4
Female	121.16	140	2.50	113.3	128.1
Total	121.39	280	2.46	112.1	128.1

The mean neck shaft angle of the right side in males was 121.63 ± 2.41 degrees (112.1-127.4) The mean neck shaft angle of the right side in females was 121.16 ± 2.50 degrees (113.3-128.1) The mean neck shaft angle of the right side in the total population was 121.39 ± 2.46 (112.1-128.1) The difference in the mean neck shaft angle of males and females on the right side was found to be statistically insignificant (p value: 0.104).

Table 3: Distribution according to Neck Shaft Angle (Left))

	Neck Shaft Angle (Left)				
	Mean	**N**	**SD**	**Min**	**Max**
Male	121.33	140	2.36	111.8	126.9
Female	120.94	140	2.51	113.5	130.8
Total	121.13	280	2.44	111.8	130.8

The mean neck shaft angle of the left side in males was 121.33° ± 2.36° degrees (111.8°-126.9°). The mean neck shaft angle of the left side in females was 120.94 ± 2.51 degrees (113.5°-130.8°). The mean neck shaft angle of the left side in the total population was 121.13° ± 2.44° (111.8°-130.8°). The difference in the mean neck shaft angle of males and females on the left side was found to be statistically insignificant (p value: 0.183).

Table 4: Showing bilateral variation

	Right Mean	Left Mean	Mean Difference	SD	P value
MALES	121.63	121.33	0.30	1.82	.052
FEMALES	121.15	120.94	0.21	1.44	.084
TOTAL POPULATION	121.39	121.13	0.25	1.64	0.009

The difference between the means of neck shaft angle of both sides were statistically insignificant in both males and females however the difference in the means of neck shaft angle of both sides were found to be stastically significant in the total population.

Discussion

In the present study the mean neck shaft angle in males on the right side was 121.63° ± 2.41 (112.1°-127.4°) and on the left side was 121.33° ± 2.36 (111.8°-126.9°). The mean neck shaft angle in females on the right side was 121.16° ± 2.50 (113.3°-128.1°) and on the left side was 120.94° ± 2.51 (113.5°-130.8°). The mean neck shaft angle of the total population on the right side was 121.39° ± 2.46 (112.1°-128.1°) and on the left side was 121.13° ± 2.44 (111.8°-130.8°) (ref to table 2 & 3). The classic textbooks of anatomy quote the neck shaft angle as 120° which may vary from 110° to 140° (Breathnach, 1958).

The femoral neck shaft angle has been examined by several authors and most authors agree that there is considerable individual variation and wide standard deviation in this angle. Hoaglund and Low (1980) stated that the average neck shaft angle in adults is 135°. Kate *et al.,* (1967) worked on1000 femora and found the average angle to be 128.4°. Siwach *et al.,* (2003) worked on 75 pairs of femora and reported the average neck shaft angle to be 123.5° whereas Togwood *et al.,* (2009), in their study on proximal femoral anatomy on 375 normal human femurs, had reported the average angle as 129.23°. Ravichandran (2011) found the average angle to be 126.55° in the Indian population. The neck shaft angle showed the highest variation when compared with the western literature and also between the Mongoloids and Caucasoids. Saikia *et al.,* (2008) studied the neck shaft angle in the north east population and found it to be around 139.5°. Gnudi *et al.,* (1999) in their study among the Italian population found the neck shaft angle to be 122.6°. Pulkinen *et al.,* (2004) reported the neck shaft angle to be 128.3° whereas Irdesel (2006) found the angle to be 131.5° in post menopausal Turkish women. Nissen *et al.,* (2005) in their study among the Danish population found the angle to be 131±5° in males and 129±5° in females.

Table 5: Showing values of Neck Shaft Angle in studies on dry femora

Name of Authors	No. of Cases	Neck Shaft Angle
Siwach *et al.,* (2003)	75 femurs	123.5°
Togwood *et al.,* (2009)	375 femurs	129.23°
Ravichandran (2011)	578 femurs	126.5°

Table 6: Showing values of neck shaft angle in radiological studies

Name of Authors	No. of Cases	Neck Shaft Angle
Saikia *et al.,* (2008)	104 adults	139.5°
Gnudi *et al.,* (1999)	329 women	122.6°
Pulkinen *et al.,* (2004)	40 women	128.3°
Irdesel *et al.,* (2006)	140 post-menopausal women	131.5°
Nissen *et al.,* (2005)	249 adults	131±5° in males
		129 ± 5° in females
Present study (2010)	280 adults	Males right- 121.63° ± 2.41
		Males left- 121.33° ± 2.36
		Females right- 121.16°± 2.50
		Females left- 120.94° ± 2.51

The present study was comparable with studies done on Indian femora by Siwach *et al.,* (2003) and Ravichandran *et al.,* (2011).

The classical literature describes the angle of the femur axis or inclination angle as being of about 150° in infants; 140° in youngsters; 125° in adults; and 120° in the elderly (Issac, 1997). The reduction of this angle follows a remodeling of the inferior limbs that change from the "varus" position in the newborn to the "valgus" position in the adult (Tardieu & Damsin, 1997). Gnudi *et al.,* (2002) has indicated that Neck Shaft Angle is directly related with fracture risk. Callis *et al.,* (2004) and Peacock *et al.,* (1995) found neck shaft angle values to be higher in fracture cases. In one study of 114 postmenopausal women (49 cervical, 25 trochanteric fractures and 40 controls), the combination of Neck Shaft Angle with some other geometrical parameters and Bone Mineral Density improved the assessment of fracture type. Neck Shaft Angle was significantly greater in the cervical fracture group than in the controls, but there was no major difference in the trochanteric group compared with the controls (Pulkkinen, 2004).

In the present study no significant sex-specific differences were found in the neck shaft angle. When searching for sexual differences in the neck shaft angle Hoaglund & Low, found that in Caucasian people the angle was 136° in men and 134° in women; and in chinese people from Hong-Kong 135° in men and 134° in women, thus in both groups a smaller angle was found in women. Togwood *et al.,* (2009) found no differences based on gender in the measurements defining the neck-shaft relationship as we have also noticed in the present study.

With regard to bilateral symmetry there was no significant difference in the means of neck shaft angle of the right and left side in both the male and female population when considered separately. However significant bilateral differences in the means were found in the total population (p value 0.009).

Anderson and Trinkaus (1998) in their survey of femoral neck shaft angles in modern, historic and prehistoric population samples reported that even though individual bilateral asymmetry existed in the neck shaft angle and some samples exhibited sexual dimorphism, there were no consistent patterns in either respect, nor was there any geographic patterning to femoral neck-shaft angles. Chhibber and Singh (1970) suggest that left limb is dominant. Whether a person is right handed or left handed more people use left lower limb for weight bearing. Whereas De Sousa *et al.,* (2010) did not find any difference between the sides, showing a natural tendency to bilaterality.

The differences observed in various measurements obtained may be due to some being directly obtained from the dry bones while others from radiological studies of patients and radiographic examination in dry femurs and there may be some differences among observers also.

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Such results highlight the degree of variability likely to be encountered in a surgical population and challenge surgeons to be mindful of the impact that individual anatomic variation might have on outcomes for procedures not taking this variability into consideration.

The present study concludes that neck shaft angle does not differ with side or gender both in males and females in the North –West Indian population. The average neck shaft angle of the total population on the right side is 121.39 ± 2.46 degrees and on the left side is 121.13 ± 2.44 degrees.

The clinical importance of neck shaft angle of femur lies in the diagnosis, treatment and follow-up of fractures of neck of femur, trochanteric fractures, slipped upper femoral epiphysis, developmental dysplasia of the hip and neuromuscular disorders of the lower extremity.

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