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Morphometric analysis of angle of inclination of human adult femur from north India: A radiological study

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Abstract
Background: The femur is the longest & strongest bone in the body and has three parts; proximal, distal end and a long shaft. The neck shaft angle varies with age, stature & width of pelvis. Knowledge of neck shaft angle is an important to know the race to which they belong but also helps in the diagnosis, treatment and fellow-up of hip fracture, slipped upper femoral epiphysis, developmental dysplasia of the hip
Objective: To determine the angle of inclination in human adult femur as per morphometric parameters and to find out any variation in the angle of inclination.
Material and Methods: A total of 70 cases of Antero-posterior view of pelvic radiograph taken from the Department of Radiology, IIMS & R, Integral University, Dahod were enrolled for present study. After taking the X-ray film, marked the inclined line on X-ray film along the long axis of the neck of femur and long axis of shaft of femur. Then the angle between them was measured.
Results: Out of 70 samples most of the cases were between 20-30 years (35.7%) Among that 37(52.9%) were males while 33(41.9%) were females. The mean right angle of inclination was $126.76^0 \pm 4.33^0$ and left angle of inclination was $128.10^0 \pm 5.34^0$. The right side of angle of inclination was higher in the age group of 20-30 years. The left side of angle of inclination was higher in the age group of 31-40 years. The right side and left side both of angle of inclination was higher in males than females.
Conclusion: Anatomical study of femur bone serves helpful data to understand different aspect of clinical disease conditions, including common site of fracture, changes in osteoporosis, associated congenital anomalies as well as medico legal cases.

Keywords: angle of inclination, femur, morphometric analysis, neck shaft angle

1. Introduction
The femur is the longest & strongest bone in the body and has three parts; proximal, distal end and a long shaft. The femur neck making an angle with the long axis of shaft, known as neck-shaft angle, femoral carrying angle, angle of inclination, Cervico-diaphyseal angle and collodiaphyseal angle [1]. Its length is associated with a striding gait, its strength with the weight and muscular forces which it must withstand. Its shaft is almost cylindrical. It has a proximal rounded articular head projecting medially from its short neck. The femoral neck length is approximately 5cm long & connects the head to shaft at an average angle of 135°. This angle facilitates movements at the hip joint, enabling the limb to swing clear of the pelvis [2].
The neck shaft angle varies with age, stature & width of pelvis. When this angle >135°, condition is known as coxa valga. When angle <120°, it is known as coxa vara [3]. The angle of femoral neck is reduces with aging. In early infancy the neck shaft angle is about 150°, in childhood 140°, in adult about 125° and in elderly about 120° [4].
The neck-shaft angle and angle of inclination also known as collo-diaphyseal angle (CDA) of femur is defined as the angle made by the long axis of shaft and the long axis of the upper anterior column. The angle is widest at birth and diminishes steadily until the adult condition is reached. It is less in female than in male, owing to the increased breadth of the lesser pelvis and greater obliquity of the shaft of the femur [2].
Knowledge of neck shaft angle is an important to know the race to which they belong but also helps in the diagnosis, treatment and fellow-up of hip fracture, slipped upper femoral epiphysis, developmental dysplasia of the hip. Knowledge of normal asymmetry of right and left neck shaft angle may be great value in evaluation of patients with known or assumed patho-logical conditions and in correctional osteotomies in case of femoral fractures. This study was done to determine the angle of inclination in human adult femur as per morphometric parameters and to find out any variation in the angle of inclination.

2. Material and Methods
2.1 Study Population
This was laboratory based Cross sectional descriptive type of observational study carried out in Department of Anatomy, Zydus Medical College and Hospital, Dahod over a period of one year. A total of 70 cases of Antero-posterior view of pelvic radiograph taken from the Department of Radiology, Zydus Medical College and Hospital, Dahod were enrolled for present study.

2.2 Methodology
After taking the X-ray film, marked the inclined line on X-ray film along the long axis of the neck of femur and long axis of shaft of femur. Then the angle between them was measured.

2.3 Statistical analysis
The results are presented in mean±SD. The Unpaired t-test was used to compare the continuous variables between the two strata. One way analysis of variance was used to compare more than two means. The Pearson correlation coefficient was calculated. The p-value<0.05 was considered significant. All the analysis was carried out by using SPSS 16.0 version.

3. Results
A total of 70 samples were included in the study. Among that about one third of the cases were between 20-30 years (35.7%) followed by 31-40 (25.7%), >50 (21.4%) and 41-50 (17.1%) years. The mean age of the cases was 39.01 ±1(4.79) years.

Out of 70 cases 37(52.9%) were males while 33(41.9%) were females. Male to female ratio was 1.1:1.

The mean right angle of inclination was 126.76^0±4.33^0 with range 118^0-135^0 and left angle of inclination was 128.10^0±5.34^0 with range 118^0-136^0. The overall angle of inclination was 127.42^0±4.53^0 with range 118.5^0-135^0 (Table 1)

The right side of angle of inclination was higher in the age group of 20-30 years (127.52^0±4.30^0) followed by 41-50 years (127.17^0±3.73^0) and the least was >50 years (125.13^0±5.19^0). Similarly the left side of angle of inclination was higher in the age group of 31-40 years (129.08^0±5.73^0) followed by 41-50 years (128.75^0±5.24^0) and the least was >50 years (125.93^0±5.18^0). However, the difference was statistically not significant (p>0.05). (Table 2)

The right side and left side both of angle of inclination was higher in males (127.22^0±4.15^0) and (128.73^0±5.45^0) respectively compared to females (126.24^0±4.52^0) and (127.39^0±5.20^0) respectively. However, the difference was statistically not significant (p>0.05). (Table 3)

4. Discussion
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. It has shaft, proximal end and distal end. The shaft is slightly convex anteriorly [5].

A total of 70 samples were included in the study. About one third of the cases were between 20-30 years (35.7%) followed by 31-40 (25.7%), >50 (21.4%) and 41-50 (17.1%) years. The mean age of the cases was 39.01 ±1(4.79) years. More than half (52.9%) of the cases were males. Our results are concordant with a study conducted by Akbar and Kalimullah [6] who reported out of the total of 91 cases, 55 (60.4%) were male and 36 (39.6%) were female with mean age 58.24 (6.49).

The angle is widest in infancy, and becomes lessened during growth, so that at puberty it forms a gentle curve from the axis of the body of the bone. In the adult, the neck forms an angle of about 125° with the body, but this varies in inverse proportion to the development of the pelvis and the stature. The angle decreases during the period of growth, but after full growth has been attained it does not usually undergo any change, even in old age; it varies considerably in different persons of the same age.

In the female, in consequence of the increased width of the pelvis, the neck of the femur forms more nearly a right angle with the body than it does in the male. It is smaller in short than in long bones, and when the pelvis is wide. In addition to projecting upward and medial ward from the body of the femur, the neck also projects somewhat forward; the amount of this forward projection is extremely variable, but on an average is from 12° to 14°.

The angulations was studied by many workers; Keats was first adopted the use of radiographs to study this angulations [7], Cheng and Lowet *et al*. [8] studied the neck – shaft angle in American skeleton through x-ray, discovered an average value of 125^0 and Hogland and Weng *et al*. [9] did a radio-graphic study on Hong Kong Chinese vs. Caucasians and found the neck – shaft angle in Caucasian was more than Hong Kong Chinese.

In the present study, the mean right angle of inclination was 126.76^0±4.33^0 with range 118^0-135^0 and left angle of inclination was 128.10^0±5.34^0 with range 118^0-136^0. The overall angle of inclination was 127.42^0±4.53^0 with range 118.5^0-135^0. Our results are concordant with the study conducted by Hartel *et al*. [10] who reported the calculated median angle of inclination was 122.2° (range 100.1–146.2°, IQR 117.9–125.6°). In another study conducted by Akbar and Kalimullah *et al*. [6] who showed that the mean neck – shaft angle of both sides of female population were significantly higher than male (rig-ht side p = 0.009, left side (p = 0.05). The mean left neck – shaft angle of the total population was higher than right side (p = 0.05).

In another study the comparative analysis of the angle of the femur neck between the right and left sides of adults' demonstrated values similar to those described in the classic literature for adults with mean significantly smaller on the right side (122.5º) than on the left side (125.6º). As for the length of the femur neck in the study was observed larger values on the left side (23.5 mm) than on the right side (22.3 mm) [11].

In the present study, the right side of angle of inclination was higher in males (127.22^0±4.15^0) compared to females (126.24^0±4.52^0). However, the difference was statistically not significant (p>0.05). Our findings are in agreement with Parsons *et al*. [12] and Kaur *et al*. [13] who reported markedly higher mean angles of inclination being 126° in males and 125° in females and average neck shaft angle 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 respectively. However Hartel *et al*. [10] reported of angle of right inclination was higher in females (123.0^0) compared to males (121.5^0) (p = 0.007)

W did not found statistically significant correlation between the age and angle of inclination in the present study. However Hartel *et al*. [10] showed that angle of inclination was tended to decrease in older subjects with the significant difference.

Table 1: Distribution of angle of inclination

Side	Angle of inclination (^{0}) (Mean±SD)	Range
Right	126.76^0±4.33^0	118^0-135^0
Left	128.10^0±5.34^0	118^0-136^0
Both	127.42^0±4.53^0	118.5^0-135^0

Table 2: Comparison of right side and left side angle of inclination with age

Age in years	Right side angle of inclination (^{0}) (Mean±SD)	Left side angle of inclination (^{0}) (Mean±SD)
20-30	127.52^0±4.30^0	127.40^0±5.15^0
31-40	126.78^0±3.93^0	129.08^0±5.73^0
41-50	127.17^0±3.73^0	128.75^0±5.24^0
>50	125.13^0±5.19^0	125.93^0±5.18^0
ANOVA p-value	0.40	0.35

Table 3: Comparison of right side and left side angle of inclination with gender

Gender	Right side angle of inclination (^{0}) (Mean±SD)	Left side angle of inclination (^{0}) (Mean±SD)
Male	127.22^0±4.15^0	128.73^0±5.45^0
Female	126.24^0±4.52^0	127.39^0±5.20^0
Unpaired t-test p-value	0.35	0.30

5. Conclusion

The angle of inclination in adult human femur gives a basic structural and functional knowledge to prevent the abnormality with the help of orthopedic surgeon and society. This study will also be use for forensic anthropology to determine the racial variations of the femoral anteversion and also to the anatomists.

6. References

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