ORIGINAL RESEARCH

A Comparative Study of Difference Between Neck Shaft Angle of Dry Cadaveric Human Femur and Living Human Femur Radiographically

Subhash Modi[1], Vinita Kumari[2], N. K. Karmali[3], M. K. Goyal[4], S. K. Chouhan[5]

[1]Tutor,[5]Associate Professor, Department of Anatomy, MGM Medical College, Jamshedpur, Jharkhand, India
[2]Assistant Professor, Department of Pharmacology, MGM Medical College, Jamshedpur, Jharkhand, India
[3]Assistant Professor, Department of Anatomy, Phulo Jhano Medical College, Dumka, Jharkhand, India
[4]Associate Professor, Department of Community Medicine, MGM Medical College, Jamshedpur, Jharkhand, India

Correspondence:
M. K. Goyal
Associate Professor, Department of Community Medicine, MGM Medical College, Jamshedpur, Jharkhand, India
Email: dr_mkg2002@yahoo.co.in

ABSTRACT
Background: Development of Human race took years from four years to two legs. The lower limb in the process of development modified and consists of hip joint, femur, tibia and fibula. The hip joint is one of the largest and most stable joints in the body. It is a multiaxial ball- and-socket joint that has maximum stability because of the deep insertion of the head of the femur into the acetabulum. The joint depends on the angle from between the femur neck and the diaphysis, keeping the inferior limbs more distant from the pelvis and allowing greater rotation of hip joint. The neck-shaft angle is widest at birth and diminishes gradually until adolescence. It is smaller in females. The neck is laterally rotated with respect to shaft (angle of anteversion) some 10-15^{o} values of this angle vary between individuals.
Objective: To measure and compare the difference between neck shaft angle of dry cadaveric human femur and living human femurradiographically.
Methodology: The angle between the two lines of axes passing through the middle of neck and middle of shaft is known as Neck shaft angle or angle of Inclination and was measured by goniometer on a sample of 100 dryfemora.
Results and Conclusion: The mean neck-shaft angle in the present study was 129.62±5.5°. No difference was observed on sides (right and left), with respect to the neck-shaft angle in cadaveric femur was observed in the present study. Sidedifference with respect to the neck shaft angle was also noted in the present study.Left side femora had mean neck-shaft angle of 128.28° which was comparatively less than on the right side130.64°.
Key words: Dry Femora, Neck-Shaft Angle, X-Ray Hip Joint.

INTRODUCTION
The transition of gait from quadrupled to bipedal was an important aspect of the development to human race. The human race developed over the years of transition from four legs to two. In the process of development, the human lower limb also modified and is consist of hip

joint, femur, tibia and fibula. The neck – shaft angle of femur is defined as the angle form by neck axis and long axis of the shaft offemur.

It is also named as neck-shaft angle (NSA), angle of neck of femur, angle of inclination, collo-diaphyseal angle, cervico-diaphyseal angle and caputcollum-diaphyseal angle. The angle is wide in infancy and childhood and decreases with age; the neck shaft angle shows wide variation with relation to gender, smaller in female due to wide pelvis. There is also a racial difference in angle due to morphology of neck and shaft offemur.

In bipeds, the hips have a great responsibility of transmitting the ground reaction against the body weight while at the same time preserving mobility. To mechanically accommodate this postural change the head and neck of femur undergo angulation and rotation locomotion from the very beginning. The proximal femur in the human is subjected to large variety and magnitude of force during day to day activities.

The hip joint is one of the largest and most stable joints in the body. It is a multiaxial ball-and-socket joint that has maximum stability because of the deep insertion of the head of the femur into the acetabulum. The joint depends on the angle from between the femur neck and the diaphysis, keeping the inferior limbs more distant from the pelvis and allowing greater rotation of hip joint.

The neck about 5cm long, narrowest in its mid part and widest laterally and connect the head to the shaft at an average angle of 135^{o} (called angle of inclination or neck-shaft angle) this facilitates movement at the hip joint, enabling the limb swing clear of the pelvis.

The neck-shaft angle is widest at birth and diminishes gradually until adolescence. It is smaller in females. The neck is laterally rotated with respect to shaft (angle of anteversion) some $10\text{-}15^{o}$ values of this angle vary between individual (Eckhoff 1994).[1]

Neck has two surfaces

1. Anterior surface of neck is flat. It meets with the shaft at inter trochanteric line and it is entirelyintracapsular.[2]
2. Posterior surface is convex above downward and concave from side to side. It meets the shaft at intertrochanteric crest. Only its medial half inintracapsular.[2]

The head and neck of femur undergo angulation and rotation from the very beginning to accommodate this postural change mechanically.

The length of femur and stature are of forensic and anthropological significance. Bone markers such as the head and neck of femur can be used in determining femoral length when only a fragment of proximal femur is available.

The availability of geometrical data describing the proximal femur allows guidelines to be developed for the functional dimensions of femoral component. These anatomic data also allow assessment of the match between the shape of the existing components and the proximalfemur.

Awareness of the anatomic differences between genders for acetabular anteversion angle and neck-shaft angle may help to reduce the relatively higher incidence of dislocation in females and may lead to different implant design for male and female patients

It is important to know the normal acetabular and femoral anteversion angle for proper implant positioning and to prevent dislocation in total hip arthroplasty

Knowledge of normal asymmetry of right & left neck shaft angle of femur may be of great value in evaluation of patient with known or assumed pathological condition and in correctional osteotomies in case of femoral fracture.

The neck shaft – angle can be estimated from a proximal femoral fragment and the required size of the length of the neck can be determined to design prostheses for the restoration of normal neck shaft angle.

Considering the above factors, the present study was undertaken to measure the neck- shaft angle of femur in adult human cadaveric bones and radiologically for better understanding of the proximal end if femur.

NECK-SHAFT ANGLE

The femoral neck-shaft angle or the angle of inclination is the obtuse angle formed by the intersection of the femoral shaft axis with the femoral neck axis. The angleof inclination allows greater mobility of the femur at the hip joint because it places the head and neck more perpendicular to the acetabulum in the neutral position. The angle of inclination also allows the obliquity of the femur within the thigh, which permits the knees to be adjacent and inferior to the trunk. All of this is advantageous for bipedalwalking.
The torsion angle or angle of declination is between the long axis of the superior end of the femur (head and neck) and the transverse axis of the inferior end (femoralcondyles).
The angleof inclination combined withthe torsion angle, allows rotatory movements of the femoral head within the obliquely placed acetabulum to convertinto flexion and extension, abduction and adduction and rotational movements of thethigh.
Average neck-shaft angle is 135° in adults and ranges from 125°-140°. The neck-shaft angle is widest at birth and diminishes gradually until adolescence. It is smaller in females. In the child the pelvis is narrow before the bladder descends into the pelvis, so the neck and shaft of femur are nearly in line with each other. As the pelvis widens the neck becomes more horizontal and the angle between neck and shaft becomessmaller.
In the adult the neck shaft angle varies from 120 to 140°. A decrease in the neck-shaft angle is known as coxa-vera, while if the angle is over 140° it is known as coxavalga.[3]

MEASUREMENT OF NECK SHAFT ANGLE
HUMAN DRY FEMUR BONE

Anatomically, the neck-shaft angle can be measured by different methods like
- Directly on thebone
- Sharp shadowtracing
- AnthropometricmeasurementsusingMartin'sDioptrograph,Ried'sosteometricboard.

The neck-shaft angle can be measured by drawing femoral neck axis and femoralshaftaxis.
Axis of the head and neck, femoral neck axis is a line drawn from the centre of the head through the centre of the narrowest portion of the neck.
Axis of the shaft or diaphysis, femoral shaft axis is a vertical line drawn through the centre (medio-lateral) of the shaft. The neck-shaft angle can be assessed by the intersection of the above axes and is measured by using protractor or goniometer.
Radiologically the neck-shaft angle can be measured on the obtained antero-posterior radiographs of hip, pelvis or cadaveric bones. The two lines are drawn through and parallel to the mid axis of the femoral shaft and femoral neck. Theanglesubtendedisthenmeasuredbyusingprotractororgoniometer.
Radiologically the neck-shaft angle is about 125 – 135°.
The normal neck-shaft can also measure by other methods like
- Trignometric fluoroscopicmethod
- Biplanar radiographicmethod
- Dual X-ray scanabsorptiometry
- CTscan

- Three-dimensional radiographic methodetc.

OBJECTIVE

To measure and compare the difference between neck shaft angle of dry cadaveric human femur and living human femur radiographically.

METHODOLGY

100 adult dry human cadaveric femurs were taken as study material from the Department of Anatomy, M.G.M Medical College, Jamshedpur, Jharkhand.

a) **Neck-shaft angle of femur –** The angle between the two lines of axes passing through the middle of neck and middle of shaft is known as Neck shaft angle or angle of Inclination and was measured bygoniometer.
b) **Exclusion Criteria** - Bones with visible previous procedures like bone fixation, or with deformities or immature bones wereexcluded.

X-Ray Images of Pelvis AP - 25 X-ray plates of living femur (Hip joint in Antero-posterior view) was taken from the patients attending the Radiology department of M.G.M. Medical College and Hospital, Jamshedpur, Jharkhand.

Exclusion Criteria- the AP radiographs of the pelvis included in this study were from skeletally mature patients who did not present osteoarthrosis, fracture or femoral infectious lesions. In case female pregnancy is also excluded.

OBSERVATIONS

In the present study 100 dry femurs and 25 X-rays of Hip joint (AP view) were studied for neck-shaft angle, neck length and neck width. Out of 100 cadaveric femora 44 were ofright(44%)sideand56ofleftside(56%).Genderwisedifferentiationwasnotdone in cadaveric femora so the data analysis for gender in X-rays was also not done. The data were observed separately for cadaveric femora, as a group and also on different sides (Right and Left) and similarly in x-ray as a group and side wise. The observed data were also compared among the group and on sidewise.

NECK-SHAFT ANGLE

CADAVERIC

The mean neck-shaft angle in both sides (including right and left) was 129.62±5.5° with a range of 119°-141°. The neck shaft angle between right and left side was also calculated and mean of neck shaft angle on right side was observed 130.64±5.8° with a range of119°-141, whilein the left side the mean was 128.28±5.3° with a range from119°-141°.

Statistical data analysis was done and there was no significant difference observed between the neck-shaft angle of right and left side of cadaveric femurs (p=0.10).

X-RAY

The neck-shaft angle in X-rays ranged from 118-138° with a mean of 129.5±5.0°.

Statistical data analysis was done and there was no significant difference observed between the neck-shaft angle of right and left side femur in x-rays (p=0.91).

COMPARISON OF FEMORAL NECK SHAFT ANGLE BETWEEN CADAVERIC FEMORA AND X- RAYS

Femoral neck shaft angle in the range between 125° to <130° was observed maximally in both the groups and there was no statistically significant difference observed between theneck-shaft angle of cadaveric femora and radiographs (p=0.94).

COMPARISON OF FEMORAL NECK SHAFT WIDTH BETWEEN CADAVERIC FEMORA AND X- RAYS

In cadaveric dry femora, half (50%) of the femoral neck width was in the range between 30 mm to <35 mm whereas in the x-rays the neck width was maximally observed in the range between 25 to <30 mm. Despite the difference in the width,there was no statistically significant difference observed between the femoral neck length of cadaveric femora and radiographs (p=0.87).

Table 1: Femoral Neck Shaft Angle in Dry Femora

Observed Data (100)	Femoral Neck Shaft Angle in dry femora (in degrees)
Minimum	119
Maximum	141
Mean±S.D	129.62±5.5°

Graph 1: Femoral Neck Shaft Angle in cadaveric femora

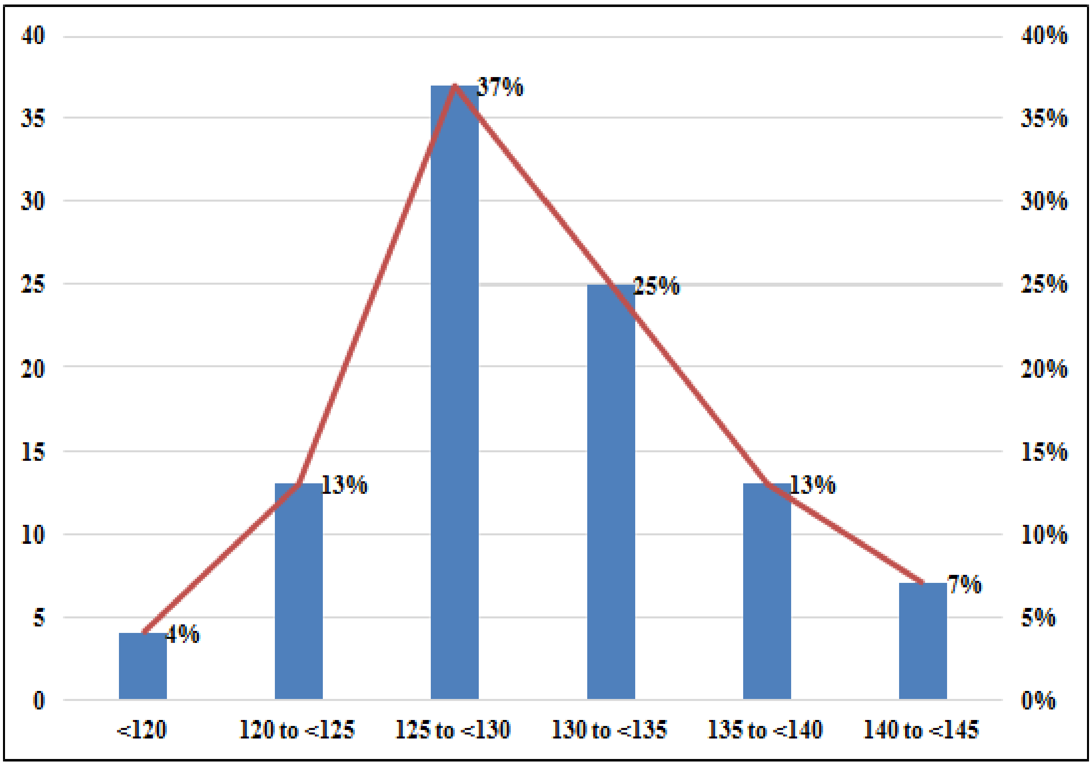

Table 2: Femoral Neck Shaft Angle in Dry Femora (Side-wise)

Observed Data (100)	Femoral Neck Shaft Angle in dry femora (in degrees)	
	Right (n=44)	**Left (n=56)**
Minimum	119	119
Maximum	141	141
Mean±S.D	130.6±5.8°	128.3±5.3°

Table 3: Femoral Neck Shaft Angle in X-rays (Inclusive of Both Side)

Observed Data (50)	Femoral Neck Shaft Angle in X-rays (in degrees)
Minimum	118°
Maximum	138°
Mean±S.D	129.5±5.0°

Graph 2: Femoral Neck Shaft Angle in X-rays

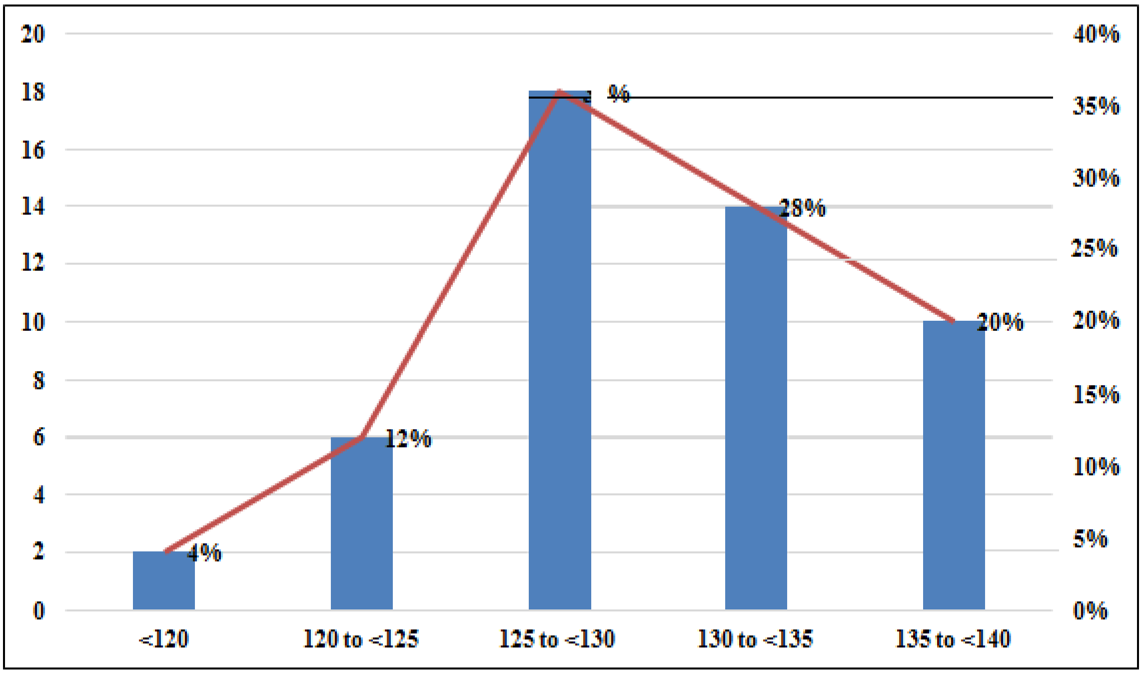

Table 4: Femoral Neck Shaft Angle in X-ray (Side-wise)

Observed Data (50)	Femoral Neck Shaft Angle in X-rays (in degrees)	
	Right (n=25)	**Left (n=25)**
Minimum	118	119
Maximum	138	138
Mean±S.D	129.5±5.2°	129.5±4.8°

DISCUSSION

The femoral neck angle decreases with age. It has been described in classical literature that the angle of the femoral neck is measured approximately about 150° in infants; decreases to 140° in youngsters; and 125° in adults; and further decreases to approximately 120° in the elderly. The reduction of this angle follows a remodelling of the lower limbs that change from the "varus" position in thenewborn to the "valgus" position in theadult.

Comparative analysis of femur neck-shaft angle between cadaveric and radiographically was done along with the analysis on right and left side of dry femurs. Results of the present study were compared to the values described in classicliterature.

The mean neck-shaft angle in the present study was 129.62±5.5°, which was higherthan earlier Indian studies of Issac[4]1997 and D Ravichandran 2011with mean neck- shaft angle of 126.70° and 126.55°respectively.

No difference was observed on sides (right and left), with respect to the neck-shaft angle in cadaveric femur was observed in the present study. Side difference with respect to the neck shaft angle was also noted in the present study. Left side femora had mean neck-shaft angle of 128.28° which was comparatively less than on the right side 130.64°. This was similar to previous study by Isaac in South Indian, the meanneck-shaftangleontherightsidewas126.90°andontheleftside,126.50°.

Table 5: Mean Neck-Shaft Angle Of Human femora In Different studies

Year	Author	Region	Mean (degree)
2020	**Present study**	Jamshedpur	129.20
1997	**Isaac** [4]	South Indian	126.70
1987	**Yoshioka** [3]	Canada	131.00
1986	**Singh** [5]	Indian	131.10

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