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Femoral neck anteversion, Neck shaft angle and Greater trochanter thickness - Anthropometric study and their Clinical implications

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ABSTRACT:

Introduction: Proximal femur anthropometric measurements are important to determine the size of the implants especially in joint replacement procedures and fracture fixations. Measurements vary between the populations of various geographical locations. So it is vital to know normal anatomical measurements of proximal femur of our Indian population.

Aims and objectives of the study: Our aim of the study was to measure the angle of anteversion of femoral neck, neck shaft angle and thickness of greater trochanter and to correlate them clinically.

Materials and methods: We have included 134 femurs for the study from the department of anatomy. Measurements were taken using Goniometer, sliding caliper, digital calipers and osteometric board.

Results: Of these 134 femurs, right and left side distribution was 72 (53.7%) and 62 (46.3%) respectively. On right side, mild anteversion was seen in 9 (12.5%) femurs, moderate anteversion in 55 (76.38%) femurs , severe degree in 3 (4.16%) and marked degree of anteversion seen in 5 (6.94%) femurs. On left side, mild anteversion was seen in 9 (14.51%) femurs, moderate anteversion in 50 (80.64%), severe in 2 (3.22%) femurs and marked anteversion was noted in 1 (1.61%) femur. The mean value of neck shaft angle for left femur is more than the right femur. The difference in p-value for greater trochanter thickness was not statistically significant.

Conclusion: The study would be advantageous in the arena of Orthopedic surgery for various hip pathologies like fracture fixation and joint replacement surgeries regarding selection of appropriate implants, forensic anthropology and also to the anatomists.

KEYWORDS: Femoral neck anteversion, neck shaft angle, greater trochanter thickness, Goniometer, Osteometric board

INTRODUCTION

Femoral neck anteversion, neck shaft angle and greater trochanter thickness are the important anatomical constraints in clinical orthopedics. Femoral neck anteversion is the angle made by the femoral neck with reference to the transcondylar plane of the distal end of femur. It usually ranges between 15-45 degrees. If the axis of the neck gradients forwards to the transcondylar plane, the angle of torsion is called anteversion, similarly if it inclines posterior to the transcondylar plane, it is called retroversion/ retro torsion. If the axis is located in the same plane of transcondylar axis, it is called neutral version [1]. An increased angle of anteversion is associated with failure of treatment of Congenital dysplasia of hip, Perthe's disease, cerebral palsy, slipped epiphysis of femoral head, anterior polio myelitis, in toeing, flat foot, postural defects etc,. A decreased femoral torsion has been associated with rickets, toing out, chondrodystrophy etc., [2]

Neck shaft angle or the angle of inclination is the angle between the axis of femoral shaft and the axis of femoral neck. It differs with age, stature and width of pelvis. When the angle is greater than 135 degrees , it is called coxa valga and when it is less than 120 degrees called the coxa vara. It decreases with age , in early infancy it is about 150 degrees, in childhood 140 degrees, in adult 125 degrees and in the elderly people, it is 120 degrees. Recent studies indicate that a greater neck-shaft angle may increase the risk of proximal femoral fracture.

The greater trochanter is a large , irregular quadrilateral eminence and a part of the skeletal system. It is directed laterally, medially and slightly posterior. It is about 2.4 cm lower than the femoral head [3]. It was found that a lower neck-shaft angle less than 134 degrees might result in increased risk of greater trochanteric pain syndrome (GTPS) in females. Greater trochanter which would be wider and with increased adiposity combine to increase internal compression and shear combined with adiposity related systemic effects [4]. Anthropometric measurements of this region are important in the selection of suitable intramedullary implants which can be accommodated without disrupting the cortices.

METHODOLOGY

Our study was conducted on 134 dry femurs. The bones were collected from the department of Anatomy. Osteometric board, lead pencil, scale, Goniometer, sliding calipers, digital vernier calipers were used.

Inclusion criteria: 72 right and 62 left dry femurs were included in the study.

Exclusion criteria: Bones with bony arthritis, broken bones, immature unossified (children) bones, those having deformity like bowing were excluded.

Measurement of Femoral neck anteversion: The femoral version was measured by Kingsley and Olmsted method which was considered as gold standard procedure.

The femur bone was placed on osteometric board. At the maximum anteroposterior thickness of the center of the femoral head and at the base of the neck, two points are noted using sliding calipers. The line passing through these points is the center of head neck axis. When the bone is lying on the horizontal surface, the line passing through the posterior most points of both condyles of femur is the retro condylar line. The horizontal limb of the goniometer was placed at the surface of osteometric board and this represents the plane of reference against which anteversion is measured with the vertical limb which was held parallel along the center of head neck axis. **(Fig. 1)**

Femur having positive femoral neck anteversion value including those having zero were categorized as anteverted femurs, while those having negative value were considered to be retroverted femurs. Anteverted femurs were further divided into mildly anteverted (0-5^0), moderately anteverted (6-15^0), severely anteverted (16-25^0), markedly anteverted (> 25^0) . Retroverted femurs were not found in the present study.

Measurement of Neck shaft angle: One point was marked at the center of femoral head and another at the midpoint of the narrowest part of neck using lead pencil. The line joining these two points represents the axis of the neck. These measurements were taken using sliding calipers. For the axis of the shaft, two midpoints were taken, one point at the upper end of the shaft, another at the lower end, and later these two points are joined and extended to cut the axis of the neck. Thus, the angle made by the axis of the shaft and axis of neck was measured using goniometer. **(Fig. 2)**

Fig.1.Shows the measurement of femoral neck anteversion using goniometer

Fig.2. Shows the measurement of femoral neck shaft angle

Fig .3. Shows the measurement of greater trochanter thickness

Thickness of greater trochanter was measured using digital vernier calipers and recorded in millimeters **(Fig.3)** The results were analyzed and were presented as mean, standard deviation, minimum, maximum and range **(Table - 1& 2)**

OBSERVATION & RESULTS

Out of 134 femurs, right and left side distribution was 72 (53.7%) and 62 (46.3%) respectively. Out of 72 right sided femurs, mild anteversion seen in 9 (12.5%) femurs, moderate anteversion in 55 (76.38%) femurs , severe degree in 3 (4.16%) and marked degree of anteversion seen in 5 (6.94%) femurs. Out of 62 left sided femurs, mild anteversion seen in 9 (14.51%) femurs, moderate anteversion seen in 50 (80.64%), severe in 2 (3.22%) femurs, and marked anteversion seen in 1 (1.61%) femur.

Table: 1. Side wise biostatistical analysis of Femoral version, Neck shaft angle and Greater trochanter thickness

Femoral neck anteversion						
Side	**Number**	**Mean**	**Standard deviation**	**Standard error**	**T value**	**Probability value**
Right	72	10.72	6.841	0.806	1.363	0.175
Left	62	9.3226	4.63689	0.58889		
Neck shaft angle						
Side	**Number**	**Mean**	**Standard deviation**	**Standard error**	**T value**	**Probability value**
Right	72	124.69	3.755	0.443	5.987	0.000*
Left	62	129.39	5.28	0.671		
Greater trochanter thickness						
Side	**Number**	**Mean**	**Standard deviation**	**Standard error**	**T value**	**Probability value**
Right	72	38.0168	3.49189	0.41152	0.29	0.772
Left	62	38.2082	4.13668	0.52536		

There was significant difference in p-value (0.000) between left and right side neck shaft angle. But p-value for femoral version and thickness of greater trochanter were not statistically significant. Majority of femur (76.4% right and 80.64% left) showed an angle between 6-15^{0}

Table. 2. Showing the minimum, maximum, range and average for Femoral version, Neck shaft angle and greater trochanter thickness

Side of Femur	Minimum	Maximum	Range	Average
Femoral neck anteversion				
Right	2	32	2 to 32	10.72 +/- 6.84
Left	2	32	2 to 32	9.32 +/- 4.64
Neck shaft angle				
Right	118	134	118 to 134	124.69 +/- 3.75
Left	118	138	118 to138	129.39 +/- 5.28
Greater trochanter thickness				
Right	27.86	45.07	27.86 to 45.07	38.01 +/- 3.49
Left	26.34	46.8	26.34 to 46.80	38.20 +/- 4.14

DISCUSSION

The knowledge of the normal ranges of the femoral version, neck-shaft angle and greater trochanter thickness and their swaying factors would help orthopedic surgeons during hip surgeries [5]. Determining the angle of femoral torsion is important for proper pre-operative planning in patients with various pathologies such as hip dysplasia, Coxa Vara, congenital club foot , Slipped upper femoral epiphysis and other developmental abnormalities associated with hip and knee joint. According to literature, angle of femoral torsion was found to be steadily higher in patients with idiopathic osteoarthritis of the hip joint.

Wolf's law explains about the remodeling in adult bones. It states that every change in the function of bone is followed by a change in its internal and external structure. Various muscles attached to femur generate torsional forces by their contractile forces and passive elastic nature. Resection of medial or lateral rotator muscles of hip results in a change in the angle of femoral torsion. So, the changes in hip muscle forces are related to an abnormal angle of femoral torsion. During intrauterine life the chronic contractions of the external rotators of hip region form the angle of femoral anteversion [6].

Femoral version mainly could be a result of fetal development, heredity, environmental factors and intrauterine position [7]. In the early intrauterine life, because of the limb bud medial rotation, FNA can occur, that gradually increases after birth [8] . It would be first seen at 7 weeks of gestation measuring around -10 degrees, gradually increases and reaches +12 degrees during adulthood [9]. The angle of femoral torsion has been measured by various techniques using plain x ray method, CT (computed tomography) scan, clinical methods, digital photographs with image tool software and dry specimens [10,11,12]. However, few studies found that the angle varies in population and also the method followed for the study [13]. Although the emerging techniques using CT scan have shown to be plus /minus 1% accurate , there is no universal regime for locating the femoral neck axis and the femoral condylar axis. Hence assessment of the femoral torsion on dry bones is still considered to be the most precise method . A study by Jain et al have documented that measurement of anteversion on dry femur is the gold standard [14].

Thus, in the present study femoral neck anteversion and neck shaft angle were measured using goniometer on dry femur. The mean anteversion on right femur bones was 10.7 , on left femurs 9.3 and the average was 10.72+/- 6.84 on right side and 9.32+/- 4.64 on left side. A statistically significant difference was found for the angle of anteversion between right and left side bones.

Various studies performed on these parameters found to have given diverse data as shown in Table:3. The values of FNA in the present study were similar to few studies [15,16]. However, in few other studies, the values were more than the present study. [17,18]. These variations might be due to the ethnicity, gender, side of the body, procedures adopted and even lifestyle.

Table. 3. Shows the values of femoral neck anteversion in various studies

Study	Femoral neck anteversion
Jain AK et al	8.4 degrees
Maheswari et al	10.6
Varlekar et al	16.8
Ravichandran et al	18.9
Srimathi T et al	9.49 (Rt) 10.13 (Lt)
Current study	10.7 (Rt) 9.3 (Lt)

Femoral neck anteversion, Neck shaft angle and Greater trochanter thickness - Anthropometric study and their Clinical implications

The femoral neck is approximately 5 cm long and connects the head to the shaft at an average angle of 135° which is called angle of inclination or neck–shaft angle. This facilitates movement at the hip joint, enabling the limb to swing clearly of the pelvis. The importance of neck shaft angle of femur lies in the diagnosis, treatment and follow up of fractures of neck of femur, trochanter and neuromuscular disorders of the lower extremity.

The neck shaft angle of femur allows greater mobility of the femur at the hip joint. All the clinicians must be familiar with normal neck-shaft angle for better understanding of hip joint and to restore the normal angle with appropriate implants while fixing the fractures around the trochanter. The neck-shaft angle is one of the important parameter to design the prosthesis for hip replacement and implants to fix the fractures around the trochanter. It is important not to fix the hip either in varus or valgus which will lead to asymmetric gait and causes stress on neurovascular structures as well.

In the present study the mean neck shaft angle was 124.69 +/- 3.75 in the right femur and 129.39 +/- 5.28 in the left femur . The mean neck shaft angle of the left femora was feebly higher than in the right femora, however it was not statistically significant ($p>0.05$). So there is no significant difference between mean neck shaft angle of right and left femora. The present results are in agreement with Shakil et al study [19].

The greater trochanteric morphology has a great impact for introduction of intramedullary nail. Lack of knowledge of its morphology may cause iatrogenic fracture or mal reduction. Not many studies were done on its morphology.

CONCLUSION

The inferences of the study on arthroplasty procedures can't be overstated as these are intended to match the normal anatomy as far as possible. A strong correlation has been established between the occurrence of thigh pain and inadequate fit and fixation of the implant. The clinical symptoms are due to the bone implant disparity which result in micromotion. Due to oversized implants there is increased incidence of intraoperative complications like splintering and fractures. Therefore, recognizing normal ranges of the parameters and their prompting factors would help surgeons to perform better hip surgeries and foresee the danger of hip disorders or injury.

CONFLICT OF INTEREST: None

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