A STUDY ON FEMORAL ANTEVERSION IN ADULT DRY FEMORA OF SOUTH INDIAN POPULATION

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ABSTRACT

BACKGROUND

Femoral Neck Anteversion (FNA) is an important parameter for diagnosis of gait abnormality in children, risk of various congenital and acquired orthopaedic disorders as well as corrective osteotomy and hip arthroplasty. Femoral anteversion is the lateral rotation of the neck of the femur to the long axis of its shaft. Variability in FNA has been reported and is due to torsional forces applied on femur during development.

The aim of this study was to estimate the angle of anteversion of femur in both genders on both sides. The present study was an attempt to provide baseline data of FNA in South Indian population, in particular, Andhra Pradesh.

MATERIALS AND METHODS

The study was conducted mechanically on 70 dried adult unpaired human femora, i.e. 48 male and 22 female bones. The Kingsley Olmsted[1] method was used for the study and the data was analysed.
Statistical analysis - Statistical analysis was done using student unpaired 't' test. The data was analysed using GraphPad Prism 5.0 (Free Trial Version).

RESULTS

Out of the 70 femora undertaken, mean value of FNA obtained in male is 15.95, 14.1 on right and 17.8 on left sides and in female it is 19.2, 21.8 on right and 16.6 on left side. Statistical analysis revealed significant ($p < 0.05$) greater average anteversion in female bones and right-left variations being greater on the left side.

CONCLUSION

In the present study, the mean FNA was 17.8 deg. There was a gender variation for the FNA values in the population studied with females showing higher value than the male with a statistically significant difference. The reason for the difference obtained could be the small sample size of female femora due to the rarity of the donated female bodies. The value was higher on the left side than the right; 50% of the femora had the range of 16 - 25 deg of FNA. The overall mean of femoral anteversion determined is very much different from the studies in various regions in India.

KEYWORDS

Angle, Femoral Torsion, Centre-Neck Axis, Transcondylar Axis, Retrocondylar Plane.

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BACKGROUND

Structural architectural studies of femur lead to the recognition of the anterior torsion of the femoral neck. Angle of femoral torsion or femoral anteversion is a normal torsion or twist present in femur that plays an important role in stability and function of the hip joint. It is the result of multiple factors such as evolution, heredity, foetal development, intrauterine position and mechanical forces.

The average adult femoral anteversion has been documented to range between 7 - 16 degrees in multiple skeletal surveys (Elfman, 1945; Takai et al, 1985; Yagi and Sasaki, 1986; Yoshioka et al, 1987).[2,3,4] Le Damany (1903)[5] quoted it to range from -25 to +37 degrees. The Gray's Anatomy states that the transverse axis of the head of the femur makes an angle of approximately 15 degrees with the transverse condylar axis and orthopaedics books quote it to range from 10 - 30 degrees.

Thus, a review of the global literature reveals a wide range of normal FNA with racial and geographic variation.[6,7,1,8,9,10] This variation is expected to exist because of different social needs of the different races. Since Indians

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are quite often habitual squatters, they tend to externally rotate the hips and use them in extreme range of motion. This would certainly make their hips to be evolutionally and morphologically different from Western counterparts.

If the axis of the neck inclines anterior to the transcondylar plane, the angle of torsion is called anteversion. If it points posterior to the transcondylar plane, it is called retroversion. If the axis is in the same plane of transcondylar axis, then it is called neutral version. Orthopaedic replacement surgery of femoral neck requires the femoral anteversion angle to be in consonance with the population anteversion angle. Currently, most of the prostheses are customised according to the FNA in the Western population. This study will throw a light on the FNA in the South Indian population to design a suitable prosthesis, so that the replacement translates into adequate functional outcome.

The present study had the objective to evaluate the normal anteversion range in adult South Indian femora.

MATERIALS AND METHODS

Cross-sectional study on unpaired seventy dry adult femora, 48 of male (23 right and 25 left) and 22 of female (9 right and 13 of left) devoid of any gross pathology were used to measure the femoral neck angle. The material for the study was collected from the bone bank of Department of Anatomy, GVP Medical College, Visakhapatnam, Andhra Pradesh.

Inclusion Criteria

Adult dry unpaired femora devoid of any gross pathology were included in the study.

Exclusion Criteria

Femora with evidence of disease - skeletally deformed femora having osteophytes on head and dysplastic head were excluded.

Each femur was studied with respect to gender (male and female) and side (right and left) determination. The gender was determined based on the combination of maximum diameter of head and maximum midshaft AP diameter.[12] The femoral anteversion angle was measured by Kingsley Olmsted method,[1] which is considered the most accurate method.

The femoral neck anteversion angle is the angle between the neck and the knee axes projected on a plane perpendicular to the shaft axis [Figure 1].

There are no great discrepancies between the use of the head-neck axis and the neck-centre axis in normal femurs. When pathologic displacement of the femoral head has occurred, the neck-centre axis may be used in order to estimate the premorbid femoral neck anteversion. The tangent to the back of the femoral condyles projected along the shaft axis is a clear and unambiguous definition that is biomechanically relevant, as it is directly concerned with the hinge joint of the knee.[12] Hence, the angle between the retrocondylar line and the centre neck axis-line is taken as FNA.

In this method, the femur was placed on an osteometric table with the posterior aspect of the two femoral condyles and the posterior aspect of the greater trochanter touching a smooth horizontal surface. Two smooth blocks, whose thickness was same were placed one beneath the femoral condyle and the other beneath the posterior aspect of the greater trochanter and they were arranged exactly at the level of the zero degree on the 360-degree protractor attached to one end of the board [Figure 2]. The antero-posterior width of the neck was determined at two points on the neck of femur by vernier calipers and taking midpoint of these, a line joining these two points was taken as the centre neck axis line. Horizontal plates at the zero degree level represent the retrocondylar axis. A transparent fibre plate having short and long arms with markings on it was used to measure the angle. The marking on the long arm is aligned along the centre neck axis marked and the angle subtended by the short arm on the protractor represents the FNA [Figure 3]. All measurements were repeated twice by two independent observers to identify any intra- and inter-observer variability of this technique. Data collected was tabulated according to gender and sides and statistically analysed.

Statistical Analysis

The data was analysed using GraphPad Prism 5.0 (Free Trial Version). For comparing the continuous variables, i.e. the mean FNA between males and females and between the left and right side, the students' unpaired 't' test was used. P value < 0.05 was taken to be statistically significant.

RESULTS

The mean FNA obtained in the study was 17.8 with a standard deviation of 7.7. It was found that the FNA in the females was more than that of males. The mean of left-sided femora was more than that of right-sided femora.

The mean FNA in male femora was 16.8 and in female 21.3 with a mean difference of 4.5. A statistically significant difference was found for the angle between male and female bones with a p value less than 0.05 [Table 1].

The mean of left femora was 22.15 and that on right femora was 15.74 with a mean difference of 6.4 [Table 2].

The FNA of right femora in males was 13.0 and in females it was 19.4 with a mean difference of 6.4. The p value obtained is less than 0.05 and it is statistically significant. The FNA of left femora in males was 20.0 and in females it was 22.3 with a mean difference of 2.3 [Table 3].

27% of the bones included in the study had the FNA between 21 - 25 degrees followed by 22.9% of the bones with FNA between 16 - 20 degrees. Only 4.3% of the bones had FNA between 31 - 35 degrees. In 50% of the femora, the FNA was between 16 - 25 degrees [Table 4].

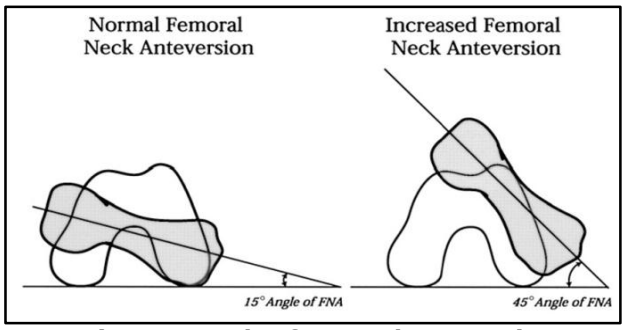

Figure 1. Angle of Femoral Anteversion

Figure 2. Osteometric Table

Figure 3. Measurement of the FNA using Fibre Plate

	Male (n=48)	Female (n=22)	Mean Difference	P value
Mean FNA	16.8	21.3	4.5	0.0197*
* = Statistically Significant				

Table 1. Mean FNA in Male & Female

	Left (n=32)	Right (n=38)	Mean Difference	P value
Mean FNA	22.15	15.74	6.4	0.0004

Table 2. Mean FNA in Right & Left Femora

Angle of Anteversion	Male	Female	Mean Difference	P value
Right	13.0	19.4	6.4	0.0362 *
Left	20.0	22.3	2.3	0.4
* = Statistically Significant				

Table 3. FNA of Right & Left Femora in Male & Female

Range (In Degrees)	Number of Bones	%
≤ 5	04	5.7
6 - 10	12	17.1
11 - 15	09	12.8
16 - 20	16	22.9
21 - 25	19	27.1
26 - 30	07	10.0
31 - 35	03	4.3

Table 4. Distribution of FNA

DISCUSSION

The knowledge of normal FNA is of extreme importance in selection of patients for prostheses and preoperative planning for total hip replacement surgery and in various orthopaedic diagnosis.[13] FNA develops due to twists of the femur from torsional forces applied perpendicular to the epiphyseal growth plate.[14] According to Hueter-Volkmann law of epiphyseal pressure, an increase in pressure across epiphysis decreases its growth and vice versa.[15] Wolff's law explains remodeling in adult bones, which states that every change in the function of bone is followed by a change in its internal and external architecture. Various muscles attached to femur create torsional forces by their contractile forces and passive elastic nature.

Habitual sleeping and sitting postures, in which hip is held at the end of the medial or lateral rotation may produce a change in the FNA. It is important to know the angle of anteversion in a particular population.

Studies to find the average anteversion in normal population are available mainly by direct observations on dry bones. In the recent years, FNA has been measured using roentgenography, ultrasound, Computerised Tomography (CT) and Magnetic Resonance Imaging (MRI) techniques by many researchers.

The studies by these techniques on FNA have mainly been done to check the accuracy or reliability of the mechanical method rather than to estimate the average value, thus limiting the sample type and its size.

Estimation of anteversion on dry bone is considered to be the most accurate method.[1,9] The center of the head was not used to estimate the neck axis, as it has been shown that majority of the femoral heads are not in the center of the femoral neck.[13,9,1,10,16] A variety of neck axes are used in the measurement of the femoral neck anteversion. The Kingsley and Olmsted method has been used in the present study. Various other methods have been used by researchers to determine the FNA, and wide variation has been documented for the mean FNA. The source of variation may be the precise location of the central axis.[12]

In the present study, there was no incidence of retroversion in any of the femora. All specimens showed anteversion except for one femur that showed neutral version. The mean anteversion in male bones was 13.04 and 20.4 degrees on the right and left sides respectively averaging to about 16.8 degrees. In females, it was 19.44 and 22.3 degrees on the right and left sides respectively averaging to about 21.3 degrees.

The FNA has been reported to be 11.4 to 19.8 degrees by Computerised Tomography (Sugano et al, 1998; Hermann et al, 1998)[17,18] and 15 to 28 degrees by various biplanar x-ray techniques based on specimens and living subjects (LaGasse et al, 1998).[19] Braten et al (1992) found the average anteversion to be 18 degrees in normal females and 14 degrees in normal males using ultrasound.[20]

Dunlap et al and Kingsley and Olmsted reported FNA of 8.7 and 8.02 in Western population.[1,13] Kimaporn et al (2005) have obtained a value of 15.5 in Thai population.[21]

Jain et al and Maheshwari et al[9,10] have done a study in North Indian population and they found a value of 8.4 and 10.6 respectively. Srimathi et al (2012) have obtained a value of 9.8 in South Indian population.[22] The value obtained in the present study is much higher than the values obtained in the works of the above authors.

Ankur et al and Varlekar et al have quoted FNA to be 12.4 and 16.8 respectively in their study in population of Western parts of India.[23,24]

Anil Kumar et al quoted a value of 13.9 in their study in Maharashtrian population.[25]

Vidhyadhar Rao in his study in the population of Karnataka (South India), quoted a value of 14.0.[26]

The higher difference in the values compared with the present study could be because of the method adopted by different authors and may also be due to the difference in the sample size in each study.

The value is more close to the works of Varlekar et al (16.8) and Ravichandran et al[24,27] (18.9) who have studied the population of Gujarat and Andhra Pradesh respectively. The value is less than that obtained in the Assam Population by the work of Saikia et al (20.4).[28] Gender and side, significant differences in FNA have been noted in numerous previous studies.[1,22,23.25,27,29] In the present study, FNA appeared to be more in females. This finding correlated with those of Parson et al, Ankur et al and Anil Kumar et al.[29,23,25] In the present study, FNA of left was observed to be higher which suggests a right sidedness of lower limb with increased muscle tone. This finding correlated with that of Zalwadia et al and Ravichandra et al.[23,27] Results obtained from the present study done on South Indian population differed from those obtained in studies of population of other parts of the country as well as those from the Western studies. The results obtained in the present study were near to those obtained in the study done in South Indian population by Ravichandran et al.[27]

Smaller sample size, non-availability of paired femora and rarity of the female type femora were the limitations of the present study.

CONCLUSION

In the present study, the mean FNA was 17.8 deg. There was a gender variation for the FNA values in the population studied with females showing higher value than the male with a statistically significant difference. The reason for the difference obtained could be the small sample size of female femora due to the rarity of the donated female bodies. The value was higher on the left side than the right; 50% of the femora had the range of 16 - 25 deg of FNA. The overall mean of femoral anteversion determined is very much different from the studies in various regions in India.

REFERENCES

[1] Kingsley PC, Olmsted KL. A study to determine the angle of anteversion of the neck of the femur. J Bone Joint Surg Am 1948;30A(3):745-751.

[2] Elftman H. Torsion of lower extremity. American Journal of Physical Anthropology 1945;3(3):255-265.

[3] Yagi T, Sasaki T. Tibial torsion in patients with medial-type osteoarthritis of knee. Clin Orthop Relat Res 1986;213:177-182.

[4] Yoshioka Y, Siu D, Cooke TD. The anatomy and functional axes of the femur. J Bone Joint Surg Am 1987;69(6):873-880.

[5] Le Damany. Les torsions osseuses leur role dans la transformation des members. Journal of Anatomical Physiology 1903;39:426-450.

[6] Tonnis D, Heinecke A. Acetabular and femoral anteversion: relationship with osteoarthritis of the hip. J Bone Joint Surg Am 1999;81(12):1747-1770.

[7] Reikeras O, Bjerkreim I, Kolbenstvedt A. Anteversion of the acetabulum and femoral neck in normal and in patients with osteoarthritis of the hip. Acta Orthop Scand 1983;54(1):18-23.

[8] Hoaglund FT, Low WD. Anatomy of the femoral neck and head, with comparative data from Caucasians and Hong Kong Chinese. Clin Orthop Relat Res 1980;152:10-16.

[9] Jain AK, Maheshwari AV, Singh MP, et al. Femoral neck anteversion: a comprehensive Indian study. Indian J Orthop 2005;39(3):137-144.

[10] Maheshwari AV, Jain AK, Singh MP, et al. Estimation of femoral neck anteversion in adults-A comparison between preoperative, clinical and biplane X-rays methods. Indian J Orthop 2004;38:151-157.

[11] Soni G, Dhall U, Chhabra S. Determination of sex from femur: discriminant analysis. J Anat Soc India 2010;59(2):216-221.

[12] Hoiseth A, Reikeras O, Fonstelien E. Aspects of femoral neck anteversion. Theoretical considerations and experimental results. Acta Radiologica 1988;29(6):689-694.

[13] Dunlap K, Shands AR Jr, Hollister LC Jr, et al. A new method for determination of torsion of the femur. J Bone Joint Surgery Am 1953;35-A(2):289-311.

[14] Le Veau BF, Bernhardt DB. Developmental biomechanics. Effect of forces on the growth, development, and maintenance of the human body. Phys Ther 1984;64(12):1874-1882.

[15] Swanson AB, Greene PW Jr, Allis HD. Rotational deformities of the lower extremity in children and their clinical significance. Clin Orthop Relat Res 1963;27:157-175.

[16] Fabry G, Macewen GD, Shands AR. Torsion of femur. JvBone Joint Surg 1973;55A(8):1726-1738.

[17] Sugano N, Noble PC, Kamaric E. A comparison of alternative methods of measuring femoral anteversion. J Comput Assist Tomogr 1998;22(4):610-641.
[18] Hermann KL, Egund N. Measuring anteversion in the femoral neck from routine radiographs. Acta Radiol 1998;39(4):410-415.
[19] La Gasse DJ, Staheli LT. The measurement of femoral anteversion. A comparison of the fluoroscopic and biplane roentgenographic methods of measurement. Clin Orthop Relat Res 1972;86:13-15.
[20] Braten M, Terjesen T, Rossvoll I. Femoral anteversion in normal adults. Ultrasound measurements in 50 men & 50 women. Acta Orthop Scand 1992;63(1):29-32.
[21] Khamanarong K, Hipkaeo W, Chatuparisute P, et al. Version of femoral neck: a cadaveric dried bone study. Int J Morphol 2014;32(2):464-468.
[22] Srimathi T, Muthukumar T, Anandarani VS, et al. A study on femoral neck anteversion. JCDR 2012;6(22):155-159.
[23] Zalawadia A, Ruparelia S, Shah S, et al. Study of femoral neck anteversion of adult dry femora in Gujarat region. NJIRM 2010;1(3):1-5.
[24] Varlekar P, Gosai BB, Nagar SK, et al. Study of angle of femoral torsion in Western region of India. NJIRM 2011;2(4):60-64.
[25] Dwivedi AK, Bhatnagar R. Anthropometric study of angle of femoral torsion in Maharashtrian population. Med J DY Patil Univ 2016;9(2):200-203.
[26] Vidhyadhara S, Rao SK. Uncemented primary press-fit total hip arthroplasty: a 3 to 6 years of experience. J Orthop Surg (Hong Kong) 2007;15(1):50-55.
[27] Ravichandran D, Sankar KD, Bhanu PS, et al. Angle of femoral neck anterversin in Andhra Pradesh population of India using image tool software. JIMSA 2014;27(4):199-200.
[28] Saikia KC, Bhuyan SK, Rongphar R. Anthropometric study of the hip joint in north eastern region population with computed tomography scan. Indian J Orthop 2008;42(3):260-266.
[29] Parsons FG. The characters of the English thigh bone. J Anat Physiol 1914;48(Pt 3):238-267.