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Original Research Article

FEMORAL ANTEVERSION ANGLE IN DRY FEMORA OF SOUTH INDIA BY COMPUTER ASSISTED IMAGE ANALYSIS METHOD

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ABSTRACT

The femoral anteversion angle (FA) is defined as the angle formed by the projection of the femoral neck axis & the retrocondylar axis. In the present study, the following parameters were measured in dry femora of South Indian origin: 1) FA. 2) Side differences in FA. 3) Intra observer & inter observer reliability in measuring FA. About 170 femora that were available in the department of Anatomy were used for the study. 92 femora were of right side & 78 were of left side. Two axes – femoral neck axis & retrocondylar axis were drawn & the angle was measured. The results were tabulated & the mean FA & standard deviation were calculated & compared between right & left side for significance. The mean FA was 11.4° (Range between -20° to 36°). There was no significant difference in FA on right & left sides. There was good intra & inter observer reliability in measuring FA. The findings of the present study will be helpful to clinicians, therapists & researchers as ready references to FA among South Indian population.

KEY WORDS: Femur, Femoral anteversion, Head neck axis, Retrocondylar axis.

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INTRODUCTION

The femoral anteversion angle (FA) is defined as the angle formed by the projection of the femoral neck axis & the retrocondylar axis. The femoral neck axis is the line drawn from the centre of the femoral head to the centre of the femoral neck at the narrowest part of the neck. The retrocondylar axis is the tangent to the back of the femoral condyles. The FA ranges from 8º to 20º [1].

If the axis of the neck inclines forward to transcondylar plane the angle of torsion is called femoral anteversion, antetorsion, anterior twist or 'plus angle'. If it tilts posterior to the transcondylar plane it is called retroversion, retrotorsion, posterior twist or 'minus angle' & if the axis of the neck is in the same line of the transcondylar plane, it is known as neutral version [2].

The FA is an important factor for hip stability & normal walking [3].

The increased FA is associated with Perthe's disease, slipped epiphysis of femoral head, cerebral palsy, medical femoral torsion, postural defects, squinting patellae, apparent genu valgum, external tibial torsion, flat foot & intoing [4]. A decreased FA is associated with chondrodystrophy, toeing out, rickets, torn acetabular labrum of hip [5,6].

A sound knowledge of the normal range of FA is important for corrective osteotomies, arthroplasty & manufacturers of hip prosthesis [5]. In India with the increasing demand for total hip replacement, this anteversion angle becomes more significant [7]. Racial variations in anthropometric parameters exist because of genetic & various socio-cultural practices. In India, the data on FA established from Western population is being used. Indians use more of floor level activities like squatting, therefore they tend to externally rotate their hips & use them in extreme range of motion. This makes the Indian hips to be evolutionally and morphologically different from Western counterparts. Therefore the data from Western population may not be applicable to the Indian population [8,9].

However the Indian data on FA is limited, hence the present study was undertaken.

MATERIALS AND METHODS

171 femora available in the department of Anatomy were used for the study. 92 femora were of right side & 79 were left side. Femora with gross deformities were excluded from the study. The bones were labeled & the parameters were measured. FA was measured by analysing the end on view digital photographs of the proximal end of the femurs with Microsoft Power Point 2007 software.

The bone was placed on a flat board covered with a graph sheet. Each femur was placed with the posterior surface of its condyles & greater trochanter touching the surface of the board. The digital photographs of end-on view of the proximal end of the femurs were taken (Figure 1).

The pictures taken were transferred to the computer & analysed using Microsoft Power Point 2007 software. The FA was measured by using Magilligan method [10].

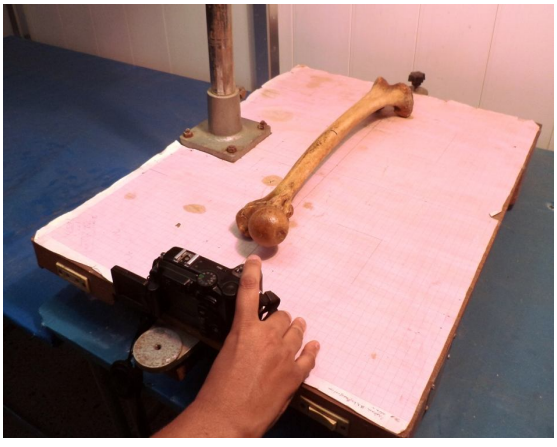
Lines were drawn to mark the midpoint of head & neck of femur. Two horizontal lines (a & b) were drawn, each passing through the anterior & posterior most point of the head respectively. (Figure 2) Another line (c) was drawn joining the anterior & posterior most points of the head of femur. Another line (d) was drawn joining the narrowest part of antero- posterior thickness of the neck. The mid points of head (c) & neck (d) were marked. The line passing through these 2 points represents head neck axis.

A horizontal line is drawn parallel to the horizontal plane of the board which represents retrocondylar axis. The angle between the head neck axis & the retrocondylar axis which represents FA (Figure 3) was measured using a protractor.

The results were tabulated & the mean FA & standard deviation were calculated & compared between right & left side for significance. The level of significance was set at $p < 0.05$. The data were analysed by using SPSS'; version 16.0 (SPSS Inc., Chicago, IL, USA). The measurements were repeated by the principal investigator on 20 randomly selected femora to assess intra-observer reliability. Another observer independently made the above measurements on 20 randomly selected femora to test the reliability of the method.

RESULTS

Fig. 1: Method of taking End-On view photograph of proximal end of femur.



The mean FA on right side was 10.6°± 8.0° & on left side it was 12.3°± 9.7°. Since there was no statistically significant differences between right & left FA (P value 0.59) the average on right & left FA was calculated & was used for comparison. The mean FA was 11.4°± 8.8° & range between -20° to 36°. There is a good intra

observer correlation in measuring FA (Smearman's rank correlation was 0.94). There is a good inter observer correlation in measuring FA. (Smearman's rank correlation was 0.99).

Fig. 2: Analysis of the End-On view photograph using microsoft power point.

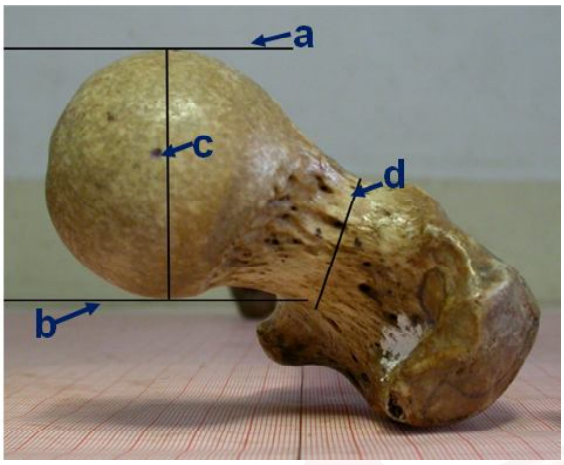


Fig. 3: Relevant axes and measurement of femoral anteversion angle.NA- head neck axis, RCA- retrocondylar axis, FA- femoral anteversion angle

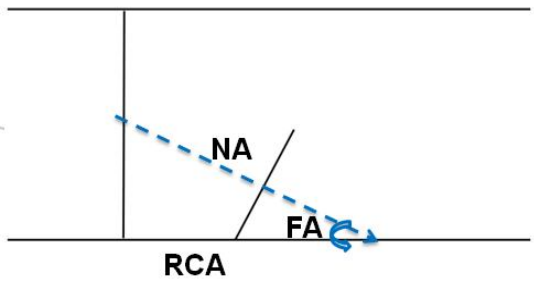


Fig. 4: Pictures of minimum, average & maximum Femoral Anteversion angle.

DISCUSSION

The average FA in the present study was 11.4°. This was comparable with other Indian studies done by Maheshwari AV (11.7°) and Jain AK (11.5°) (Table 2) where biplanar x-ray method was used [8,9].

The average FA in the present study was within the range of previous Indian studies (7.4° to 13.7°). Only one Indian study had very high FA of 20.4° [11]. (Table 1).

Table 1: Comparison of FA of present study with other foreign studies.

Sl.no	Authors	Year	Population	Method	FA
1	Kweon DC [28]	2002	Korean	CT	20.1°
2	Kweon DC [28]	2002	Korean	MRI	20.4°
3	Umebese PF [29]	2005	Nigerian	X- ray	28.0°
4	Toogood PA [25]	2009	American	Dry bone- Digital Photo	9.7°
5	Kulig K [30]	2010	American	USG	20.7°
6	Kulig K [30]	2010	American	MRI	19.0°
7	Atkinson HD [31]	2010	British	CT	M- 8.0° F- 9.0°
8	Present study	2016	India	Dry bone- computer assisted	11.4°

However the FA in the present study was lower than most of the foreign studies. (Table 2). Thus, the FA varies in different populations. The lower FA in Indian population may be a racial characteristic or it may be of developmental origin. The smaller FA may be attributed to the prolonged detorsion of the femur in Indians, probably due to functional and nutritional factors. Kate and Robert (1963) have suggested that it may also be associated with the squatting habit of the Indians [12,13].

Table 2: Comparison of FA of present study with other Indian studies.

Sl.no	Authors	Year	Population	Method	FA
1	Siwach RC [32]	2003	Rohtak	Dry bone– X-ray	13.7°
2	Maheshwari AV [8]	2004	Delhi	Biplane - X-ray	11.7°
3	Maheshwari AV [8]	2004	Delhi	Clinical	13.0°
4	Jain AK [9]	2005	Delhi	CT	7.4°
5	Jain AK [9]	2005	Delhi	X-ray	11.5°
6	Jain AK [9]	2005	Delhi	Clinical	13.1°
7	Jain AK [9]	2005	Delhi	Dry bone- Mechanical	8.1°
8	Nagar M [33]	2006	Delhi	Dry bone- Mechanical	M-16.3° F-10.9°
9	Saikia KC [11]	2008	Guwahati	CT	20.4°
10	Shrikant AR [13]	2009	Pune	Dry bone- Mechanical	8.7°
11	Zalawadia A [7]	2010	Gujarat	Dry bone- Mechanical	12.4°
12	Maheshwari AV [8]	2010	Delhi	CT	8.0°
13	Shrimathi T [23]	2012	Tamil Nadu	Dry bone- Mechanical	9.8°
14	Present study	2016	Bengaluru	Dry bone- computer assisted	11.4°

The reason for this great disparity between the present study and the western studies may be due to seems to be the different methods adopted to measure the angle. Different investigators have used different axes at proximal end of femur to define the FA. Earlier, Reikera et al (1983) and Yoshioka et al (1987) found lower FA

of 7 and 8 degrees respectively in Caucasian skeletal survey [14,15].

These lower average values of anteversion can be accounted for by the different techniques employed. They have used a transepicondylar axis rather than the retrocondylar axis as the distal axis. As a routine, it is the retrocondylar axis which is used by the orthopaedicians in clinical practice. Yoshioka et al., [15] subsequently used the retrocondylar axis in the same skeletal population and found the average anteversion to be 13 degrees. Evidently the angle of anteversion is dependent on the axis used for its measurement.

In the present study the angle was found to vary in the range of -20° to +36°. According to various workers, it ranges from -25° to 54° [16]. The extreme anteversion may be attributed to persistant version. Postnatal sitting and sleeping postures have been implicated as mechanisms that either cause torsional abnormalities or contribute to persistent femoral antetorsion [17].

The standard deviations were substantial in most of the studies (Present study = 8.8°) and their ranges included values well beyond what modern prostheses currently are able to reproduce. This is of concern to modern surgical technique. 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 [18]. The prevalence of retroversion in the present study was 7.01 %. Kate & Robert (1963), A K Jain and Shrikant AR reported it to be 7.7, 9.3 and 9.4% respectively in Indian population [9,12,13]. However when compared to Kingsley (1909) (prevalence of retroversion 14.8%) it is significantly less in Indian population ($p < 0.001$) [19]. The development of the retroversion may be associated with the disorders of development. It probably represents the arrest of development of the angle towards positive side from the original -10 at 17mm stage of the embryo. So also, unchecked continuation of the process of detorsion (which occurs during first two years) due to developmental, mechanical and endocrine factors peculiar to that individual may result in the angle of retroversion in adults. Kate & Robert (1963) noted that the retroversion is exaggerated in some cases due to twisting of lower end of femor outwards instead of inwards. Thus, it may be associated with skeletal abnormalities in the individual [12].

In the present study the FA was found to be greater in the left femora by 1.7 degrees than in the right femora which was statistically insignificant. There are inconsistent reports worldwide about the bilateral differences in femoral anteversion. Many western researchers noted that the angle is more on the left side [20,21] while others found it to be more on right side [21,22]. In the Indian literature Jain AK [9], Shrikant AR [5], Maheshwari AV [8] & Shrimathi T [23] found angle on the left femora to be more than the right, which was statistically significant. Though statistically significant ($p < 0.01$), the small value of the difference has less clinical relevance.

This bilateral difference may be related to hip laterality & postural dynamics. Cerebral hemispheric dominance affects the lower limb in a fashion demonstrating a lateralization index increasing from proximal to distal joints. The resulting higher muscular tones may have affected the FA regression on the dominant side. In addition, maintaining an extreme hip posture during sitting or sleeping in which the hip is held at or near the end of medial or lateral rotation, may produce changes in the FA angle. Oriental societies are accustomed to floor level activities (e.g. squatting) with increased lateral rotation that inversely affects the FA angle. The presence of higher FA angle values on the left side in our tested subjects suggests a right lower limb sidedness with increased muscle tone & probably a floor level postural habitus bringing the left hip to medial rotation more than the right [24].

There is a worldwide disparity in opinions about bilateral differences in FA. Greater right side anteversion has been documented by Kingsley et al (1948) and Yoshioka et al (1987) in Caucasians, Oriental & African population [25,26]. However to have a concrete conclusion on this issue, a comparison should be done between the femoral anteversion of right & left femora of same individuals. Knowledge of this normal

In the present study the mean FA was 11.4°. There was no femur with FA less than -20° & the maximum FA observed was 36°. There was no significant difference in FA on right & left sides. There was good intra & inter observer reliability in measuring FA. The findings of the present study will be helpful to clinicians, therapists & researchers as ready references to FA among South Indian population. Any deviation from this value should be correlated with clinical findings. It is hoped that these morphometric findings on FA could be of some use possibly in designing prosthesis for Indian population. However, for the purpose of authentic use further progressive study in the same direction is desirable.

CONCLUSION

In the present study the mean FA was 11.4°. There was no femur with FA less than -20° & the maximum FA observed was 36°. There was no significant difference in FA on right & left sides. There was good intra & inter observer reliability in measuring FA. The findings of the present study will be helpful to clinicians, therapists & researchers as ready references to FA among South Indian population. Any deviation from this value should be correlated with clinical findings. It is hoped that these morphometric findings on FA could be of some use possibly in designing prosthesis for Indian population. However, for the purpose of authentic use further progressive study in the same direction is desirable.

Conflicts of Interests: None

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