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Computed tomography measurement of femoral neck anteversion in South Asian adult population: A records - based study at a tertiary care hospital

[1]Dr. Mayur Gaikwad S.M., Postgraduate in orthopaedics, Mandya Institute of Medical Sciences, Mandya, Karnataka, India-571401

[2]Dr. Manjappa C.N.**,** Professor and Head of Department of Orthopaedics, Mandya Institute of Medical Sciences, Mandya, Karnataka, India-571401

Corresponding Author: Dr. Mayur Gaikwad S.M., Postgraduate in orthopaedics, Mandya Institute of Medical Sciences, Mandya, Karnataka, India-571401.

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Abstract

Background: Femoral neck anteversion (FNA) angle, the angular relationship between the femoral neck and the distal femoral condyles, plays a critical role in hip biomechanics and surgical planning. Variations in FNA are associated with gait abnormalities, hip dislocations, and influence implant alignment in orthopedic procedures. While normative FNA data exists for Western populations, limited reference data is available for South Asian adults.

Objective: To measure the femoral neck anteversion angle in a South Asian adult population using computed tomography (CT) and compare findings with established literature.

Methods: This records-based study was conducted at Mandya Institute of Medical Sciences, Karnataka, using pre-existing CT scans of the hip and femur. FNA was calculated by superimposing axial CT images of the femoral head-neck and distal femoral condyles. A total of 83 femurs (from adults aged 18–80 years) were analyzed. Statistical comparisons were made by sex, side, and age groups.

Results: The mean FNA was 17.57° ± 13.16°. Males (n=43) had a mean FNA of 17.65°, while females (n=40) had 17.48°, with no statistically significant difference (p = 0.954). A significant side-wise difference was noted, with left femurs showing higher anteversion (21.28° ± 6.69°) than right femurs (15.67° ± 15.16°, p = 0.022). No significant differences were observed across age groups (p = 0.120).

Conclusion: The FNA values in this South Asian cohort align with global reference ranges, demonstrating high

inter-individual variation but no significant influence of age or sex. The observed laterality difference suggests potential anatomical asymmetry, underscoring the importance of individualized assessment during orthopaedic surgical planning. These findings may support regional considerations in implant design and clinical decision-making.

Keywords: Femoral Neck Anteversion, Computed Tomography.

Introduction

The angle between the femoral neck and femoral shaft is known as femoral neck anteversion (FNA) angle, indicating the degree of torsion of the femur. It affects the biomechanics of the hip, as moment arms and the line of action of muscles around the joint are altered. It varies by up to 30 degrees in apparently normal adults. It varies by age and is highest at period of gestation and the angle progressively decreases with age through childhood, puberty and into adulthood. There is a further decrease at a much lower rate during adulthood into old age.[1]

It is measured by various methods including the clinical examination (Craig's test), Ultrasonography (USG), Computed tomography (CT) and Magnetic resonance imaging (MRI). CT and MRI are more reliable compared to USG and clinical examination which are not reliable and show large inter and intra observer differences. CT is now a more readily available, reliable and relatively cheap method but carries the disadvantage of radiation exposure.[2]

The FNA is of clinical importance in patients presenting with gait abnormalities, hip dislocations (common in excessively anteverted or retroverted femur heads), during surgical implant (screws, helical blades, pins etc.) placement into the head/neck of femur and therefore influence the implant design. Its measure is also significant during hip replacement surgeries where surgeons would want to place the prosthesis in appropriate anteversion so as to recreate the native hip FNA angle and avoid discrepancies between the limbs.[3]

The purpose of our study is to measure the FNA angle in South Asian sample adult population and compare with the current knowledge of FNA angles in the global adult population and design of surgical implants and prosthesis.

Objective

To determine the femoral neck anteversion angles of South Asian adult population from computed tomography scans.

Methodology

This was a records-based study of the adult population who had undergone CT scans of full-length femurs. The source of our data was the Picture Archiving and Communication System of the Department of Radiodiagnosis, Mandya Institute of Medical Sciences, Mandya. Data collection was done after approval from the Institutional Ethics Committee. The measurements of femoral neck anteversion was made from pre-existing database of computed tomography (CT) scans of pelvis, hip and femur done for unrelated reasons. The femoral neck anteversion was measured by superimposing the axial images of the CT scan at the level of femur head-neck and femoral condyles and the angle formed by the femur head-neck axis to the intercondylar axis was measured as the angle of femoral anteversion and the findings were documented in a proforma along with other details such as patient name, age, sex.

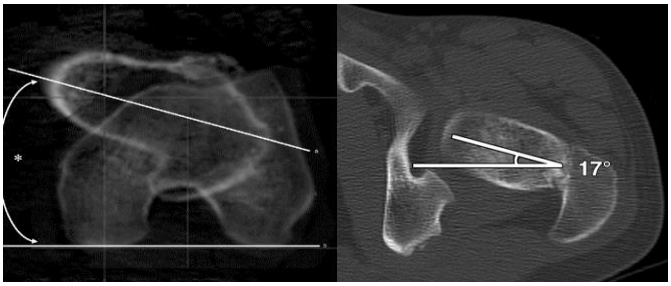

Figure 1: CT measurement of Femoral neck anteversion using axial sections.

Inclusion criteria

1. Patients who have underwent CT scans of the hip and femur.
2. Age group: 18 to 80 years

Sample size: It is based on a previous study on Indian adult population by R Srivatsa et al. who in their study of anatomic specimens found a mean FNA angle for right femur was 12.09° ± 4.56°, and for left femur it was12.53° ± 3.28°.[3]

If $n = (Z_{1-\alpha/2}^2\ \sigma^2)/d^2$;

Where, d = 10% of mean i.e. 1.209 for right femur and 1.253 for left femur

$Z_{1-\alpha/2}^2 = 1.96$ standard normal variate

$\sigma = 4.56$ for right and 3.28 for left

Then, n is 54.649 for right femur and 26.324

Therefore, we get a round number sample size of 55 right femurs and 26 left femurs.

Sampling method: Convenience sampling

Exclusion criteria

1. Measurement of the side with hip and femur pathology (e.g. Fractures, dysplasia, tumours and infection)

Data analysis

All the data collected was entered into an Excel sheet, and the data was statistically analysed. The presentation of the Categorical variables like sex and side of limb will be done in the form of numbers and percentages (%). On the other hand, the continuous data like age and femoral neck anteversion angle will be presented as the means ± standard deviation.

Results

1. 83 computed tomography scans of femurs were used to measure the femoral neck anteversion angle. The mean FNA angle was 17.57° with a standard deviation of 13.16°.
2. 43 were males who had an average FNA angle of 17.65° +/- 11.79°, and 40 were females with an average FNA of 17.48° +/- 14.64°.
3. 55 right femurs were measured to have an average FNA angle of 15.67° +/- 15.16° whereas 28 left hips had an average FNA of 21.28° +/- 6.69°.
4. Tests of statistical significance showed that there was no significant difference in Femoral neck anteversion angles by age group or sex. However, the FNA angles were statistically significant with respect to laterality/ side of the hip (p-value = 0.022), suggesting anatomical asymmetry.

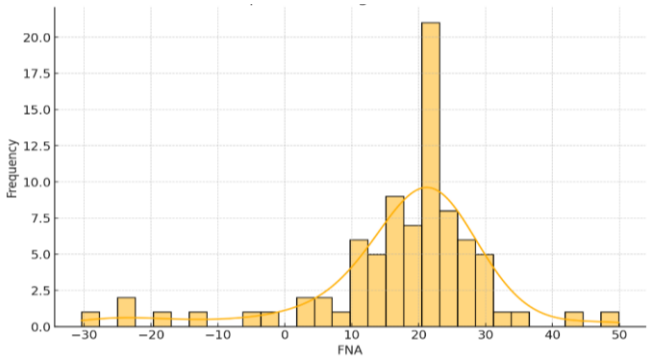

Figure 2: Histogram showing frequency distribution of femoral neck anteversion angles

Table 1: FNA angles of Males v/s Females

Sex	Count	Mean FNA angle	Standard deviation
Females	40	17.48°	14.64°
Males	43	17.65°	11.79°

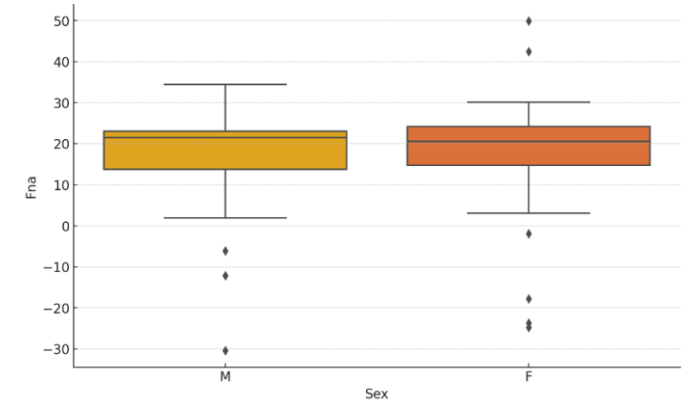

Figure 3: Boxplot of FNA angles by Sex

Table 1: FNA angles of Right v/s Left hips

Side	Count	Mean FNA angle	Standard deviation
Left	28	21.28°	6.69°
Right	55	15.67°	15.16°

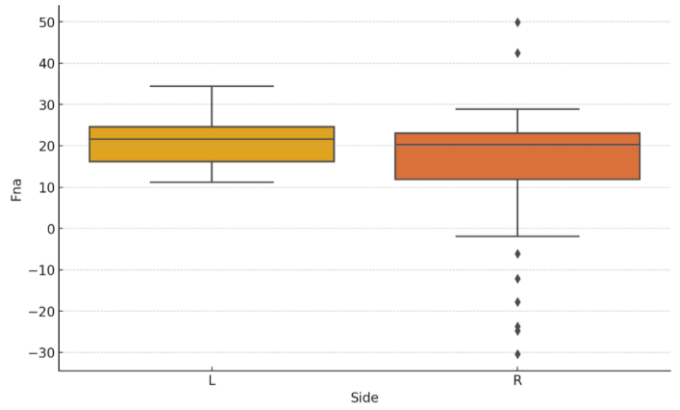

Figure 4: Boxplot of FNA angles by Side

Table 3: Mean FNA with according to various age groups

Age group	Count	Mean FNA angle	Standard deviation
21-30	12	19.95°	6.35°
31-40	16	12.58°	13.12°
41-50	20	19.03°	13.68°
51-60	5	13.14°	21.16°
61-70	19	21.52°	12.84°
71-80	9	10.86°	10.69°
>80	2	32.1°	14.70°

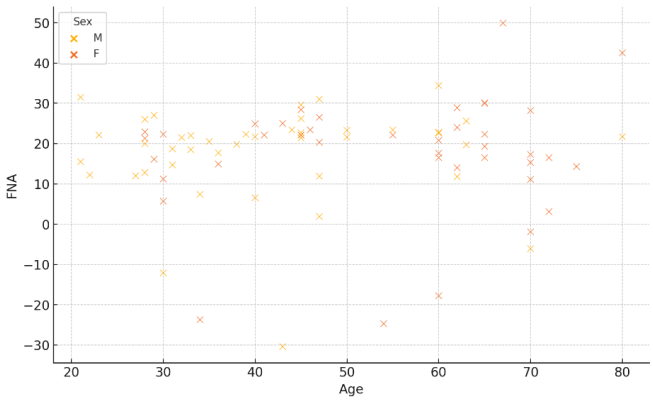

Figure 5: Scatter-plot of Age v/s FNA angles by Sex

Discussion

The femoral neck anteversion angle (FNA) is an anatomical parameter that describes the angular relationship between the femoral neck and the femoral condyles when viewed in the transverse plane. More precisely, it is the angle between the axis of the femoral neck and the transcondylar axis of the distal femur. This angle represents the degree to which the femoral neck projects anteriorly relative to the femoral shaft and plays a critical role in determining the alignment and biomechanics of the hip joint.

Understanding and accurately measuring the FNA is essential in various clinical and orthopaedic settings. Normal anteversion in adults typically ranges between 10° and 20°, though this can vary based on age, sex, and ethnicity. Abnormal anteversion — either increased (excessive anteversion) or decreased (retroversion) — is associated with several musculoskeletal disorders. These include developmental dysplasia of the hip (DDH), femoro-acetabular impingement (FAI), patellofemoral instability, gait abnormalities (e.g., in-toeing or out-toeing), hip osteoarthritis etc.

Correctly identifying variations in FNA is also crucial for preoperative planning in procedures such as total hip arthroplasty, osteotomies, and intramedullary nailing,

where the femoral alignment influences implant positioning and post-surgical biomechanics.

Several methods have been developed to estimate the femoral neck anteversion angle, ranging from clinical assessments to highly accurate imaging-based techniques. Clinical physical examination is used in children and often includes measurement of hip rotation in the prone position (Craig's test, also known as the trochanteric prominence test). However, it is not accurate and reliable because it is highly subjective and influenced by soft tissue tightness and examiner skill. Radiographic methods using plain radiographs (e.g., Dunn's view) may provide a rough estimate but are limited by projectional inaccuracies. Computed Tomography (CT) is considered the gold standard for FNA measurement due to its high accuracy and reproducibility. Techniques such as the Murphy or axial oblique methods define reference axes for the femoral neck and condyles in 3D space. Magnetic Resonance Imaging (MRI) provides a radiation-free alternative and is particularly useful in pediatric populations. Slightly less precise than CT in bony landmark definition but valuable for combined soft tissue evaluation.

The findings of the present sample on femoral neck anteversion (FNA) are largely consistent with established literature, particularly regarding average values and variability. The mean FNA in this study (~14°–15°) aligns closely with reported normative ranges in adult populations, such as those by Tönnis and Heinecke (1999)[5] and Ruwe et al. (1992)[6], which typically fall between 8° and 16°. While prior studies have suggested that females may exhibit slightly higher anteversion due to pelvic morphology, this sample showed no statistically significant difference between sexes (p = 0.954), supporting the variable nature of such findings across populations. Notably, the study identified a statistically significant difference in FNA between the left and right sides (p = 0.022), a result not commonly observed in prior research, where side-to-side variation is generally considered negligible. Furthermore, no significant differences in FNA were found across age groups (p = 0.120), contrasting with literature that describes a decrease in anteversion from childhood to adulthood but consistent with studies focusing on adult cohorts. Overall, the results of this small South Asian adult population corroborate with the wide inter-individual variation in FNA and reflect patterns reported in both cadaveric and imaging-based anatomical studies internationally.

Study	Sample Type	Mean FNA angle	Notable Findings
Current Study	CT study (n = 83)	17.57°	High side variation; no age/sex effect
Tönnis & Heinecke (1999)	CT study (n = 1,000 hips)	13.5° (men), 16.5° (women)	Higher anteversion in women
Ruwe et al. (1992)	CT study (children and adults)	8° to15°	Age dependent reduction in anteversion
Fabry et al. (1973)[7]	Clinical observation (n = 600 children)	~30° (children)	Children have high anteversion
Kaiser et al. (1985)[8]	Radiographic study	Not specified	Side differences minimal
Kingsley & Olmsted (1948)[9]	Cadaveric study (n = 400 femora)	8° (men), 14° (women)	High anatomical variation with outliers

Conclusion

This study aimed to assess femoral neck anteversion (FNA) angles in a South Asian adult population using computed tomography, a gold-standard imaging modality known for its accuracy and reproducibility. The mean FNA in this sample was 17.57°, falling well within the globally accepted adult normative range of 10°–20°. No significant differences were observed in FNA with respect to age or sex, aligning with several previous reports that highlight the variable nature of these associations across populations. However, a statistically significant difference between right and left femurs was observed ($p = 0.022$), suggesting the presence of anatomical asymmetry, a finding that is infrequently reported in prior studies. Compared to established literature, the values and variability in this study are consistent with global trends, reinforcing the anatomical diversity of FNA while emphasising the importance of population-specific data. These findings are particularly relevant in clinical and surgical contexts—especially for hip arthroplasty, fracture fixation, and implant design—where understanding native FNA is crucial for restoring biomechanics and ensuring successful outcomes. The data obtained from this study contribute valuable insights into FNA in South Asian adults and may inform region-specific orthopaedic strategies and prosthetic design considerations.

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