

# A STUDY OF FEMORAL NECK ANTEVERSION ANGLE IN CENTRAL INDIAN POPULATION: A GUIDE FOR ORTHOPAEDIC SURGERIES INCLUDING HIP ARTHROPLASTY

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## ABSTRACT

**Background:** Femoral neck anteversion angle is the angle which measures the anterior rotation of the neck of the femur around the shaft. Its variation in the various population groups is attributed to various factors such as heredity, diet, climatic factors and lifestyle. This angle is clinically significant for orthopedicians while doing hip arthroplasties and osteotomies where it is pertinent to restore the anatomy of proximal femur for stability of the hip joint.

**Context and purpose of the study:** There is no baseline data of Femoral Neck Anteversion angle for Central Indian population. The present study was aimed to fill this lacuna and to give the normal values of femoral neck anteversion angle for above specified population.

**Materials and methods:** 152 dried femora were procured from department of anatomy consisting of 77 femora of right side and 75 femora of left side. Anteversion angle is recorded using goniometer. Means were calculated and statistically correlated for laterality using independent student 't' test. p value was thus obtained.

**Results:** Mean anteversion angle of right side was found to be  $19.03^\circ \pm 12.11^\circ$  and that of the left side came out to be  $18.62^\circ \pm 10.8^\circ$ . Among 152 femora taken, 7 retroverted and 7 neutral verted femora were also found in the study.

**Conclusion:** So much variation in the angle of anteversion along with the presence of retroversion (4.6%) and neutral version (4.6%) is a challenge for both implant designer companies as well as orthopedicians. Thus, present study acts as a guide for normal values and range of this clinically significant angle.

**KEY WORDS:** Hip arthroplasty, Angle of anteversion, femur neck fracture, Anthropometry.

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Access this Article online	Journal Information
<b>Quick Response code</b>  <b>DOI:</b> 10.16965/ijar.2018.313	<b>International Journal of Anatomy and Research</b> ISSN (E) 2321-4287   ISSN (P) 2321-8967 <a href="https://www.ijmhr.org/ijar.htm">https://www.ijmhr.org/ijar.htm</a> DOI-Prefix: <a href="https://dx.doi.org/10.16965/ijar">https://dx.doi.org/10.16965/ijar</a> 
	Article Information
	Received: 09 Jul 2018 Peer Review: 09 Jul 2018 Revised: None
	Accepted: 13 Aug 2018 Published (O): 05 Sep 2018 Published (P): 05 Sep 2018

## INTRODUCTION

Anteversion is defined as the angle by which the femoral neck deviates forwards from the axis of the femoral condyles, projected on to the horizontal plane. It was way back in 16th century that Da Vinci with the help of anatomical illustrations described that neck of femur is anteverted in position[1]. The reason behind this

torsion of femoral neck is reported by various authors. They attributed it to rotational forces which are applied to the neck of the femur during fetal life and genetic predisposition, since it has been shown that femoral anteversion varies between the different races[2,3]. Fabry G et al[4] explained change of this torsion angle from around 30° at birth to

approximately 15° in an adult and attributed it to the action of the internal rotators. Beals RK[5] reported an increase in Femoral Neck Anteversion Angle (FNA) in cases of cerebral palsy. Femoral neck can also be retroverted which was explained by Lange F et al[6] as due to contracture of external rotators of hip due to reduced uterine space.

Its value is quoted in standard anatomical and orthopedics textbooks as 10-30° [7,8]. These values are mainly given by foreign authors. FNA varies in various races. Also, to have an idea of normal range of FNA in a given population is vital for an orthopedician. An indispensable outcome of orthopedic surgeries such as Osteosynthesis for fractures, Osteotomies, Hemi- and Total joint arthroplasty is to restore the anatomy of proximal femur to as near as normal for improving the long term outcome of the patient's hip joint stability. The above quoted challenge is further compounded by high variations in the values of FNA[9] along with the presence of neutral version and retroversion of femoral neck. Also, knowledge of anteversion angle is helpful in designing the suitable intramedullary fixators and for defining the axes for orthopedic surgeries. With so much clinical implication of a single angle whose normal parameters in central Indian population is still under shadows of ambiguity, the present study was done with the primary objective of giving a range of normal values of FNA for central Indian population.

## MATERIALS AND METHODS

A total of 152 dried femora, 77 of right side and 75 of left side of either sex were studied in Department of Anatomy, Pandit J.N.M Medical College, Raipur, Chhattisgarh. Femora with gross deformities or those damaged were excluded from the study.

Study definition of Femoral neck Anteversion Angle: The angle formed by the transverse axis of femoral condyles and the transverse axis of the femoral head and neck projected on to the horizontal plane[10].

Various authors have measured FNA by various methods such as X rays, CT scan, MRI but its measurements using dried femora is considered

as the most accurate one. A goniometer was used for measuring FNA in present study which is a cheaper alternative to expensive radiological modalities especially in third world countries. The measurements once measured were again measured by the other author to negate any inter-observer bias.

The measurements thus obtained were recorded and tabulated in MS Excel Spread Sheet. SPSS version 20 was used to evaluate the statistical difference in the values of FNA of two sides by using 'Independent student T test'. p value was obtained.

**Fig. 1:** Showing the angle of anteversion as the angle between longitudinal axis of neck of femur and the horizontal axis.



## RESULTS

Average value of FNA of right side was  $19.03^\circ \pm 12.11^\circ$  and of left side was  $18.63^\circ \pm 10.8^\circ$ . Range of FNA was  $-15^\circ$  to  $46^\circ$ . No significant difference is observed in the values of FNA obtained of Right and Left side, **p value** being 0.831(>0.05). Among 152 femora taken for the study, 7 Neutral-verted (4.6% of the sample) and & 7 Retroverted (4.6% of the sample) femora were found. Range of Femoral neck retroversion angle (FNR) was -4 to -15 on the right side and -10 to -15 on the left side.

**Table 1:** Table showing findings of the present study.

	FNA Mean $\pm$ SD (In degrees)	95% Confidence Interval (Mean $\pm$ 2SE)		p Value
		Lower	Upper	
Right Femora	$19.03^\circ \pm 12.11^\circ$	16.29	21.77	0.831
Left Femora	$18.63^\circ \pm 10.8^\circ$	16.14	21.11	

## DISCUSSION

Femoral neck anteversion and Acetabular anteversion maintains the congruity and thus

stability of the hip joint[11].

This angle is important in diagnosis and pre operative planning for various orthopedic pathologies such as slipped upper femoral epiphysis, congenital club foot, hip dysplasias and thigh varum. Wedge JH et al found the increased FNA in cases of Idiopathic hip arhrosis[12].

Knowing the values of FNA for a population helps in designing prosthesis ideally suited to them.

In the present study, average value of Right FNA was  $19.03^{\circ} \pm 12.11^{\circ}$  whereas that of left side was  $18.63^{\circ} \pm 10.8^{\circ}$ . In the present study, no significant differences in values of FNA in right and left side (p value being 0.831) was observed.

**Table 2:** A tabulated review of works done by foreign authors on FNA.

S.no	Authors	Year	Region of study	FNA(in degrees)	Method used
1	Braten et al[20]	1992	Norwegian	M: $14 \pm 7.8^{\circ}$ (-2 to 29) F: $18 \pm 7.4^{\circ}$ (3 to 33)	Ultrasound
2	Schneider B[21]	1997	German	$10.4^{\circ} \pm 6.3^{\circ}$	MRI
3	Husmann et al[22]	1997	French	$24.7 \pm 8.7^{\circ}$ (0.29 to 44.5)	CT
4	Sugano et al[23]	1998	Japanese	T: $19.8 \pm 9.3^{\circ}$ (3.0 to 50.1) M: $16.9 \pm 7.1$ F: $22.6 \pm 10.6^{\circ}$	CT
5	Maruyama et al[24]	2001	Japanese	Total: $9.8 \pm 8.5^{\circ}$ (-15 to 34) M: $9.8 \pm 9.0^{\circ}$ (-15 to 30) F: $9.8 \pm 8.0$ (-12 to 34)	Cadaver
6	Mahaisavariya et al[25]	2002	Thai	$11.37 \pm 7.65^{\circ}$ (0.13 to 34.92)	CT
7	Kweon DC[26]	2002	Korean	$20.1^{\circ}$	CT
8	Kweon DC[26]	2002	Korean	$20.4^{\circ}$	MRI
9	Khang et al[27]	2003	Korean	CT: $17.9 \pm 10.7^{\circ}$ Cadaver: $17.9 \pm 7.4^{\circ}$ T: $17.9 \pm 10.2^{\circ}$ (2 to 30)	CT Cadaver
10	Umbese et al[3]	2005	Nigerian	$28 \pm 5^{\circ}$	X-ray
11	Lee et al[28]	2006	Korean	$18.5 \pm 7.2^{\circ}$	CT
12	Toogood et al[29]	2008	American	$9.73^{\circ}$ (-14.63 to 35.90)	Cadaver
13	Kulig K[30]	2010	American	$20.7^{\circ} \pm 11.0^{\circ}$	USG
14	Kulig K[30]	2010	American	$19.0^{\circ} \pm 11.3^{\circ}$	MRI
15	Bargar et al[31]	2010	American	$13.8 \pm 7.9^{\circ}$ (-6.1 to 32.7)	CT
16	Koerner et al[32]	2013	American	T: $8.84 \pm 9.66^{\circ}$ M: $8.70 \pm 9.44^{\circ}$ F: $9.51 \pm 10.72^{\circ}$	CT
17	Yun et al[33]	2013	Korean	T: $9.0 \pm 8.1^{\circ}$ (6.9 to 11.1) L: $9.0 \pm 7.4^{\circ}$ (7.1 to 10.9) R: $9.0 \pm 8.8^{\circ}$ (6.7 to 11.3)	CT
18	Wright et al[34]	2014	Netherlander	$12.6 \pm 8.2^{\circ}$ M: $9.8 \pm 7.4^{\circ}$ F: $15.5 \pm 8.1^{\circ}$	CT
19	Ming Han et al[35]	2015	Chinese	Male: T- $6.55 \pm 9.56^{\circ}$ (-12 to 29) R- $6.02 \pm 10.85^{\circ}$ (-12 to 28) L- $7.08 \pm 9.30^{\circ}$ (-7 to 29) Female: R- $10.02 \pm 11.69^{\circ}$ (-16 to 35) L- $6.02 \pm 10.85^{\circ}$ (-8 to 31) T- $8.02 \pm 11.40^{\circ}$ (-16 to 35)	Goniometer
20	Jiang n et al[16]	2015	Chinese	T: $10.54 \pm 9.31^{\circ}$ Males: $9.28 \pm 8.61^{\circ}$ Females: $16.27 \pm 10.26^{\circ}$ L: $10.16 \pm 9.22^{\circ}$ R: $10.92 \pm 9.42^{\circ}$	CT

**Table 3:** A tabulated Review of works done by Indian authors on FNA.

S. No	Authors	Year	Geographical Area	FNA (in degrees)	Method used
1	Siwach RC[36]	2003	Rohtak	13.7°±7.9°	Dry bone–X-ray
2	Maheshwari AV[13]	2004	Delhi	11.7°±4.6°	Biplane X-ray
3	Maheshwari AV[13]	2004	Delhi	13.0°±2.7°	Clinical
4	Jain AK[14]	2005	Delhi	7.4°±4.6° 11.5°±5.4° 13.1°±4.6° 8.1°±6.6°	CT X-ray Clinical Dry bone-Mechanical
5	Nagar M[37]	2006	Delhi	M-16.3° F-10.9°	Dry bone-Mechanical
6	Saikia KC[38]	2008	Guwahati	20.4°±8.6°	CT
7	Rokade S[39]	2008	Maharashtra	R-7.98° L-9.7°	Dry bone- Mechanical
8	Shrikant AR[15]	2009	Pune	8.7°±6.6°	Dry bone-Mechanical
9	A Zalawadia[40]	2010	Gujarat	12.4°±18.4°	Dry bone-Mechanical
10	Rawal et al[41]	2012	Indian	M: 8.49±4.68 ° F: 12.6±2.92 °	CT
11	Ravichandran D et al[42]	2014	Andhra Pradesh	R-18.54±9.05 ° L-19.42±10.89°	Dry bone-Image software
12	Verma L et al[9]	2016	Indian	R-14±8.98° L-12.9±8.22°	Dry bone-Image software

Some previous authors noted significantly greater FNA on left side[13,14,15] while others on right side[16,17]. Previous authors have found values ranging from 6.55° to 28°. Such a huge variation in the value of FNA obtained can be attributed to the difference in race studied. Also, previous authors used different methods to estimate FNA such as Ultrasound, CT scan, MRI, X ray and goniometer. In the present study, goniometer of dried femora was used to measure FNA. Range of FNA was -15° to 46°. Post natal sitting and sleeping postures contributes to extreme values of femoral torsion[18]. The prevalence of retroversion and neutral-version were 4.6% each, i.e 7 femora with neutral version and 7 femora with retroversion out of 152. Other authors who have reported prevalence of retroversion are Verma L et al[9](6%), Jain AK et al[14](9.3%), Shrikant AR et al[15](9.4%) and Kingsley PC et al[19](14.8%). Mean FNA was found to be more than previous Indian studies.

**Potential Implications:** The present study provided the Normal values of Femoral neck anteversion angle for subjects belonging to Central India. This is of huge surgical implication for surgeries such as Hip arthroplasty and

Osteotomy where knowledge of normal range of anteversion angle helps the surgeon to prevent failure of surgeries. Also, it helps the implant designers to construct prosthesis of appropriate angle to suit the patients of specified population.

## CONCLUSION

The present study was conducted with the primary objective of knowing the normal parametric range of FNA angle. The angle of anteversion for a patient of central india is supposed to approximate the range and the mean quoted in the study. Thus, it helps an orthopaedic surgeon to avoid failures of Hip Arthroplasty and osteotomy. It will also guide the implants designer to draw prosthesis tailored for central Indian population.

## ABBREVIATIONS

**FNA-** Femoral Neck Anteversion

**SD-** Standard Deviation

**Conflicts of Interests:** None

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**How to cite this article:**

Diwakar Dhurandhar, Jagriti Agrawal, Deepti Chandrakar. A STUDY OF FEMORAL NECK ANTEVERSION ANGLE IN CENTRAL INDIAN POPULATION: A GUIDE FOR ORTHOPAEDIC SURGERIES INCLUDING HIP ARTHROPLASTY. *Int J Anat Res* 2018;6(3.3):5698-5703. **DOI:** 10.16965/ijar.2018.313