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Original Research Article

Study on Femoral Neck Anteversion and its Radiological Correlation in Population

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Abstract:

Background and Objectives: Anatomists and orthopaedics have long been interested in the femoral neck anteversion angle (FNA) since it is widely recognised as an important factor for hip stability. To study the Femoral neck anteversion (FNA) angle in dry femora.

Methodology: The study was conducted after receiving approval from the Ethical Committee of BHU Varanasi. Study duration of Two years.

Conclusion: In the present study, the mean FNA angle measured Physically and Radiologically were 13.22° and 15.65° with Standard Deviation of 4.20 and 4.65 respectively. The range was from 5°-27° on physical measurement and from 6°-29° on radiological measurement.

Keywords: FNA, Standard deviation, Congenital dislocation of hip.

Introduction

Anatomists and orthopaedics have long been interested in the femoral neck anteversion angle (FNA) since it is widely recognised as an important factor for hip stability [1-4]. It is multifactorial result of evolution, heredity, foetal development, intrauterine position, and mechanicalforces [1].

Abnormal FNA sometimes can be associated with many clinical problems ranging from harmless intoeing gait in the early childhood, which could be a reason for parents concern for children future, to disabling osteoarthritis of the hip and the knee in the adults [1]. The femoral neck anteversion (FNA) is the inclination of the axis of the femoral neck with reference to the knee axis i.e. intercondylar axis, projected on a plane perpendicular to the shaft axis.

A line passing through the centre of the femoral head & neck (bisecting the cervical cortex) and meeting the shaft axis at right angle represents the axis of the femoral neck. The coronal line passing through the femoral condyles represents the knee axis. The FNA describes the normal torsion or twist present in the femur measured as the angle between these two axes [5]. Femoral anteversion is a physiological condition, within certain variations in degrees and differences depending on age [1,8]. If the axis of the neck inclines forward (anterior to the transcondylar plane), the angle of torsion is called anteversion, antetorsion or anterotation. Similarly, if it points backward (posterior to the transcondylar plane), it is called retroversion, retrotorsion or retrorotation [1].

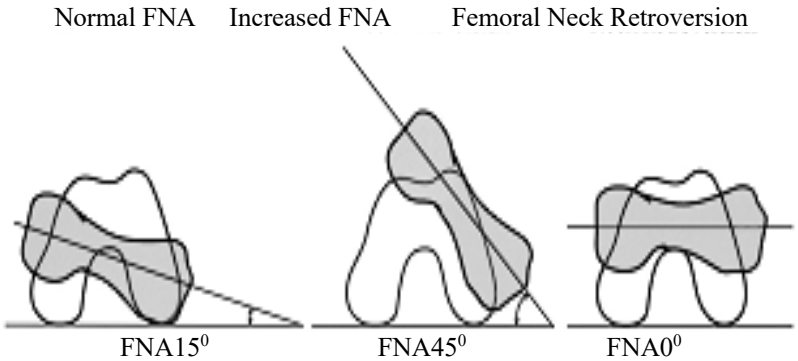


Figure 1: Illustration of Normal, Increased and Decreased FNA

Concerning retroversion the things can be sometimes confused, because this term is sometimes used to describe anteversion which is below the normal range [1]. The terminology describing inclination of the femoral neck vary in different study. [9] In German studies the term antetorsion is mostly used [10,11]. In Anglo-Saxon studies, the most widely used terms are torsion of the femur, and femoral anteversion angle [12]. Paediatric Orthopaedic Society of North America called an FNA angle above 2 SD of mean for age, medial torsion of the femur [13]. The normal values given for the FNA for children and adults differ considerably in the available literature. Different techniques of examination, as well as different population, may explain the different results.

Objectives

To study the Femoral neck anteversion (FNA) angle in dry femora.
To study radiological correlation with the morphometric Femoral neck anteversion angle.

Material and Methods

The cross sectional study with purposive sampling, 100 Dry Femora of known sex and side available at Department of Anatomy, BHU Varanasi. The study was conducted after receiving approval from the Ethical Committee of BHU Varanasi. Femoral neck anteversion angle (FNA) bears a clinical importance ranging from intoeing gait to osteoarthiritic neck femur fracture. Determination of FNA angle required for selection of prosthesis of different hip arthroplasty. Knowledge on FNA angle can be better utilized for early intervention like lifestyle modification in the vulnerable population where FNA angle is altered.

Inclusion criteria

*Dry adult Femora.
*Femora of known sex.

Exclusion criteria

*Femora with deformity.

*Femora with osteoarthiritic change.

*Non adult femora.

Method of Data Collection

Selection of bone (femur): 100 dry femora (55 left and 45 right) were selected among which 45 bones are of female and 55 bones are of male. Bones were examined for any deformity. Bones without deformity were measured for FNA angle.

of neck anteversion angle: FNA angle are measured by Kingsley Olmsted (KO) Measurement method. FNA was measured thrice for each bone and the average is taken to alleviate bias.

Radiograph of the dry Femora: Biplanar radiography were done for each femur by Digital X-ray machine after keeping the bone in a flat firm surface.

Radiological measurement of anteversion angle: Radiological measurement of FNA were taken for each bone by using the console of Digital X-ray.

Study Parameters:

Measurement of neck anteversion angle (FNA) in dry femur.
Radiological measurement of neck anteversion angle (FNA).

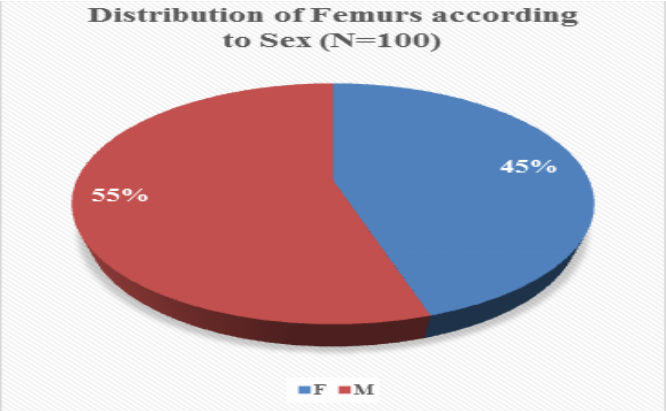
All articles cited in the study were checked for PMID from Pubmed website and DOI (Digital Object Identifier) in any metasearch website. Details of all books including site of publication were cross-checked in World Cat Online catalogue, British library catalogue and library of Congress catalogue.

Statistical Analysis:

At the end of study, changes of all the parameters from their baseline values was calculated & presented in tabular form for each study group. All the data were copied into Microsoft Excel and contingency tables were prepared for qualitative data.

Results

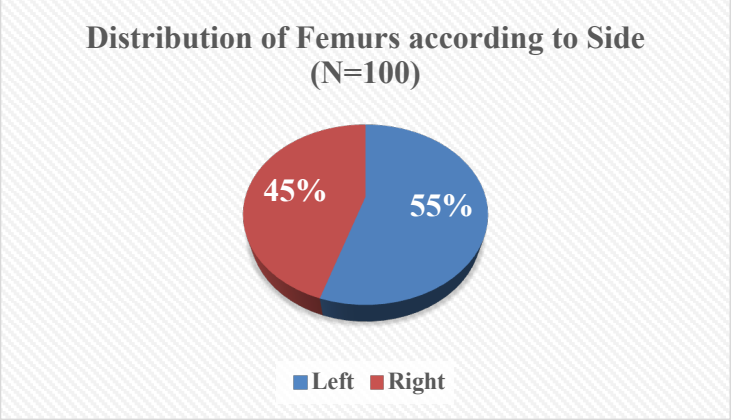
Distribution of femurs according to Sex (N=100)



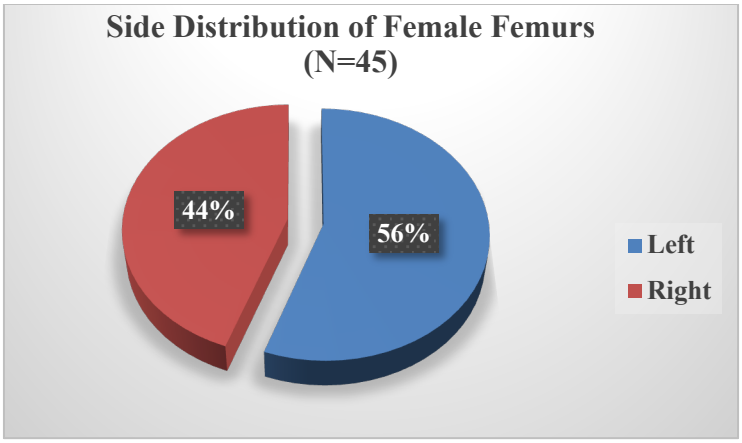
Showing distribution of femurs according to sex: 55% are Male femurs and 45% are Female femurs.

Distribution of femurs according to Side (N=100)

Distribution of femurs according to side: 55% are Left sided femurs and 45% are Right sided femurs.



Distribution of Side in Female Femurs (N=45)



Showing side distribution in female femurs: 56% of left side and 44% of right side

Distribution of Side in Male Femurs (N=55)

Showing side distribution in male femurs: 55% of left side and 45% of right side

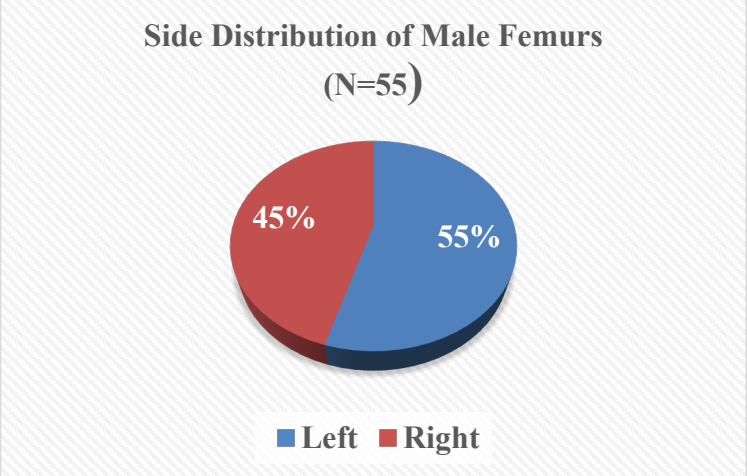


Table: 1: Mean and Standard Deviation of Physically Measured FNA and Radiologically measured FNA

		Physical FNA	Radiological FNA
N	Valid	100	100
	Missing	0	0
Mean		13.22	15.65
Median		13	15
Mode		12	16
Std. Error of Mean		0.4201	0.4657
Std. Deviation		4.201	4.657
Variance		17.65	21.68
Coefficient of Variation		0.3178	0.2975
Range		22.00	23.00
Minimum		5	6
Maximum		27	29
Percentiles	25	10	12
	50	13	15
	75	15	18

Mean FNA by Physical measurement (KO Method) is 13.22° with SD of 4.201 and Mean FNA by Radiological measurement is 15.65° with SD of 4.657.

Table: 2: Comparison of Physically Measured FNA and Radiologically Measured FNA in both sex.

	SEX	N	Mean	Std. Deviation	Std. Error Mean
Physical FNA	Male	55	13.76	4.333	0.5843
	Female	45	12.56	3.98	0.5934
Radiological FNA	Male	55	16.4	4.817	0.6496
	Female	45	14.73	4.33	0.6454

P value and Statistical significance (Physical FNA):

Statistical significance of the Physical FNA value for sex was tested by Independent Sample t test and the two tailed p-value is 0.1535. By conventional criteria, the difference is not statistically significant at $p<0.01$.

Confidence interval:

The mean of Male femurs minus Female femurs equals 1.21.
95% confidence interval of this difference: From -0.46 to 2.87

Table: 3: Correlation between Physical & Radiological FNA in Female bones

		Mean	N	Std. Deviation	Std. Error Mean
Female Femur	Physical FNA	12.56	45	3.98	0.59
	Radiological FNA	14.73	45	4.33	0.65

Paired Samples Correlations				
		N	Correlation	Sig.
Female Femur	Physical FNA & Radiological FNA	45	.904	.000

P value and Statistical significance:

The two-tailed P value is <0.0001
By conventional criteria, this difference is considered to be extremely statistically significant.
Confidence interval:

The mean of Physical FNA of Female femur minus Radiological FNA of Female Femur equals -2.18.
95% confidence interval of this difference: From -2.57 to -1.79.

Table: 4: Correlation between Physical & Radiological FNA in Left bones

		Mean	N	Std. Deviation	Std. Error Mean
Left Femur	Physical FNA	13.35	55	3.75	0.51
	Radiological FNA	15.45	55	4.15	0.56

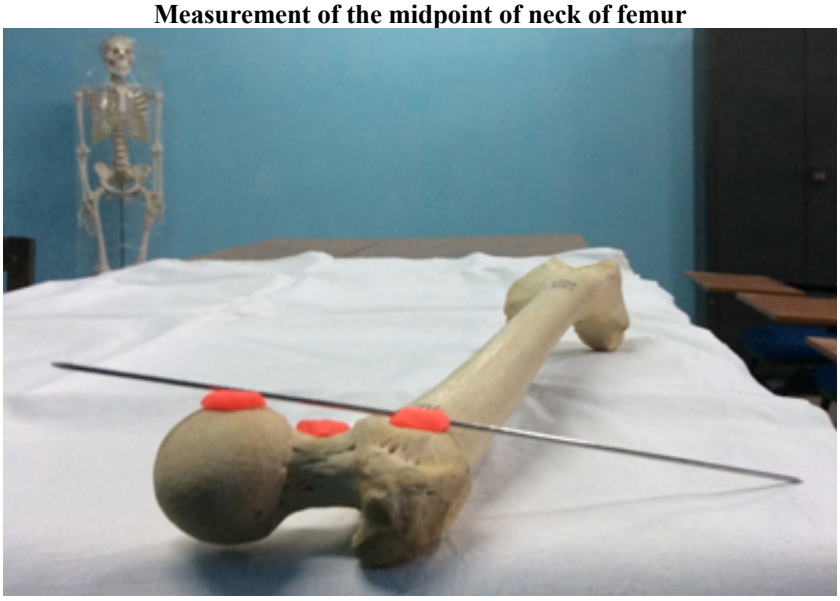
Paired Samples Correlations				
		N	Correlation	Sig.
Left Femur	Physical FNA & Radiological FNA	55	.910	.000

P value and Statistical significance:

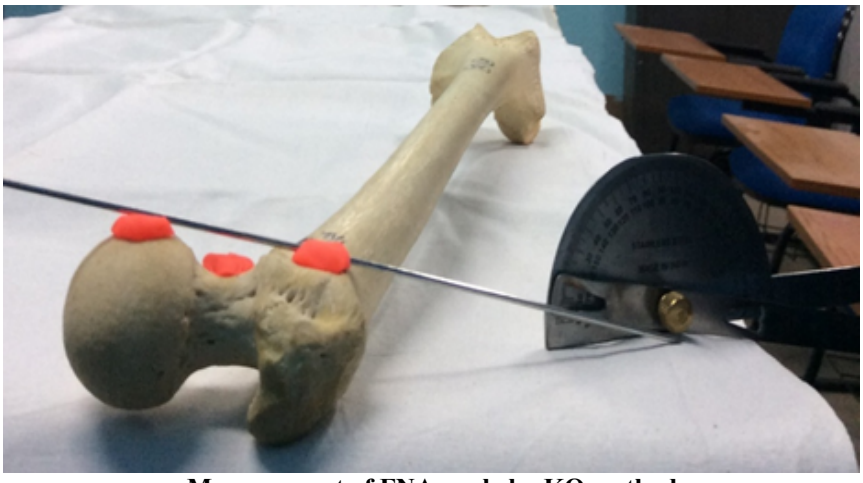
The two-tailed P value is <0.0001
By conventional criteria, this difference is considered to be extremely statistically significant.
Confidence interval:

The mean of Physical FNA of Left femur minus Radiological FNA of Left femur equals -2.11.
95% confidence interval of this difference: From -2.46 to -1.76

Measurement of the midpoint of neck of femur



Placement of K-wire before measurement



Measurement of FNA angle by KO method

Discussion

The femur twists from torsional forces applied perpendicular to the epiphyseal growth plate. Wolff's Law explains the remodelling in adult bone. It states that every change in the form and the function of a bone is followed by changes in the bone's internal and external architecture in accordance with mathematical laws. Femoral Neck Anteversion also may develop because of changes in the stress placed on the adult femur diaphysis by torsional forces. Muscle, by either its passive elastic connective tissue or its contractile force, contributes the greatest stress on bones3 and adds the torsional force on the femur. At birth, anteversion is about 40 degrees. During first year of life, it decreases by about 8 degrees, thereafter 1 degree per year until in the adult it is an average of 10-15 degrees4. It is multi-factorial as a result of evolution, heredity, foetal development, intrauterine position, and mechanical forces. A precise measurement of femoral neck anteversion is important in various orthopaedic diagnosis and procedures1-5. It is important to know the angle of anteversion in a particular population and this should be documented by a method that is accurate, easily available and reproducible6. The accurate estimation of femoral neck anteversion in living subjects has always been difficult with lots of shortcomings and lack of reproducibility1. Estimation of anteversion on dry bone is considered to be the most accuratemethod1. But their greatest drawback is that involvement of femora from some of the skeletons with pathologic conditions having extreme range of values cannot be ruled out and then they may influence the statistical analysis7. It is also assumed that though it may give a profile of the sample population, it may not be relevant for clinical practice since clinical measurement of the angle of anteversion may be different from those obtained on dry femora. However, it is still worthwhile to conduct this study and compare the data with various races and document the range of normal FNA and the existent racial variation. To know the different relationship between the various measurements this study was conducted to estimate the FNA using Physical measurement of Dry bones and biplane X-ray methods. The average adult femoral anteversion has been documented to range between 7°-16° in multiple skeletal surveys (Elfman, 1945; Takai et al, 1985; Yagi and Sasaki, 1986; Yoshioka et al, 1987) whereas Le Damany (1903) quoted it to range from - 25° to + 37°. The Gray's Anatomy states that the transverse axis of the head of the femur makes an angle of approximately 15° with the transverse condylar axis and orthopaedics books quote it to range from 10°-30° [8-10].

Table: 5: Comparative analysis of mean FNA angle in femurs of both sex in different Studies.

Author(s)	Mean FNA
Parson FG et al	15.3°
Kingsley PC et al	8.02°
Kate BR et al	8.8°
Ankur Zalawadia et al	12.4°
Jain AK et al	8.9°
Siwach RC et al	13.68°
Present Study	**13.22°**

The mean FNA angle measured physically by Kingsley Olmsted (KO) method in 55 male femurs in this present study was 13.76° with Standard Deviation (SD) of 4.333 and Standard error of mean was 0.5843 Mean FNA angle in 45 Female femurs measured physically by the same method in present study was 12.56° with Standard Deviation (SD) of 3.98 and Standard error of mean was 0.5934 In the present study FNA angle of 100 femurs were also measured radiologically by taking bi-plane X-ray of the bones followed by measurement of the angle from the console by using specified tools present in the console. By radiological measurement the mean FNA angle of male and female bones were 16.4° and 14.73° with SD of 4.817 and 4.33 respectively [11]. The mean of the same angle of left and right sided bones on radiological measurement were 15.45° and 15.89° with SD of 4.154 and 5.245 respectively. The difference of angle between sex as well as for sides in radiological measurement were not statistically significant [12].

The difference in measurement of FNA angle between physical method (KO method) and radiological method (Bi-plane X-ray method) in respect to side and sex were statistically significant. Jain AK et al have obtained the mean FNA angle by X-ray as 11.5° with SD of 5.4 in their study. The mean of males by X- ray was11.5° with SD of 5.9and mean of females was 11.4° with SD of 4.7 in the study. The mean of right side was 10.6° with SD of 5.3and of left side was12.3° with SD of 5.4 by X-ray in the same study. Statistically significant difference has been found between the right side and the left side (p= 0.001), but there was no such significant difference found between the two sexes (p= 0.86) [13-14].

Conclusion

In the present study, the mean FNA angle measured Physically and Radiologically were 13.22° and 15.65° with Standard Deviation of 4.20 and 4.65 respectively. The range was from 5°-27° on physical measurement and from 6°-29° on radiological measurement. 59% bones are in the range of 11°-16° of FNA angle while measured physically. 26% bones are in 5°-10° range and 11% and 4% are in the range of 17°-22° and 23°-27° respectively. The mean FNA angle measured physically in male femurs in this present study was 13.76° with Standard Deviation (SD) of 4.333 and Standard error of mean was 0.5843 while the mean FNA angle in female femurs was 12.56° with Standard Deviation (SD) of 3.98 and Standard error of mean was 0.5934. The difference between FNA angle in respect to sex is not statistically significant.

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