

Combined Anteversion Angle in Skeletally Immature Children in a Tertiary Care Centre – A Computed Tomography Based Epidemiological Study

Dr.Gautam Mazumder¹, Dr.Lokesh Sambath², Prof .T.D.Bhattacharyya³

¹(Associate Professor, Department of Orthopaedics, Gauhati Medical College and Hospital,India)

²(Resident, Department of Orthopaedics, Gauhati Medical College and Hospital,India)

³(Professor and Head, Department of Orthopaedics, Gauhati Medical College and Hospital,India)

Corresponding Author: Dr.Lokesh Sambath

Abstract

Abnormal femoral neck anteversion (FNA) and/or acetabulum anteversion (AA) have long been implicated in the etiogenesis of hip osteoarthritis (OA), developmental dysplasia of the hip (DDH), and hip impingement. Since studies on skeletally immature children are sparse on this topic, the purpose of this study was to measure the normal values of FNA, AA and the combined anteversion (CA= FNA+ AA), comparison among genders and sides (right and left).A cross sectional study was conducted among 51 skeletally immature children belonging to the age group 1 to 15 years in GMCH from September 2018 to August 2019 using standardized 2D computed tomographic (CT) methods.The overall mean values of AA, FNA with PCA, FNA with IEA, CA with PCA and CA with IEA are 13.10, 15.25, 14.17, 28.35 and 27.27. The mean value of FNA with PCA in male children is 12.87 and in female children is 20.80 which is statistically significant with p value of 0.020 (By Levene's Test for Equality of Variances).

From this study we have concluded that Combined Anteversion (CA) angle in both adults and children are almost equal but AA and FNA was found to be different among these two groups. FNA was found to be more in children and it tends to decrease with age while AA tends to increase with age till adulthood. It shows that Combined Anteversion plays an important role in maintaining the hip stability in both children and adults. There is no significance difference between the right and left sides. Anteversion angle in females is slightly higher as compared to the male children.

Key words: Hip joint, femoral neck anteversion, acetabulum anteversion, combined anteversion angle

Date of Submission: 23-06-2020

Date of Acceptance: 11-07-2020

I. Introduction

The hip joint is one of the most complex joint of the human body which is equipped with the biomechanical attributes to perform dual functions of mobility as well as stability. The hip joint like the rest of the body undergoes a process of continuous remodeling with the growth of the child till the skeletal maturity. While the adult skeletal anthropometry has been studied extensively, the same characteristics in the paediatric skeleton has remained unexplored .Biomechanics of the hip joint grossly depends on the relation between the acetabulum and the femoral neck and head. The femoral and acetabulum anteversion is valuable in the evaluation of normal and pathological hip joint. The increased femoral anteversion angle is associated with CDH, Perthes disease, SCFE, Medical femoral torsion, apparent genu valgum, External tibial torsion, flat foot, and intoeing^{1, 2}. The decreased femoral neck anteversion has been associated with rickets, chondrodystrophy and toeing out^{3, 4}. Combined anteversion (CA) has been defined as the sum of the femoral neck anteversion (FNA) and the Acetabular anteversion (AA)⁵. The purpose of this study is to measure the normal FNA, AA and CA in skeletally immature children by using 2D Computed Tomography scan and also to assess gender variability and age wise correlation of the femoral and acetabular anteversion angle.

II. Materials And Methods

It is a single hospital based cross sectional study based on doing 2D computed tomography (CT) of pelvis with bilateral knee joints for all skeletally immature children (age 1 to 15) coming to the Radiology Department for CT abdomen for some pathology other than skeletal pathology with verbal consent from the patient party. The study period is from September 2018 to August 2019 done at Gauhati Medical College and Hospital. A total of 51 skeletally immature children were analyzed in this study of which there were 30 males and 21 females. Of the 51 skeletally immature children, a total of 102 variables (right and left) have been

included for this study. Patients with congenital malformations of the skeletal system, developmental dysplasia, and previous fractures around the pelvifemoral region, metabolic bone diseases, stunted growth, and tumor around the pelviacetabular region are excluded from this study. For keeping the authenticity and to avoid the inter observer error, all the morphometric measurements were done by a single independent person. The patients were placed in supine position with hips extended and thighs horizontal and parallel. A sequential series of 1mm thick tomographic cross sections were obtained from the acetabulum and femoral head and neck and also from the knee joints for femoral condyles. Each patient has been scanned with a PHILIPS MX 16–16 slice MDCT scanner. All the children in this study were scanned using CT scan by a standard protocol using 16 slice scanner with slice thickness of 1 mm, 120 kV, with pitch of $1(0.7552)$ and pediatric dose of 19.80 CTDI and 991.36 of DLP.

Acetabular anteversion

The tomogram through the centre of the acetabulum was selected for measurement of the Acetabular anteversion angle, which is defined as the ventral orientation of the acetabulum related to the sagittal plane of pelvis. A measuring point was assigned at the anterior edge of the acetabulum and a second at the posterior edge. The line connecting these points was drawn, and the angle formed by this line and the plane sagittal to the pelvis was determined as the Acetabular anteversion angle^{6,7}.

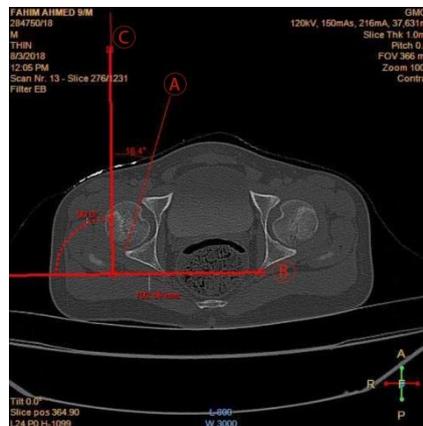


Fig 1: Measurement of acetabular anteversion angle

Femoral neck anteversion angle

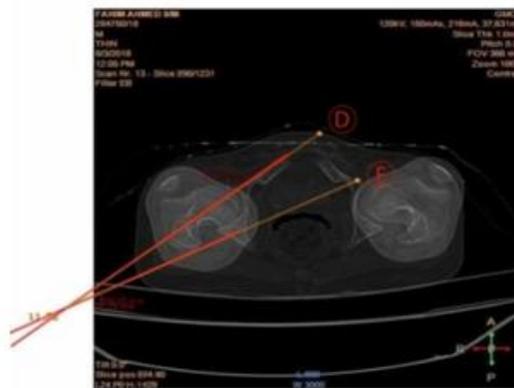
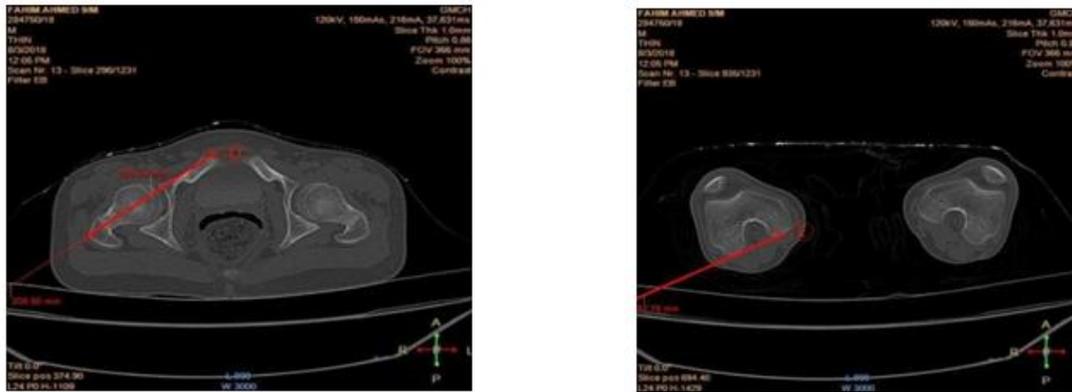
Femoral neck anteversion angle can be measured by two methods:

Method 1: by using Posterior condylar axis (PCA)

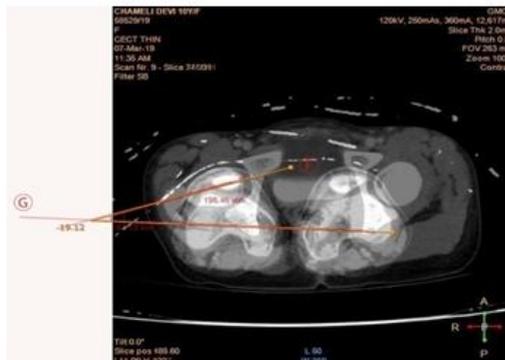
Method 2: by using Inter epicondylar axis (IEA)

Method 1: A measuring point was set in the centre of the head and projected onto the section through the middle part of the femoral neck. The centrepoint of the neck was then identified, and the line connecting the two measuring points drawn (figures 2,3,4). The angle formed by this line and the reference plane was determined as the femoral neck anteversion angle. The reference plane was determined by scanning the femur condyles, and the dorsal tangent of the condyles served as the reference plane in this method⁷.

Method 2: In this method, we used the IEA as a reference. Inter epicondylar axis is the plane that is formed between the medial and lateral epicondyle of the femur⁸ (figures 5,6,7). The femoral condyles are not accessible to permit assessment of whether the condylar axis is coincident with the coronal plane when a subject is posed in the anatomical neutral posture. As an alternative, Wu et al based the neutral rotation of the femur from the transepicondylar line in their non-orthogonal joint coordinate frame. The transepicondylar line is considered to be externally rotated relative to the coronal plane. This is due to the condylar twist angle caused by the posterior projection of the medial femoral condyle being greater than that of the lateral condyle.



Figs. 2,3,4: Measurement of FNA by Method 1



Figs. 5,6,7: Measurement of FNA by Method 2

III. Results

A total of 102 hip joints were analyzed in this study comprising of 30 male and 21 female skeletally immature children. The mean value for AA is 13.10 with SD of 4.75 median value of 12.7 and range value of 8.35 - 17.85. The mean value for FNA with PCA is 15.25 with SD of 9.08, median value of 14.06 and range value of 6.17 – 24.33. The mean value for FNA with IEA is 14.17 with SD of 8.77, median value of 12.8 and range value of 5.4 – 22.94. The mean value for CA with PCA is 28.35 with SD of 10.56, median of 27.09 and range of 17.79 – 38.91. The mean value for CA with IEA is 27.27 with SD of 9.74, median of 25.57 and range of 17.53 – 37.01.

The acetabular anteversion angle of children from age 1 to 5, 6 to 10 and 11 to 15 is 11.43, 13.36 and 13.7 respectively, FNA with PCA of children from age 1 to 5, 6 to 10 and 11 to 15 is 16.34, 14.49 and 15.36 respectively, FNA with IEA of children from age 1 to 5, 6 to 10 and 11 to 15 is 16.99, 12.76 and 14 respectively.

The mean value of AA, FNA with PCA, FNA with IEA, CA with PCA, CA with IEA in male patients are 12.06, 12.87, 11.95, 24.93, 24.02 respectively and in the female children are 14.27, 20.80, 16.65, 32.20, 30.93 respectively.

The mean value of AA ,FNA WITH PCA ,FNA WITH IEA , CA WITH PCA, CA WITH IEA on right are 13.34, 15.91, 14.58, 29.25, 27.92 respectively whereas on left are 12.85, 14.59, 13.76, 27.45, 26.61 respectively.

The mean value for the FNA with PCA was found to be 15.25 with SD of 9.08, median of 14.06 with the range of 6.17- 24.33. The mean value for the FNA with IEA was found to be 14.17 with SD of 8.77, median of 12.8 with the range of 5.4- 22.94. There is no statistically significant difference found between the two groups.

The mean value for the CA with PCA was found to be 28.35 with SD of 10.56, median of 27.09 with the range of 17.79- 38.91. The mean value for the CA with IEA was found to be 27.27 with SD of 9.74, median of 25.57 with the range of 17.53- 37.01. There is no statistically significant difference found between the two groups.

Table 1: Overall Distribution of the respondents based on AA, FNA and CA

PARAMETER	MEAN ± SD (RANGE)
ACETABULAR ANTEVERSION	13.10± 4.75(8.35- 17.85)
FNA WITH PCA	15.25±9.08(6.17- 24.33)
FNA WITH IEA	14.17±8.77(5.4- 22.94)
CA WITH PCA	28.35±10.56(17.79- 38.91)
CA WITH IEA	27.27±9.74(17.53-37.01)

Table 2: Distribution of the respondents in the age group 1 to 5 years based on AA, FNA and CA

PARAMETER	MEAN	SD	MEDIAN	RANGE
AA	11.43	3.7	11.35	7.73 -15.13
FNA WITH PCA	16.34	11.9	13.36	4.44-28.24
FNA WITH IEA	16.99	10.87	13.75	6.12-27.86
CA WITH PCA	27.77	14.24	23.96	13.53-42.01
CA WITH IEA	28.42	13.01	26.95	15.41-41.43

Table 3: Distribution of the respondents in the age group 6 to 10years based on AA, FNA and CA

PARAMETER	MEAN	SD	MEDIAN	RANGE
AA	13.36	3.55	12.5	9.81-16.91
FNA WITH PCA	14.49	8.56	11.85	5.93-23.05
FNA WITH IEA	12.76	7.75	10.82	5.01-20.51
CA WITH PCA	27.86	9.02	27.46	18.84-36.88
CA WITH IEA	26.09	8.05	25.21	18.04-34.14

Table 4: Distribution of the respondents in the age group 11 to 15 years based on AA, FNA and CA

PARAMETER	MEAN	SD	MEDIAN	RANGE
AA	13.7	5.93	13.15	7.77-19.63
FNA WITH PCA	15.36	7.92	16.38	7.44-23.28
FNA WITH IEA	14.0	8.28	14.52	5.72-22.28
CA WITH PCA	29.10	9.77	27.92	19.33-38.87
CA WITH IEA	27.74	9.28	25.62	18.46-37.02

Table 5: Distribution of male respondents based on AA, FNA and CA

PARAMETERS	MEAN	SD	MEDIAN	RANGE
ACETABULAR ANTEVERSION	12.06	3.70	12.4	8.36-15.76
FNA WITH PCA	12.87	7.62	11.65	5.25-20.49
FNA WITH IEA	11.95	7.74	11.43	4.21-19.69
CA WITH PCA	24.93	7.06	24.87	17.87-31.99
CA WITH IEA	24.02	6.98	22.16	17.04-31.00

Table 6: Distribution of female respondents based on AA, FNA and CA.

PARAMETERS	MEAN	SD	MEDIAN	RANGE
ACETABULAR ANTEVERSION	14.27	5.52	13.05	8.75 -19.79
FNA WITH PCA	20.80	9.89	20.34	10.91-30.69
FNA WITH IEA	16.65	9.26	16.55	7.39-25.91
CA WITH PCA	32.20	12.44	32.86	19.76-44.64
CA WITH IEA	30.90	11.09	31.86	19.84-42.02

Table 7: Comparison of mean values between male and female based on AA, FNA and CA.

PARAMETER	MALE	FEMALE	P VALUE*
ACETABULAR ANTEVERSION	12.06	14.27	0.142
FNA WITH PCA	12.87	20.80	0.020
FNA WITH IEA	11.95	16.65	0.486
CA WITH PCA	24.93	32.20	0.000
CA WITH IEA	24.02	30.93	0.000

*Levene's Test for Equality of Variances

Table 8: Comparison of mean values between right and left side based on AA, FNA and CA.

PARAMETER	RIGHT	LEFT	P VALUE
ACETABULAR ANTEVERSION	13.34	12.85	0.604
FNA WITH PCA	15.91	14.59	0.467
FNA WITH IEA	14.58	13.76	0.640
CA WITH PCA	29.25	27.45	0.390
CA WITH IEA	27.92	26.61	0.499

Table 9: Comparison of FNA with PCA and FNA with IEA

PARAMETER	FNA WITH PCA	FNA WITH IEA
MEAN	15.25	14.17
SD	9.08	8.77
MEDIAN	14.06	12.8
ST ERROR OF MEAN	0.89	0.86
RANGE	6.17- 24.33	5.4- 22.94
P VALUE	0.534	

Table 10: Comparison of CA with PCA and CA with IEA

PARAMETER	CA WITH PCA	CA WITH IEA
MEAN	28.35	27.27
SD	10.56	9.74
MEDIAN	27.09	25.57
ST ERROR OF MEAN	1.04	0.96
RANGE	17.79- 38.91	17.53- 37.01

IV. Discussion

The morphology of the hip joint has always interested the orthopedic community. Although numerous studies have focused on FNA in the normal population, relatively little attention has been given to the normal AA and the CA. This may be due to the relatively complex anatomy of the pelvis and lack of unanimity in defining a reference plane. Most of the available data on this topic is from studies of normal adult populations, whereas studies on the skeletally immature children are sparse. Although three recent Indian studies discuss the normal FNA, to the best of our knowledge, no previous study has correlated the FNA, AA and the CA in normal skeletally immature children and their comparison with adult population.

Table 11: Comparison of mean values of AA, FNA and CA between children (our study) and adults (previous studies).

PARAMETERS	MEAN VALUE OF CHILDREN IN OUR STUDY	MEAN VALUE OF ADULTS FROM THE PREVIOUS STUDY ⁹
AA	13.10	19.1
FNA	15.25	8
CA	28.35	27.1

Though there is a variation found in AA and FNA between adults and children but the CA was found to be almost similar in adults as well as in children. The AA is low and FNA with PCA is high in children when compared to the adults. Thus the hip stability may be maintained by having a constant CA value in both adults and children. So any increase in the FNA may compensate by decrease in the AA for the fixed Combined Anteversion to maintain hip stability in both normal adults and children.

The mean value of FNA with PCA in male patients is 12.87 and in the female patients is 17.93 with p value of 0.020. Statistical analysis using Levene’s Test for Equality of Variances revealed significant ($p < 0.020$) greater average anteversion in female children as compared to the male children, which is similar to the study done by Dr. Ankur Zalawadia et al., where they have got 2.7° more anteversion in female compared to the male femora¹⁰.

The mean value of FNA on the right side is 15.9 and on the left is 14.59. Statistical analysis using Levene’s Test for Equality of Variances revealed no significance ($p = 0.467$) in femoral neck anteversion between right and left.

The mean value of AA on the right side and left side are 13.34 and 12.85 respectively with p value of 0.604. The mean value of AA for male and female patients are 12.06 and 14.27 respectively with p value of 0.142 as has been shown in Tables 7 and 8. It is shown that there is no significant relation between the sex and also on the sides (right and left).

Mean angle of FNA with PCA and FNA with IEA are 15.25 and 14.17 respectively with SD of 9.08 and 8.77. Statistical analysis using Levene’s Test for Equality of Variances revealed insignificant p-value (0.534) between the FNA with PCA and FNA with IEA.

V. Conclusion

From this study we have concluded that Combined Anteversion angle in both adults and children are almost equal but AA and FNA was found to be different among these two groups. FNA was found to be more in children and it tends to decrease with age while AA tends to increase with age till adulthood. It shows that Combined Anteversion plays an important role in maintaining the hip stability in both children and adults. However there is no significant difference in mean angles of AA, FNA and CA between the right and left sides. It proves that the anteversion angle of femur and acetabulum found to be symmetrical on both sides. While comparing the gender, anteversion of femur and acetabulum was found to be more in the female than male children. Significant difference is seen in FNA with PCA, CA with PCA and CA with IEA in relation to gender. So gender seems to be an important factor in influencing these angles. Regarding the FNA by 2 methods (PCA and IEA), there is no significant difference between these 2 methods. Either of these methods can be used to measure the femoral neck anteversion.

VI. Limitations of the Study

Limitations of this study are that the study group is small, considering the radiation exposure to the relative age group. To reduce the unwanted radiation exposure, the children who were undergoing CT abdomen, slices were extended only till the required range. Moreover, this study had the unequal distribution of gender which may affect the comparison of values. Hence, for the homogeneity, further observational studies involving multiple examiners with a larger number of patients are needed.

References

- [1]. Upadhyay SS, Burwell RG, Moulton A, Small PG Wallace WA. Femoral anteversion in healthy children: application of a new method using ultrasound. *J Anat* 1987;169 : 49-61.
- [2]. Kirby AS, Willace WA, Moulton A and Burwell RG. Comparison of four methods for measuring femoral anteversion. *Clinical Anatomy* 1993; 6 :280-288.
- [3]. Morscher E. Development and clinical significance of the anteversion of the femoral neck. *Reconstr. Surg. Traumat.*,1967, 9:107-125.
- [4]. Jani L. Idiopathic anteversion of femoral neck. Follow up study of 51 patients on completion of growth. *Int. Orthop.(SICOT)*, 1979, 2:283-292.
- [5]. Kingsley PC, Olmsted KL, authors. A study to determine the angle of anteversion of the neck of femur. *J Bone Joint Surg Am.* 1948;30:745–51. [PubMed]
- [6]. Reikerås O, Bjerkreim I, Kolbenstvedt A, authors. Anteversion of the acetabulum and femoral neck in normals and in patients with osteoarthritis of the hip. *Acta Orthop Scand.* 1983;54:18–23. [PubMed]

- [7]. Anteversion of the Acetabulum and Femoral Neck in Normals and in Patients with Osteoarthritis of the Hip Olav Reikerås, Ingjald Bjerkreim & Alf Kolbenstvedt. *Journal Acta Orthopaedica Scandinavica* Volume 54, 1983 - Issue 1
- [8]. Panya Luksanapruksa MD, Vatanachai Rojvanit MD, Sanyapong Sanpakit MD. Axial Radiography of the Normal Distal Femur for Assessment of Rotational Alignment in Thai. *J Med Assoc Thai* 2012; 95 (4): 526-31.
- [9]. AV Maheshwari, AK Jain, MP Singh, SK Bhargava. Estimation of femoral neck anteversion in adults - A comparison between peroperative, clinical and biplane X-rays methods. *Indian Journal of Orthopaedics*. July 2004 Volume 38 : Number 3 : P. 151-157.
- [10]. Dr. Ankur Zalawadia, Dr. Srushti Ruparelia, Dr. Shaival Shah, Dr. Dhara Parekh, Dr. Shailesh Patel, Dr. S. P. Rathod, Dr. S. V. Patel. Study Of Femoral Neck Anteversion Of Adult Dry Femora In Gujarat Region. *NJIRM* 2010; Vol. 1(3). July-Sept.

Dr.Lokesh Sambath, et. al. "Combined Anteversion Angle in Skeletally Immature Children in a Tertiary Care Centre – A Computed Tomography Based Epidemiological Study." *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*, 19(7), 2020, pp. 05-11.