Research Article

Femoral neck anteversion & hip rotation range in healthy Iraqi children: A clinical anatomical study

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Abstract

Background: Femoral neck anteversion (FNA) is a physiological torsion of the femur that plays an important role in the stability & function of the hip joint and has a great impact on the rotational movements of the limb. Abnormal development of the FNA may be associated with a number of orthopaedic problems affecting the hip joint & gait ranging from in-toeing gait to disabling osteoarthritis. The assessment of the angle is therefore important in assessing such problems & determining the best course of action in their management.

Aims: this study aims at measuring the FNA angle in healthy Iraqi children & examining its impact on hip rotational movements at different age groups.

Patients and Methods: thirty-six healthy Iraqi male children divided into 3 age groups were examined clinically for the range of hip rotation & were then subjected to X-ray estimation of the FNA angle of their hips using Ogata's Biplanar method.

Results: all the children had FNA angles & hip rotational movements within the normal range for their age with a significant regression in FNA angle with increasing age that may be related to muscular torsional forces applied to growing epiphyses. The FNA angle was inversely proportional to lateral rotation of the hip but directly proportional to medial rotation. Sides to side differences were noticed in tested subjects and were statistically significant in the (8-9 years) age group.

Conclusions: the understanding of the normal femoral neck anteversion is essential to properly reassure and educate families, in addition to identify more serious underlying structural problems that may exist.

Keywords: Femoral neck anteversion-Hip joint rotation- Biplanar X-ray

INTRODUCTION

The femoral neck anteversion (FNA) is the inclination of the axis of the femoral neck with reference to the knee axis projected on a plane perpendicular to the shaft axis [(1)]. A line passing through the center 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 [(2)]. The femoral torsion is thought to result from medial rotation of the lower limb bud in early intrauterine life [(3)] and becomes identifiable at 7

weeks of gestation [4]. On the average, FNA ranges from 30°- 40° at birth and decreases progressively throughout growth [5] at a mean rate of 1.5° per year until about 15 years of age [6]. In adults, clinicians accept an FNA angle range of 10°-30°[7] but individual variations are documented and may be related to racial differences[8], sex (being a little less in men) [9], bone remodeling due to torsional muscular forces [10] and habitual sleeping & sitting postures[11]. Abnormal FNA can be associated with many clinical problems ranging from harmless in-toeing gait in early childhood to disabling osteoarthritis of the hip & knee in adults [1]. Determining the anteversion angle & hip rotational range is crucial for the diagnosis & therapeutic planning of patients with various pathologies such as hip development dysplasia, Perthe's disease, cerebral palsy, varum thigh & in-toeing gait [12].

The aim of this study is to examine the correlation of the FNA angle measured in healthy Iraqi children against the expected angle for their age with hip rotation range

PATIENTS AND METHODS

Thirty-six Iraqi male children aged 6-11 years with no previous hip pathology were randomly selected from the outpatient clinic at Al-Yarmouk teaching hospital to participate in randomized control study after their parental consent. All the children were within the normal percentile of weight & height for their age. The children were divided into 3 age groups: 6-7, 8-9 and 10-11 years, with 12 children in each group. For each child, X-rays of each hip joint were taken to measure the FNA angle using a biplanar radiological method and the child was then examined clinically to determine the range of hip medial & lateral rotation.

Measurement of the FNA angle using a biplanar X-ray method: Ogata's method for biplanar X-ray FNA measurement was used [13]. Two views were taken for each hip; anteroposterior (AP) & lateral views, with the X-ray tube centered over the femoral neck & the X-ray beam perpendicular to the table with the child in supine position. The AP view was taken with the knees flexed to 90° over the edge of the table, bringing the knee (transcondylar) axis into the horizontal plane. The true lateral view was taken with the hip & knee flexed 90 ° and the hip rotated laterally so that the entire lateral aspect of the leg contacts the horizontal aspect of the table, thus bringing the knee axis to the vertical plane. The projected cervicofemoral angles were measured on the two views with a regular protractor. The true angle of anteversion was then calculated using the formula:

$$\tan\theta = \frac{\tan\alpha}{\tan\beta}$$, where:

θ is the true anteversion angle corrected for X-ray projection, **α** is the angle measured in the AP view and **β** is the angle measured in the lateral view. The results were compared to the expected FNA angle (eFNA) according to Svenningsen *et al* [6].

Measurement of the range of hip rotation: This was performed using long-arms 180° goniometer (King Life Tech. Co., Ltd. ®, Taiwan). The child was placed prone in underclothes with the knee flexed to a right angle & the pelvis was stabilized by the examiner's hand to prevent pelvic rotation, aiming to measure the passive (in order to increase the range of motion) medial & lateral rotation of the hip. The results were then compared to the expected range of hip rotation for age according to Whittle [14].

RESULTS

FNA angles measured radiologically (mFNA) fell within the expected normal range (eFNA) for all children for both sides with a significant decrease with increasing age (Table 1 & 2). The range values of medial & lateral rotation of the hip measured clinically (mMR,mLR) were also within expected normal range (eMR, eLR) for each age group. The range of medial rotation showed a positive correlation with the degree of FNA angle while the range of lateral rotation was inversely proportional to the angle. As the FNA angles decreases with age, the correspondent decrease in medial rotation was met by an increase in lateral rotation.

There was an asymmetry in the values of measured FNA angles & hip rotation movements between the right & left sides for each child. The asymmetry of the angle was statistically significant only in the (8-9 years) age group. However, the range of hip rotational movement in this group & other groups between the two sides was not statistically significant (Fig.1)

Table 1. The measurements of the FNA angle (mFNA), medial rotation (mMR) and lateral rotation (mLR) of the right hips of Iraqi healthy children compared to the expected values (eFNA, eMR, eLR). Measured values presented as mean ± standard deviation.

Age group (years)	eFNA (degrees)	mFNA (degrees)	eMR (degrees)	mMR (degrees)	eLR (degrees)	mLR (degrees)
6 - 7	21-29.5	24±3.4	31-67	46±5.2	30-70	40±3.1
8 - 9	18-26.5	21±1.1	33-68	42±6.6	28-65	42±5.3
10 - 11	15-23.5	19±1.9	35-68	40±4.1	26-63	43±3.7

Table 2. The measurements of the FNA angle (mFNA), medial rotation (mMR) and lateral rotation (mLR) of the left hips of Iraqi healthy children compared to the expected values (eFNA, eMR, eLR). Measured values presented as mean ± standard deviation.

Age group (years)	eFNA (degrees)	mFNA (degrees)	eMR (degrees)	mMR (degrees)	eLR (degrees)	mLR (degrees)
6 - 7	21-29.5	26±1.2	31-67	45±6.1	30-70	41±2.2
8 - 9	18-26.5	25±3.8	33-68	42±3.3	28-65	43±5.2
10 - 11	15-23.5	20±1.7	35-68	41±3.6	26-63	44±4.1

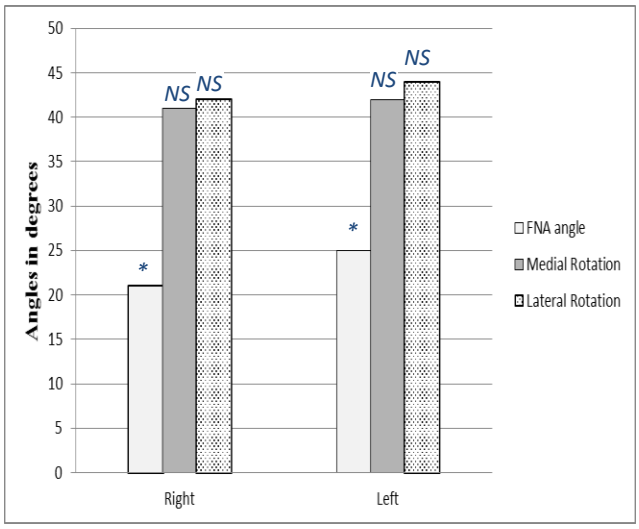

Figure 1. Right to left differences in measured femoral neck anteversion angle & rotational hip movements of healthy Iraqi children aged 8-9 years. Values presented as mean ± standard deviation. (*= statistically significant, NS= statistically not significant).

DISCUSSION

The age-related regression of the femoral neck anteversion measured in the tested children can be attributed to local muscle forces applied to the epiphyseal growth plate. According to the Heuter-Volkmann Law of epiphyseal pressure, increases in pressure across the epiphysis will decrease its growth, whereas decreases in pressure will increase its rate of growth [15]. Dynamic forces applied to the proximal femoral epiphyseal plate (e.g. increasing child weight with increasing growth) will decrease the angle by a process of bone resorption & bone reapposition [16]. Muscles, by either their elastic connective tissue or their contractile power, contribute to the greatest stress on bones [17].

FNA angle is clinically correlated to medial & lateral hip rotation [18].Individuals with higher FNA angles tend to have more medial & less lateral rotation of the hip [19]. Anatomically, a trade-off in medial & lateral rotation of the hip appears to occur. As one rotational movement increases, the other usually decreases so that the total hip motion remains equal [2].

Bilateral differences in femoral anteversion & hip movements have been documented in several studies [2, 12, 20]. This 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 [21]. The resulting higher muscular tones may affect the FNA 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 FNA angle [2]. In our society, the people are accustomed to floor level activities (e.g. squatting) with increased lateral hip rotation that inversely affects the FNA angle. The presence of higher FNA angle values on the left side in tested children suggests a right lower limb sidedness with increased muscle tone & probably a floor level postural habit bringing the left hip to medial rotation more than the right. The lack of statistical significance between the ranges of hip rotation between the two sides may be ascribed to compensational changes in the soft tissue surrounding the hip, shortening the joint capsule & surrounding muscles on one side and lengthening them on the other side. Therefore femoral torsion deformity did not result, since such deformity will only exist if an abnormal FNA angle causes one direction of rotation to exceed the opposite direction by more than 30° [22].

Conclusion

Physiological femoral neck anteversion (FNA) may be implicated in the pathogenesis of many orthopaedic conditions, like; in-toeing gait, hip developmental dysplasia, hip impingement & osteoarthritis. Such rotational variations can be found in healthy Iraqi children especially those younger than 10 years, in spite of its physical appearance, spontaneous resolution is expected.

So understanding of the normal femoral neck anteversion is essential to properly reassure and educate families, in addition to identify more serious underlying structural problems that may exist.

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