Original Article

Factors Related to Improvement of Excessive Femoral Antetorsion of The Hips in Children

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Background: In most patients with excessive femoral antetorsion, the condition is self-limiting and follows a benign clinical course. However, when the condition persists into adulthood, it can cause many problems.

Objective: This study aimed to identify factors associated with improvement of excessive femoral antetorsion.

Materials and Methods: A retrospective study was conducted of patients aged 3 to 5 years old who presented with intoeing gait due to excessive femoral antetorsion between 1 January 2007 and 31 December 2016. Medical charts were reviewed for age, gender, weight, height, body mass index [BMI], rotational profiles, Beighton hypermobility score, and treatment modalities. Univariate and multivariate logistic regression analysis were used to evaluate the association of factors potentially related to internal rotation of the hips.

Results: Sixty-three patients aged 3 to 5 years old who presented with intoeing gait due to excessive femoral antetorsion were retrospectively evaluated. Mean age at first visit was 3.5±0.5 years. At the first visit, the average internal rotation of the left and right hips at first visit were 76.5±8.8 and 75.2±9.7 degrees, respectively. The mean age at last follow-up was 5.4±1.0 years, at which time the average internal rotation of the left and right hips were 68.2±7.5 and 68.2±7.5 degrees, respectively. Internal rotation of the hips tended to decrease according to time. Univariate analysis found that age, gender, and body weight were significantly related to internal rotation of the hip. In a multivariate model, increased body weight was found to be correlated with significantly decreased internal rotation of both hips. On average, females tended to have more internal rotation of the right hip than the left hip.

Conclusion: Internal rotation of the hips tends to decrease according to time. Choice of treatment has no significant effect on femoral antetorsion improvement. Higher body weight is related to lower internal rotation of the hips, while females tend to have more internal rotation of the right hip.

Keywords: Excessive femoral anteversion, Intoeing, Children's hips

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Intoeing gait is a commonly encountered problem in pediatric orthopedics. Its etiology is multifactorial and varies with the age of the patients. In children aged between 3 and 10 years, excessive femoral neck antetorsion is known to be the leading cause of intoeing[1-3]. Parents may mention abnormal gait pattern, frequent tripping, hip and knee pain, and, most importantly, "W-sitting". Physical examination usually reveals excessive internal rotation and limited external rotation of the hips.

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Excessive femoral neck antetorsion mostly improves over time as the child grows[1-3]. However, in some patients, the pathology may persist into adulthood. Persistence of excessive femoral antetorsion may lead to lower limb deformity, knee pain from compensatory external tibial torsion, and a possible increased future risk of osteoarthritis of the hip and knee joints[4-7].

To date, there are no evidence-based recommendations for managing excessive femoral neck antetorsion. Treatment usually begins with observation

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and serial follow-up of the magnitude of the pathology[8,9]. Some authors recommended avoidance of w-sitting as a means of preventing progression of the deformity[10,11], while others believe that the patients do not need any treatment and that the deformity will spontaneously resolve over time[1,2].

At our institute, patients were advised to abstain from "W-sitting" the position in which the hips are internally rotated. Some patients were also enrolled in a program of hip external rotation stretching exercises.

This study aimed to evaluate factors involved in the recovery of excessive femoral antetorsion in children.

Materials and Methods

After receiving approval from the institutional ethics committee, a retrospective study was conducted at our institute. The study included all patients aged below 5 years who presented with intoeing gait due to excessive femoral antetorsion between 1 January 2007 and 31 December 2016. The patients included in this study had hip internal rotation of more than 60 degrees in males and 65 degrees in female. Patients with previous lower extremity fractures, tumors, or neuromuscular disorders were excluded from the study. Baseline characteristics of the patients were collected, including age at first visit, gender, weight, height, body mass index [BMI], rotational profiles at first visit, including hip internal rotation, hip external rotation, thigh foot angle, heel bisector line, and foot progression angle, Beighton hypermobility score, and treatment modalities, i.e., observation, W-sitting avoidance, hip external rotation stretching exercises.

Data on the variables of interest were collected at all subsequent visits of each patient. Recorded variables include age at each visit, weight, height, BMI, rotational profiles, Beighton hypermobility score, and treatment modalities. Each factor was evaluated exclusively to determine a possible impact on disease progression.

Statistical analyses were performed using Stata version 12.0 (StataCorp, College Station, Texas, USA). Continuous data were analyzed using mean and standard deviation (SD). Categorical data were analyzed using proportion and percentage.

One-way analysis of variance [ANOVA] was used to compare means of continuous variables from multiple visits. Univariate and multivariate regression analysis were used to evaluate the association of each variable to the progression or improvement of the pathology according to time. Potentially associated factors with a p-value <0.1 were added to the multiple regression model. Correlations with a p-value <0.05 were considered as statistically significant.

The sample size, 34, was estimated based on multiple linear regression analysis using Stata version 15.0, StataCorp, College Station, Texas, USA. The calculation was based on an alpha error of 0.05, a beta error of 0.2, a mean femoral anteversion at first visit of 75 degrees, a mean femoral anteversion at subsequent visits of 70 degrees, an SD of femoral anteversion of 10, a total of 5 follow-up visits 5, a squared partial correlation of 0.3, and a total of 4 variables.

Results

Sixty-three patients aged between 3 to 5 years who presented with intoeing gait due to excessive femoral antetorsion were included in this study. Forty percent of the patients were male. The mean age at first visit was 3.5±0.5 years. The average internal rotation of the left and right hip at first visit were 76.5±8.8 and 75.2±9.7 degrees, respectively. Other baseline characteristics are shown in Table 1. The average age at last follow-up was 5.4±1.0 years. The average internal rotation of the left and right hip at last visit were 68.2±7.5 and 68.2±7.5 degrees, respectively (Table 2). Internal rotation of the hips tended to decrease over time.

Univariate logistic regression analysis identified factors significantly related to changes of internal rotation of the hips including age of the patient, gender, and body weight. When the age of the patient increased by 1 year, for every additional one year in the age of the patient, the internal rotation of the hips

Table 1. Demographic data

Variables	n = 63
Male (n (%))	25 (39.7)
Age (mean years ± SD)	3.5±0.5
Weight (mean kg ± SD)	15.1±3.0
Height (mean cm ± SD)	98.6±6.1
BMI (mean kg/m^2 ± SD)	15.8±2.6
LIR (mean degrees ± SD)	76.5±8.8
RIR (mean degrees ± SD)	75.2±9.7
LER (mean degrees ± SD)	40.8±7.8
RER (mean degrees ± SD)	41.1±7.5

n = number of participants; SD = standard deviation; kg = kilogram; cm = centimeter; BMI = body mass index; m = meter; LIR = left hip internal rotation; RIR = right hip internal rotation; LER = left hip external rotation; RER = right hip external rotation

Table 2. Distribution of variables by time

Variables	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5	*p*-value
Age (mean year ± SD)	3.5±0.5*	4.0±0.6*	4.4±0.6*	5.0±0.8*	5.4±1.0*	<0.0001
Weight (mean kg ± SD)	15.1±3.0	16.0±3.4	17.0±4.2	17.7±4.3	18.0±3.9	<0.0001
Height (mean cm ± SD)	98.6±6.0	101.2±7.5	105.0±7.5*	106.8±6.9*	110.9±7.0*	<0.0001
BMI (mean kg/m^2 ± SD)	15.8±2.6	15.6±2.5	15.1±2.9	15.6±2.7	15.4±2.6	0.6309
LIR (mean degrees ± SD)	76.5±8.8	73.3±9.2	71.4±8.7	69.4±7.8*	68.2±7.5*	0.0006
RIR (mean degrees ± SD)	75.2±9.7	73.3±9.0	72.0±8.5	69.5±7.6	68.2±7.5	0.0105
LER (mean degrees ± SD)	40.8±7.8	41.6±8.3	41.8±9.7	42.5±9.2	42.7±6.0	0.8604
RER (mean degrees ± SD)	41.1±7.5	41.8±9.2	42.7±10.6	43.5±8.0	42.0±7.2	0.8263

*p-value <0.05 when compare to the first visit
SD = standard deviation; kg = kilogram; cm = centimeter; m = meter; LIR = left hip internal rotation; RIR = right hip internal rotation; LER = left hip external rotation; RER = right hip external rotation

Table 3. Univariate analysis

Variables	Coefficient	S.E.	*p*-value	95% CI
LIR				
Age	-1.5	0.9	0.080	-3.3, 0.2
Gender	2.3	1.2	0.049	0.0, 4.64
Body weight	-0.5	0.2	0.007	-0.8, -0.1
Height	-0.2	0.1	0.104	-0.42, 0.0
Treatment	1.0	1.2	0.402	-1.34, 3.3
RIR				
Age	-0.2	0.9	0.019	-3.8, -0.3
Gender	3.6	1.2	0.003	1.3, 5.9
Body weight	-0.6	0.2	0.001	-0.9, -0.2
Height	-0.1	0.1	0.44	-0.3, 0.1
Treatment	0.7	1.2	0.548	-1.6, 3.1

* SE = standard error; CI = confidence interval; LIR = left hip internal rotation; RIR = right hip internal rotation

decreased by 1.5 and 0.2 degrees for the left and right hip, respectively. Female patients were 2.3 times more likely to have excessive femoral antetorsion (p-value = 0.049). Moreover, at subsequent follow-up visits, internal rotation of the hips was decreased by 0.5 degrees for every additional 1 kilogram of body weight. Height, BMI, and choice of treatment were not significantly related to improvement or progression of excessive femoral antetorsion (Table 3).

Three significant factors in the univariate model (age, gender, and body weight) were added to the multivariate analysis. After adjusting for age, increase in body weight was significantly corelated with reduced internal rotation of both left and right hips, p-value = 0.036 and 0.014, respectively. Female gender was significantly correlated with increased internal rotation of the right hip, p-value = 0.002 (Table 4).

Discussion

Excessive femoral neck antetorsion is the leading cause of intoeing gait in children aged 3 to 10 years[1-3]. The diagnosis is made when hip internal rotation exceeds 60 degrees in males and 65 degrees in females[1,2]. Previous studies have reported that the amount of hip internal rotation improves with the child's growth. The most rapid change in hip internal rotation occurs between the age of 3 to 5 years, and excessive femoral neck antetorsion is usually resolved by age 7[8]. The exact mechanism of this improvement is not yet known.

In cases where excessive femoral antetorsion

Table 4. Multivariate analysis

Variables	Coefficient	SE	*p*-value	95% CI
LIR				
Age	-0.6	1.1	0.617	(-2.8, 1.6)
Gender	2.1	1.3	0.112	(-0.5, 4.6)
Body weight	-0.4	0.2	0.036	(-0.8, 0.0)
RIR				
Age	-1.0	1.1	0.367	(-3.1, 1.2)
Gender	4.0	1.3	0.002	(1.4, 6.4)
Body weight	-0.5	0.2	0.014	(-0.8, -0.1)

* SE = standard error; CI = confidence interval; LIR = left hip internal rotation; RIR = right hip internal rotation

persists, it can cause symptomatic anterior knee pain, tripping, and disturbances with sports performance[12]. In some patients, the symptoms can be explained as "miserable malalignment syndrome", where the tibia externally rotates to compensate with the intoed gait[13]. The cause of knee pain and tripping in many patients, otherwise, could not be clearly elucidated. The persistence of excessive antetorsion may also increase the risk of osteoarthritis in the hip and knee[2,13], although a large osteological cadaveric study found no association between hip and knee arthritis and increased femoral anteversion[7].

In this study, the degree of hip internal rotation decreased with growth from age 3 to 5 years, comparable to results reported in previous studies[1,2]. A previous cadaveric study found significant differences in tibial torsion and femoral anteversion between African Americans and whites[7]. This suggests that the degree of femoral antetorsion and its natural history may vary with races may have a genetic component.

Multivariate regression analysis, after adjusting for age, increase in body weight was significantly correlated with decreased hip internal rotation in both hips. Females tended to have more internal rotation of the right hip than the left.

Regarding treatment, observation has been previously recommended as excessive femoral antetorsion It has been observed that excessive femoral antetorsion is usually benign and self-limiting[1-3]. Many non-surgical modalities have been utilized with varying results. In a systematic review, gait plates, physiologically standardized shoes, and orthotic devices with gate plate extension have led to significant improvement in intoed gait pattern[14-17]; on the other hand, other devices such as shoe wedges, torqheels, and leather counter splints was have been reported to be ineffective in correcting intoeing gait[14,18]. However, those results are based on limited evidence and the study designs are of variable quality. Most of those studies enrolled patients with complaints of intoeing gait without specifying the etiology of each case, e.g., metatarsus adductus, internal tibial torsion, and excessive femoral neck antetorsion. Thus, the reports on those modalities should be viewed with caution. In cases where excessive femoral antetorsion persists into adulthood and becomes symptomatic, surgical treatment may be indicated[13]. Corrective femoral derotational osteotomy has been shown to significantly reduce tripping, falling, and hip pain and to improve points in and improve specific areas identified by the International Knee Documentation Committee-9[12,19].

At our institution, patients are either advised to abstain from "W-sitting" or are prescribed a program of hip external rotation stretching exercises. The authors believe that "W-sitting" is a position in which the hip is internally rotated, assuming the position pathology in excessive femoral neck antetorsion which could possibly lead to delayed resolution or persistence of the problem into adolescence. Conversely, hip external rotation stretching exercises place the hip in a posture opposite to that pathological position. The authors formerly postulated that this modality hastens improvement in excess hip internal rotation. However, this study found both avoidance of "W-sitting" and hip external rotation exercises to be insignificant in the course of resolution of the problem of excessive femoral anteversion.

One limitation of this study is that none of the treatment modalities used with these patients were controlled and compliance could not be guaranteed. This study is also limited by its retrospective design and by the small study population. Several factors specify factors could be more meticulously controlled and improved details needed. Future prospective studies should include a larger population with a standardized examination protocol and close monitoring of compliance to treatment regimens.

Conclusion

Internal rotation of the hips tends to decrease over time. Choice of treatment has no significant effect on femoral antetorsion improvement. Patients with higher body weight related to decreasing of internal rotation of the hips, while females tend to have more internal rotation of the right hip. Additional prospective studies are needed to identify strong risk factors and effective treatment modalities to aid disease resolution.

What is already known on this topic?

Excessive femoral antetorsion is usually self-limiting and follows a benign clinical course. When the condition persists into adulthood, however, it can lead to problems such as hip and knee pain. It is as yet not known which factors are linked to either persistence or resolution of excessive femoral antetorsion.

What this study adds?

Identification of factors associated with a good or poor clinical course of excessive femoral antetorsion could help in identifying cases with the possibility of persistence which have a high likelihood of persisting into adulthood. Identification of those factors could lead to early identification of cases at risk of having problematic symptoms in the future. Early treatment, close monitoring, and family counseling could be done accordingly. This study provides some suggestions for future research to identify those factors.

Potential conflicts of interest

The authors declare no conflict of interest.

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