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IDIOPATHIC INCREASED ANTEVERSION OF THE FEMORAL NECK

Radiological and Clinical Study in Non-operated and Operated Patients

OLAV REIKERÅS & INGJALD BJERKREIM

Sophies Minde Orthopaedic Hospital, University of Oslo, Norway

The development of femoral neck angles in children with idiopathic increased anteversion was investigated. The anteversion (AV) angle in 16 non-operated patients (n = 32) decreased from a mean of 45 degrees at the age of 7.3 years (median) to 31 degrees at the age of 15.7 years. The neckshaft (CCD) angle remained unchanged.
A subtrochanteric derotational osteotomy was performed in 24 patients (n = 48) aged 7.7 years (median). The AV angle was corrected from 47 to 3 degrees, and the CCD angle from 134 to 124 degrees. At follow-up at the age of 16.5 years the AV and the CCD angles had increased to 14 and 135 degrees respectively.
The internal rotation of the hip was increased to the same extent in the two patient groups. The degree of external rotation as well as total rotation was significantly larger in the non-operated patients compared to the patients who needed an operation.
At follow-up the rotational movements of the hip and the external torsion of the leg/foot were measured and compared with the corresponding measurements for a control group of 26 healthy subjects whose median age was 16.3 years. In the non-operated patients the internal rotation was reduced at a rate corresponding to the spontaneous reduction of the femoral anteversion, while the external rotation was unchanged. In the operated patients the rotational movements were normalized, as was the anteversion of the femoral neck. No differences in external torsion of the leg/foot were found in the three groups.
Based on these results we conclude that cases of idiopathic increased anteversion of the femoral neck are not corrected spontaneously as the child grows up. With a subtrochanteric derotational osteotomy slight overcorrection may be indicated, but simultaneous varus correction of the femoral neck seems to be unnecessary.
The degree of external rotation of the hip determines gait symptoms in patients with increased femoral anteversion. No regular compensatory external torsion of the leg/foot develops during growth.

Key words: angle; femur neck; hip; leg; osteotomy; rotation of joint; torsion

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Increased anteversion of the femoral neck is regularly found in congenital dislocation of the hip (CDH) (Fabry et al. 1973, Bjerkreim 1974). Morscher (1956) has labelled increased anteversion of the femoral neck without known cause, idiopathic. Getz (1955) and Alvik (1960), on the other hand, interpreted idiopathic increased anteversion as a manifestation of CDH.

The condition clinically appears as increased internal and reduced external rotation of the hip. In such cases it is necessary to rotate the extremity inward to centre the femoral head in the

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acetabulum. For this reason the individuals walk with their legs turned in, their gait is stumbling, and they often complain of fatigue. Clinical experience has shown that severe "toeing-in" may lead to compensatory external torsion of the leg.

The purpose of the present study of patients with idiopathic increased anteversion of the femoral neck was:

1. To evaluate the results of corrective osteotomy in relation to the natural development of the femoral neck angles.
2. To compare hip rotation and torsion of the leg and foot in non-operated and operated patients.

Figure 1. Radiogram of hip joints with idiopathic increased anteversion of the femoral neck. Derotational osteotomy performed at the subtrochanteric region on the right side.

PATIENTS AND METHODS

From 1969 to 1973, 40 patients, 31 girls and nine boys, were admitted to Sophies Minde Orthopaedic Hospital because of idiopathic increased anteversion of the femoral neck. All of them revealed a disturbed gait due to "toeing-in" and stumbling, and complained of fatigue.

In 16 patients complaints were classified as minor and operative correction not indicated. The remaining 24 patients were operated on. The correction was carried out as a subtrochanteric osteotomy in order not to damage the trochanteric apophysis (Figure 1). A plate osteosynthesis was made, and this was supplemented by a hip cast for 3 months.

The patients were followed at regular intervals with a mean follow-up of 8.7 years. Age and observation period of the patients are shown in Table 1. In all cases the femoral neck angles were measured radiologically according to the method described by Dunlap et al. (1953) as modified by Rippstein (1955), and all measurements were performed by the authors. The method of Dunlap/Rippstein has been evaluated by Gross & Halke (1970) and Henriksson (1980), who concluded that the method is accurate. In clinical practice inadequate projections cause errors in the calculations of the angles, but use of a specially designed apparatus (Rippstein 1955) ensures accuracy, and in a recent study by Reikerås et al. (1982a) the method was found to be reliable in clinical work with an accuracy within 5 degrees.

At the initial examination three consecutive clinical measurements of the rotational movements of the hip were performed by different examiners. At follow-up two consecutive measurements were done by the authors. In all cases the measurements were performed with a goniometer with an accuracy of 5 degrees, considered sufficiently accurate for the purpose of this study.

The external torsion of the leg and foot was measured while the patient was seated on a table, thighs horizontal and parallel, knees flexed 90 degrees over the edge, and lower legs hanging vertical and parallel (Figure 2). While the foot was held at a right angle at the ankle joint, the outline was traced twice. The foot was then radiographed in the dorsoplantar view, and the tracings were projected on the radiograph. The centre of the second metatarsal head was marked on the tracings, and the line connecting this point and the centre of the heel was drawn. The external torsion of the leg and foot was determined by the angle between this line and the longitudinal axis of the thigh. The mean deviation of the

Table 1. Age and observation time of 16 non-operated and 24 operated patients with idiopathic increased anteversion of the femoral neck. Median (with 25- and 75-fractiles)

Group	Years		
	Initial examination	Control examination	Observation time
Non-operated	7.3 (6.0–8.3)	15.7 (14.3–16.8)	8.4 (7.8–9.4)
Operated	7.7 (6.4–8.9)	16.5 (14.2–18.5)	8.7 (8.0–10.1)

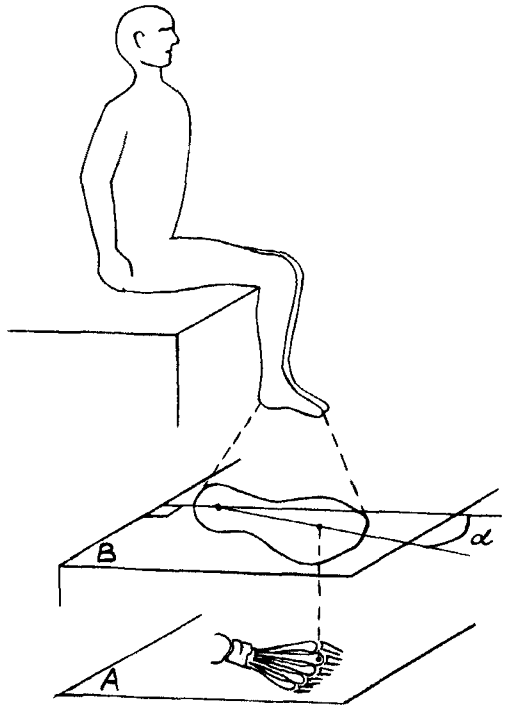

Figure 2. Measurement of the external torsion of the leg/foot. A tracing of the outline of the foot (B) is projected on a dorsoplantar radiogram of the foot (A). The centre point of the second metatarsal head is marked on the tracing, and the line connecting this point and the centre point of the heel is drawn. The external torsion of the leg and foot is determined as the angle α between this line and the longitudinal axis of the thigh.

two tracings was 0.3 ± 1.6 degrees, thus the method seems to be reliable.

The clinical readings at the follow-up examination were compared to the corresponding measurements in a control group of 20 girls and 6 boys aged 14–19 years (median 16.3 years), all of whom were admitted to the hospital because of injuries to the upper extremity, but were otherwise healthy.

The statistical analysis was run on a Digital Equipment Corporation "DEC 10" computer using standard statistical routines. Significance testing was performed using the Mann-Whitney U-test and differences regarded significant when $P \leqq 0.05$. For paired analysis the Wilcoxon test for paired differences was used. The two-tailed test was used in all cases. When indicated the Spearman coefficient of rank correlation (R) was calculated.

RESULTS

Anteversion (AV) angle (Figure 3)

At the initial examination the average value of the AV angle in the non-operated group was 45 degrees and in the operated patients, 47 degrees. The difference is not significant.

At operation a mean derotation of 44 degrees was carried out, leaving a mean AV angle of 3 degrees postoperatively.

During the observation period the AV angle in the non-operated group decreased significantly ($P < 0.001$) to 31 degrees on the average. The AV angle of the operated patients increased significantly ($P < 0.001$) to 14 degrees on the average.

Neck-shaft (CCD caput collum diaphysis) angle (Figure 4)

At the initial examination the values of the CCD angle in the non-operated group were found to be 136 degrees on the average. In the operated patients the CCD angle measured 134 degrees on the average. The difference is not significant.

At the operation an average varus angulation of 10 degrees was performed; the patients thus had a mean CCD angle of 124 degrees postoperatively.

At follow-up the CCD angle in the non-operated group was found to be 138 degrees on the

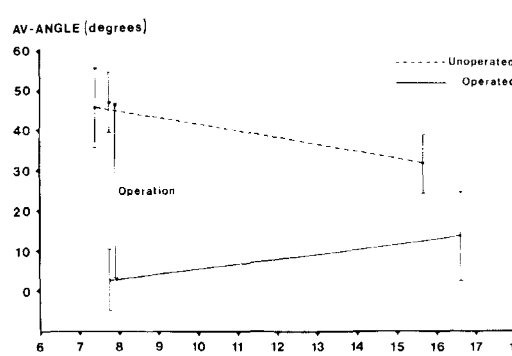

Figure 3. The development during growth of the anteversion (AV) angle in 16 non-operated (n = 32) and 24 operated patients (n = 48) with idiopathic increased anteversion of the femoral neck. (Mean ± standard deviation).

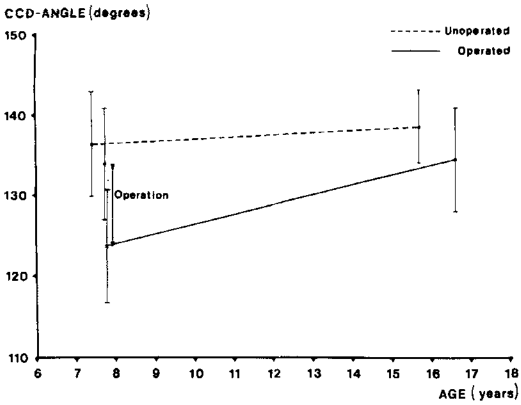

Figure 4. The development during growth of the neck-shaft (CCD caput collum diaphysis) angle in 16 non-operated (n = 32) and 24 operated patients (n = 48) with idiopathic increased anteversion of the femoral neck. (Mean ± standard deviation)

average, which did not differ significantly from the initial value. In the operated patients the values were significantly increased ($P < 0.001$); the mean CCD angle was 135 degrees.

Internal rotation (Table 2)

At the initial examination the difference between the values of internal rotation in non-operated and operated patients was not significant. No correlation was found between the increased AV angle and the degree of internal rotation (R = 0.15). In the non-operated patients the internal rotation decreased during growth in proportion to the regression of the AV angle. In the operated patients the internal rotation was normalized in accordance with the corrected AV angle.

Table 2. Internal rotation of the hip in 16 non-operated and 24 operated patients with idiopathic increased anteversion of the femoral neck and in 26 control patients. Mean (± standard deviation)

Group	*n*	Degrees	
		Initial examination	Control examination
Non-operated	32	76 (±10)	63 (±11)*
Operated	48	78 (± 8)	52 (±12)
Control	52		50 (± 9)

* $P < 0.001$.

Table 3. External rotation of the hip in 16 non-operated and 24 operated patients with idiopathic increased anteversion of the femoral neck and in 26 control patients. Mean (± standard deviation)

Group	*n*	Degrees	
		Initial examination	Control examination
Non-operated	32	28 (±10)	30 (±10)*
Operated	48	16 (± 8)*	43 (±10)
Control	52		41 (± 8)

* $P < 0.001$.

External rotation (Table 3)

At the initial examination the values of external rotation were significantly larger in the non-operated group than in the operated group ($P <$ 0.001). The correlation between the increased AV angle and the decreased external rotation was poor (R = 0.29). At follow-up the degree of external rotation in the non-operated patients was nearly unchanged, while in the operated patients it was only slightly different from the degree of external rotation in the control group.

Total rotation

At the initial examination the values of the total rotation of the hip were significantly larger in the non-operated group than in the operated group ($P < 0.005$). On re-examination the difference was evened out, and the total rotation in the three groups differed by only about 5 degrees.

External torsion of the leg/foot (Table 4)

Differences in values of the external torsion of the leg/foot were not significant, either between the non-operated and operated patients or between the control group and the two patient groups.

Table 4. External torsion of the leg/foot in 16 non-operated and 24 operated patients with idiopathic increased anteversion of the femoral neck and in 26 control patients. Mean (± standard deviation)

Group	*n*	Degrees
Non-operated	32	5 (±4)
Operated	48	4 (±5)
Control	52	5 (±3)

DISCUSSION

As demonstrated by von Lanz (1951) the anteversion of the femoral neck decreases during growth. The values of the AV angle are reported to be an average of 30–40 degrees in infants and 5–15 degrees in adults (Kingsley & Olmsted 1948, Shands & Steele 1958, Zippel 1971, Hamacher 1974). A corresponding regression has been reported in cases of idiopathic increased anteversion, but the degree of normalization has been disputed. Teinturier & Dechambre (1968), Schwarzenbach (1971) and Jani et al. (1979) observed regress to normal, as opposed to Fabry et al. (1973) who found no change in the degree of anteversion. However, for most of the patients in those series the follow-up period was insufficient.

Cyvin (1977) measured the normal anteversion in Norwegian children aged 4–6 years and found a mean AV angle of about 30 degrees. In another study the normal AV angle of Norwegian adults was revealed to be about 10 degrees (Reikerås et al. 1982b). In the present study the AV angle decreased about 15 degrees from the age of 8 years to the age of 16 years. These results indicate that children with idiopathic increased anteversion of the femoral neck will not outgrow the condition.

The development of femoral anteversion has been discussed by Morscher (1967) with reference to different previous clinical and experimental works. In his opinion regression is mainly caused by dynamic forces which may influence the epiphyseal plate and by the process of bone apposition and bone resorption. This point of view is supported by the observation that neuromuscular disorders, like cerebral palsy, are frequently associated with increased anteversion of the hip (Shands & Steele 1958, Fabry et al. 1973). In consequence of this physiotherapy has been recommended as an alternative to surgical treatment (Morscher 1967, Cyvin 1977).

Scholder (1979) has reported results of intertrochanteric derotational osteotomy in children aged 6–11 years. The AV angle was corrected from about 40 degrees to about 10 degrees, and it seemed stable during follow-up of the children to the age of 15–16 years. As opposed to Scholder we found that the corrected AV angle increased about 10 degrees during follow-up. This difference may be explained by the fact that imbalance of the dynamic forces across the hip joint is greater in subtrochanteric than in intertrochanteric osteotomy. Overcorrection therefore seems to be needed in subtrochanteric osteotomy in order to normalize the AV angle during growth. However, we prefer the subtrochanteric technique in children. It is the simplest method, and with intertrochanteric operations there is a risk of injury to the apophysis, which may result in a valgus development of the femoral neck.

During growth the CCD angle decreases slightly from 132–137 degrees in infants to 126–132 in adults (von Lanz 1951, Shands & Steele 1958, Zippel 1971, Hamacher 1974). Our measurements of the CCD angle in cases of idiopathic increased anteversion are in close agreement with the values for normal Norwegian children aged 4–6 years (Cyvin 1977). The CCD angle in the non-operated patients remained unchanged during the observation period. In the operated group a varus angulation was performed by operation, and a valgus development observed at follow-up. Corresponding findings are reported by Scholder (1979). The risk of injury to the trochanter apophysis has been mentioned. Our patients, however, underwent a subtrochanteric operation, and the apophysis can hardly have been injured. It is, therefore, reasonable to suppose that the valgus development is caused by the altered function of the muscles surrounding the hip joint, as well as by the process of bone apposition and bone resorption which follows an osteotomy. Thus, the importance of correcting the CCD angle in cases of idiopathic increased anteversion can be disputed. The problem is quite different in cases of congenital dislocation of the hip where the stimulating effect on the acetabular development is crucial.

The present results are consistent with the opinion of Cyvin (1977) that the correlation is poor between clinical and radiological findings in cases of idiopathic increased anteversion of the femoral neck. Great caution, therefore, should be taken in assessing the degree of anteversion on the basis of clinical findings only. Our results revealed no significant differences, either between the degree of anteversion, or between the values of internal rotation in the non-operated and operated patients. On the other hand, compared to patients in need of derotation, the non-operated patients had a significantly larger degree of external and total rotation of the hip. We assume that these findings account for the differences of gait and clinical symptoms in cases of increased femoral anteversion. To obtain the correct foot positioning while walking, these individuals try to rotate the extremities outward as far as possible. Patients having sufficient external rotation or succeeding in overstretching the capsule of the hip joint, will reduce the gait problem. While total rotation in the operated patients was nearly unchanged at follow-up, the values for the non-operated patients decreased by approximately 11 degrees due to reduced internal rotation. The external rotation was nearly unchanged. This can be explained by shrinking of the overstretched capsule of the hip joint with regression of the AV angle.

Steady external rotation with overstretching of the capsule should tend to subluxate the femoral head, and it has been assumed that this condition may predispose to osteoarthritis of the hip (Alvik 1960, Morscher 1967). A reduced ventral orientation of the acetabulum may to some extent reduce the effect of increased femoral anteversion on the congruity of the hip joint. Knowledge of the acetabular facing may in some cases be crucial when judging the benefits of derotational osteotomy.

It has been claimed that compensatory external torsion of the leg and foot may develop in untreated cases of increased anteversion of the femoral neck and that a derotational osteotomy should prevent such an unwanted development (Alvik 1960, Scholder 1967, Fabry et al. 1973). The tibial torsion has been investigated in anatomical and clinical studies (Le Damany 1909, Hutter 1949, Staheli & Engel 1972). The results indicate a neutral torsion of the tibia at birth, i.e. the malleoli are about level, and during growth there is a development to an external torsion of 15–20 degrees in the adult. Accurate measurements of the tibial torsion can be obtained in anatomical specimens, otherwise only approximate values are possible. The external torsion of the foot in relation to the thigh depends on the torsion of the leg. Our method is considered more reliable than measuring the level of the malleoli, which is very difficult to define.

In the present study we found no increased or compensatory external torsion of the leg or foot in the non-operated patients. The reason may be that these patients had sufficient external rotation of the hip for a more or less normal gait. It is difficult to suggest how the natural development of the torsion would have been in the operated patients with insufficient external rotation of the hip joint. Development of tibial torsion progresses most rapidly in the first years of life (Staheli & Engel 1972). Thus, if compensatory torsion of the tibia is a constant feature with increased anteversion of the femoral neck, it should have developed in most of the patients prior to operation time, and a corresponding regression should have taken place during late childhood. However, according to the investigation of Hutter (1949) developmental changes do not correct extreme torsion to any great extent. On this basis we assume that compensatory external torsion of the tibia does not develop regularly with increased anteversion of the femoral neck. It has, however, been seen clinically.

CONCLUSION

Children will not outgrow idiopathic increased anteversion of the femoral neck. A subtrochanteric derotational osteotomy should be performed with a slight degree of overcorrection. No correction of the CCD angle is necessary.

The degree of external rotation of the hip will determine symptoms of gait. If the external rotation is sufficient, the gait will be normal. A compensatory external torsion of the leg or foot does not develop regularly during growth.

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Correspondence to: Olav Reikerås, Regionsykehuset, 9012 Tromsø, Norway.