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ANTEVERSION OF THE ACETABULUM IN PATIENTS WITH IDIOPATHIC INCREASED ANTEVERSION OF THE FEMORAL NECK

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Examination of the hip joint by computed tomography was evaluated in 34 children admitted to hospital with symptoms of idiopathic increased anteversion of the femoral neck and in 6 children with congenital dislocation of the hip. Anteversion of the femoral neck and the acetabulum was determined from tomographic cross-sections, and femoral anteversion was also determined by conventional radiography. A good correlation was found between these two methods.

The relationship between anteversion of the femoral neck and that of the acetabulum was calculated in the 34 patients with idiopathic increased femoral anteversion. Increased anteversion of the femoral neck was not compensated for by a corresponding reduction in the ventral orientation of the acetabulum. In many cases the adjustment of the acetabulum to the femoral head was poor.

In some of the patients the degree of external rotation of the hip was greater than would be expected from the relationship between the anteversion of the femoral neck and that of the acetabulum. In these patients the lower limb is forced outwards when walking, causing the femoral head to dislocate laterally and forwards.

Based on the results of this study we conclude that calculation of the anteversion, both of the femoral neck and acetabulum, should play an important part in the evaluation of candidates for derotational osteotomy of the femur. Computed tomography yields valuable information in this respect.

Key words: acetabulum; anteversion; computed tomography; femur; radiology

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In orthopaedic radiology the problem of determining the anteversion of the femoral neck has been debated for some years. New methods have been developed in order to combine precision and simplicity. On the other hand, little interest has been focused on the anteversion of the acetabulum.

The relationship between the orientation of the femoral neck and that of the acetabulum is important for the mechanics of the hip joint. With increased anteversion of the neck, the congruity of the hip joint depends upon a corresponding adjustment of the acetabulum. In cases of incompatibility, stable articulation may be impossible except during inward rotation of the lower limb, and with forced outward rotation the femoral head may subluxate. In a previous report (Reikerås & Bjerkreim 1982) we have discussed the influence of external rotation on the mechanics of the hip joint with increased femoral anteversion.

During recent years the development of computed tomography (CT) has added a new technique of non-invasive study in living subjects.

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Assessment of femoral anteversion has been described by Weiner et al. (1978).

The present study was carried out

1. To evaluate the use of computed tomography in calculating the anteversion angle of the femoral neck (AV angle) and the anteversion angle of the acetabulum (AVA angle).
2. To investigate the relationship between these two angles in children with idiopathic increased anteversion of the femoral neck and to compare this relationship with the range of external rotation of the hip.

PATIENTS AND METHODS

The investigation was carried out during the years 1978 to 1980 and included a total of 40 patients; 17 girls and 17 boys aged from 4 to 12 years (mean 7.7 years) were admitted to hospital with symptoms of idiopathic increased anteversion of the femoral neck and the remaining 6 patients, 4 girls and 2 boys, aged from 3 to 5 years, had congenital dislocation of the hip.

The femoral neck angles were determined by conventional radiography according to the method of Dunlap et al. (1953) as modified by Rippstein (1955). The AV and AVA angles were also measured by computed tomography. The CT examination was carried out by a Delta Scan 50 FS with an exposure time of 18 seconds. The principles have been outlined by Aakhus et al. (1978).

The patients were placed on the table in a prone position, with hips extended and thighs parallel and horizontal. The knees were flexed 90 degrees and the lower legs parallel and vertical to the table (Figure 1). A sequential series of 13 mm thick tomographic cross-sections of the acetabulum and femoral head and neck were studied on the television monitor. The tomogram through the centre of the femoral head was selected (Figure 2A). A measuring point was then placed in the centre of the head and projected onto the section through the middle of the femoral neck (Figure 2B). The centre point of the neck was then identified and a line was constructed connecting the two measuring points. The AV angle was determined as the angle formed between this line and the horizontal plane (the table plane) (Figure 2D).

The tomogram through the centre of the acetabulum was selected for the measurement of the AVA angle, which was defined as the ventral orientation of the acetabulum related to the sagittal plane. One measuring point was placed at the anterior edge of the acetabulum and another at the posterior edge (Figure 2B). A line was constructed connecting these points, and the AVA angle was determined as the angle formed between this line and the plane sagittal to the pelvis (Figure 2D).

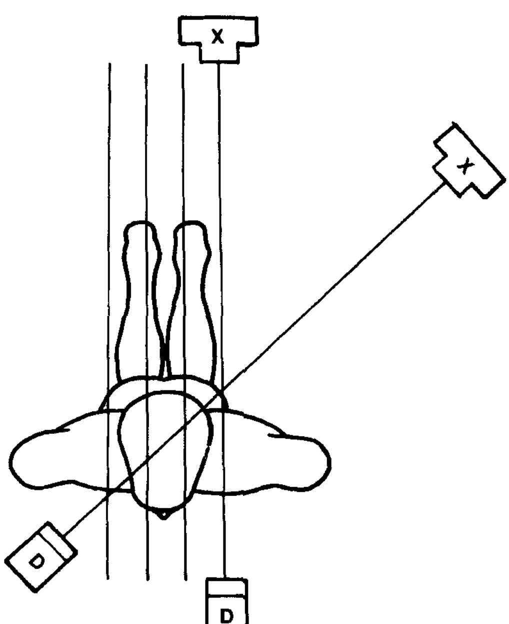

Figure 1. Positioning of the patient during examination of the anteversion of the femoral neck and the acetabulum by computed tomography. X =X-ray tube. D = detector.

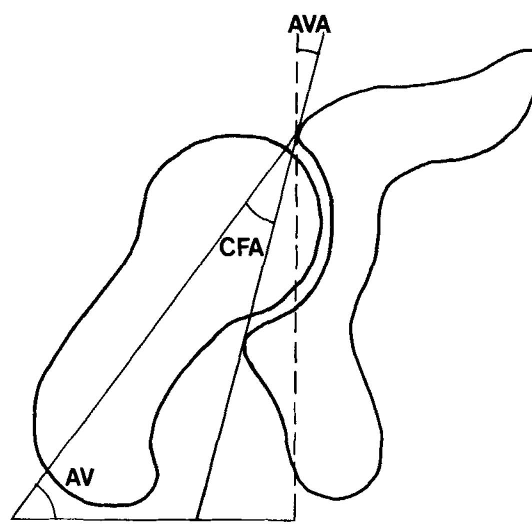

Figure 3. Unilateral cross-section of the pelvis with the hip joint demonstrating the anteversion angle of the femoral neck (AV angle) and of the acetabulum (AVA angle), and the relationship between the AV and AVA angles expressed by the angle CFA (collum femoris acetabulum).

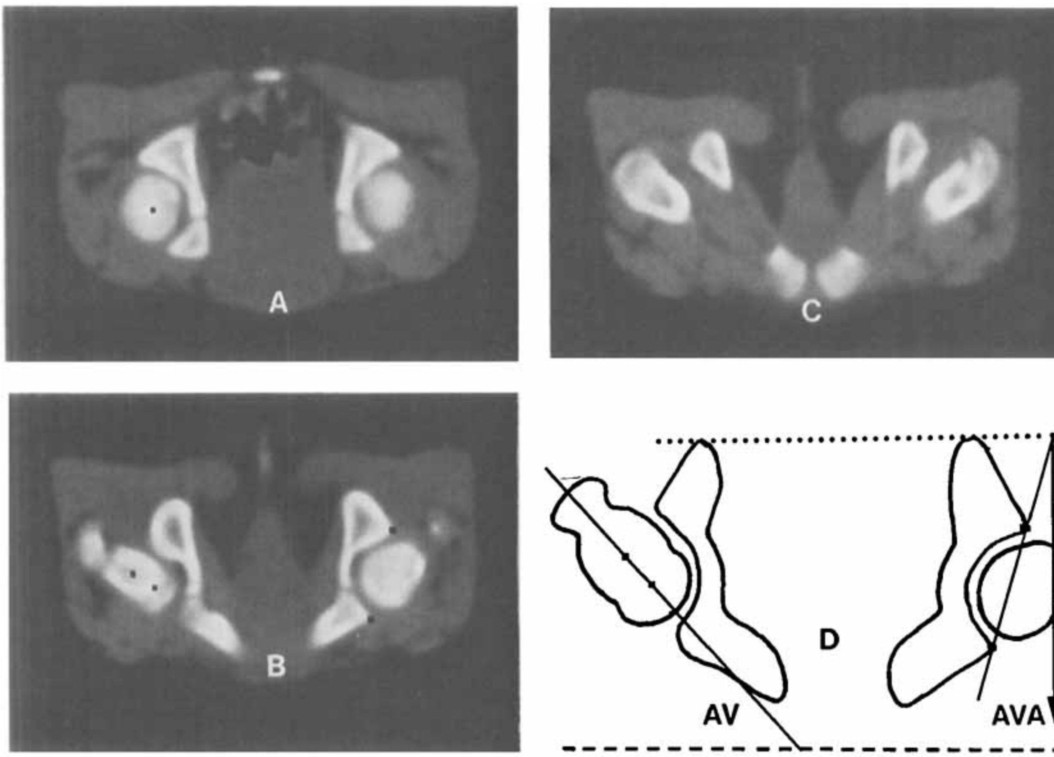

Figure 2. Computed tomograms viewed from below for determination of the anteversion of the femoral neck and the acetabulum. A. Tomogram of the femoral head. A measuring point is placed in the centre of the left head and projected onto image B, which is a section through the middle of the left femoral neck and the centre of the right acetabulum. A second measuring point is placed centrally in the left femoral neck. A measuring point is placed at the anterior and posterior edges of the right acetabulum. C. Tomogram of the lower part of the left femoral neck which was discarded for determination of anteversion. Appropriate section through the middle of the right femoral neck. D. Drawing of the tomogram shown in B, defining the anteversion of the left femoral neck (AV) and of the right acetabulum (AVA). - - - - indicates the plane of the table (= the reference plane of the AV angle), → indicates the plane sagittal to the pelvis.

In the 34 children suffering from idiopathic increased anteversion of the femoral neck, the radiographically determined femoral anteversion was related to the acetabular anteversion determined by CT. The relationship between these two angles was expressed by the CFA (collum femoris acetabulum) angle. As shown in Figure 3, this angle is 90 degrees – (AV + AVA).

The external rotation of the hips in these patients was measured with a goniometer, with an accuracy of 5 degrees, and on three consecutive occasions.

The statistical calculations were performed on a Digital Equipment Corporation "DEC – 10" computer, using standard routines. The Wilcoxon test was used for the significance testing of pair differences, and differences were regarded as significant if $P \leqq 0.05$. To express the degree of correlation between two variables the Spearman rank correlation coefficient *(R)* was calculated.

RESULTS

The relationship between the AV angle values determined by conventional radiography and by computed tomography is shown in Figure 4. The radiological measurements gave angles which were an average of 2 degrees larger than those measured by CT (standard deviation of 5 degrees). This difference is significant ($P < 0.01$). However, the degree of correlation is high ($R = 0.76$).

The relationship between the anteversion of the femoral neck and that of the acetabulum in the 34 patients with idiopathic increased femoral anteversion is demonstrated in Figure 5. No cor-

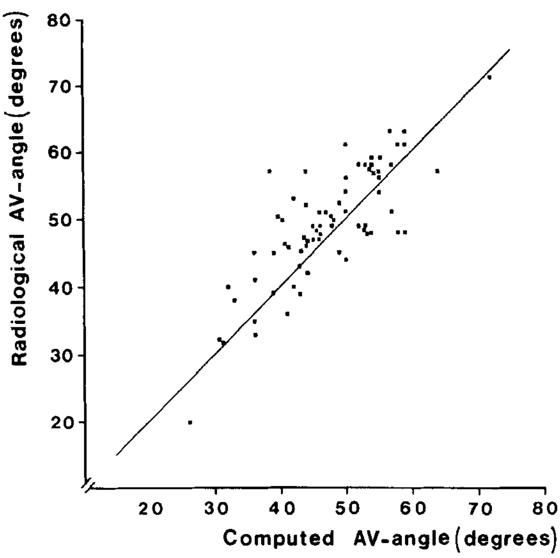

Figure 4. The relationship between the values of the anteversion (AV) angle of the femoral neck, determined by conventional radiography and computed tomography.

relation was found between the sizes of the AV and the AVA angles ($R = 0.03$).

The results of the measurements in these patients are shown in Table 1. There was no correlation between the CFA angle and the external rotation of the hip ($R = 0.12$). The values for CFA angle were on average 10 degrees higher than those for external rotation, but the standard deviations were so large that in some cases the external rotation of the hip was equal to or even greater than the CFA angle.

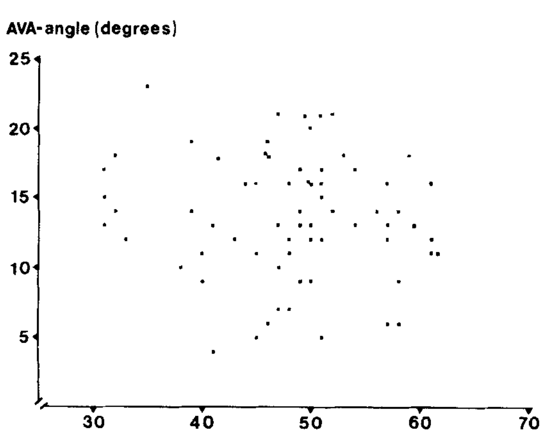

Figure 5. The relationship between the values of the anteversion angles of the femoral neck (AV angle) and the acetabulum (AVA angle) in 34 cases of idiopathic increased anteversion of the femoral neck.

Table 1. Measurements in 34 patients (68 hips) with idiopathic increased anteversion of the femoral neck. Mean (± standard deviation)

	Degrees
Anteversion angle of the femoral neck	47(±8)
Anteversion angle of the acetabulum	14(±4)
Collum femoris acetabulum angle	29(±9)
External rotation of the hip	19(±9)

DISCUSSION

Radiographic methods for assessing the anteversion of the femoral neck are encumbered with inaccuracies. In a previous study the precision of the method of Dunlap et al. (1953) as modified by Rippstein (1955) was found to be of the order of 5 degrees (Reikerås et al. 1982).

The CT technique incorporates three-dimensional data, and a single tomogram is inadequate for determination of femoral anteversion. A careful selection of tomograms should be made to avoid significant errors arising from the valgus position and the irregular anatomy of the femoral neck and head. In a recent study performed on femoral specimens, the precision of the computed method for determination of femoral anteversion was studied in detail (Høiseth et al. 1982). It was found that this method involves manifest sources of error. However, by selecting and superimposing tomograms, as done in this study, the CT method was found to be acceptable, with a difference from the control values of 0 ± 4.5 degrees.

In the present study the clinical application of the CT method was investigated. The inability of small children to co-operate represents a problem. According to Weiner et al. (1978) and Høiseth et al. (1982) the reference plane of the AV angle is determined by scanning the condyles. This requires absolute fixation of the hip joint during the interval of time between the scanning of the condyles and the scanning of the hips. By our method this problem is minimized, in that the reference plane of the femoral condyles is determined by the position of the patient with the knees flexed 90 degrees. Thus only one region is scanned. On the other hand, this technique implies the error of instability of the knee joints (Brattstrøm 1962).

The difference between the values obtained by CT and by conventional radiography was significant in this study, but the mean difference was of no practical importance. The present results are in accordance with the results of Høiseth et al. (1982). On this basis we consider the CT method to be acceptable for determination of femoral anteversion. On the other hand, the amount of radiation required is high, and with this method gonadal shielding is not possible. The method, therefore, should not be chosen for children unless it is absolutely necessary to determine the anteversion of the acetabulum.

The congruity of the hip joint depends upon the relationship between the anteversion of the femoral neck and that of the acetabulum. However, judging from the literature, less attention has been focused on acetabular orientation than on the orientation of the femoral neck, and the figures available do not agree. Studies of the pelvis have revealed that the acetabulum always faces forward. For the immature pelvis, Lanz (1951) gave a mean figure of 35 degrees. Laurent (1953) quoted values between 20 and 25 degrees, whereas McKibbin (1970) reported 9 and 4 degrees in the male and female pelvis, respectively. The disagreement among these studies may be explained by the fact that the measurements were performed with the pelvis in different positions.

The anteversion of the acetabulum depends upon the tilting of the pelvis, which varies with posture and the individual. Erect posture puts demands on the hip joint because of the anteversion of both the femoral neck and acetabulum, and assessment of acetabular anteversion in this position would be of great significance.

It was observed that the calculation of acetabular anteversion was not constant for different sections of the socket, which may be explained by the irregular anatomy of the acetabulum. In addition, on the most proximal and distal tomograms the measuring points were too close to each other to permit precise calculations. Thus, in the present study, a careful selection of the tomogram through the centre of the acetabulum was made in order to obtain consistent values for acetabular anteversion.

It is well known that inadequacies in the development of the acetabulum, as in cases of congenital dislocation of the hip, will result in the femoral head being poorly covered by the acetabulum and, subsequently, this will result in osteoarthritis. The frontal cover of the head is normally poor because of anteversion of both the femoral neck and acetabulum, and in cases of increased femoral anteversion the anterior cover is crucial. Getz (1955) and Alvik (1960) regarded increased femoral anteversion as a manifestation of congenital dislocation of the hip.

In this study increased anteversion of the femoral neck was not found to be compensated for by reduced anterior orientation of the acetabulum. The relationship between the anteversion of the femoral neck and that of the acetabulum was expressed by the CFA angle. In some cases this angle was so small that the ventral axes of the femoral neck and acetabulum were almost parallel.

It is well known that the degree of femoral anteversion decreases during growth. This fact was taken into consideration in the evaluation of the results, and the values of the anteversion of the femoral neck and the acetabulum were correlated with the age of the patients. The respective correlation coefficients (and thus the regression coefficients) were not found to differ significantly from zero. This would indicate that the present results concerning the relationship between the anteversion of the femoral neck and that of the acetabulum should be reliable.

The poor adjustment of the anteverted head in the socket may be counteracted by inward rotation of the hip. In a previous study (Reikerås & Bjerkreim 1982) we pointed out the significance of the degree of external rotation for clinical symptoms in cases of increased anteversion of the femoral neck. No correlation was found between the degree of increased anteversion and the degree of reduced external rotation of the hip. We assume that external rotation is restricted by the anterior joint capsule and by the bone structures of the hip, i.e. the impingement of the femoral neck on the dorsal rim of the acetabulum (Figure 3). Confirming this point of view, the values of the CFA angle were significantly higher than those of the external rotation of the hip. However, it was observed that in some cases external rotation was equal to or even greater than the CFA angle. This implies that these patients, by forcing the extremity outward when walking, may dislocate the femoral head laterally and forwards. This unfavourable position of the hip joint may predispose it to osteoarthritis, and it may be necessary to align the femoral neck in order to cover the anteverted head adequately.

Clinical investigations add little information with regard to the stability of the hip joint in these cases, although a relatively well-preserved external rotation may indicate instability. Therefore, when evaluating the indications for corrective osteotomy of the femur, the degree of anteversion of the femoral neck, as well as of the acetabulum, should be calculated.

CONCLUSION

In cases of idiopathic increased femoral anteversion no correlation was found between the degree of anteversion of the femoral neck and the degree of anteversion of the acetabulum. The relationship between these two angles is important in the stability of the hip joint and can not be assessed by clinical examination or conventional radiography. Computed tomography yields valuable information in this respect.

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