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ANTEVERSION OF THE ACETABULUM AND FEMORAL NECK IN NORMALS AND IN PATIENTS WITH OSTEOARTHRITIS OF THE HIP

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Anteversion of the acetabulum and of the femoral neck was determined by use of computed tomography in 47 adults with normal hips and in 39 patients with osteoarthritis. The normal anteversion of the acetabulum was found to be 17 ± 6° (mean ± standard deviation) and of the femoral neck 13 ± 7°. In the patients with osteoarthritis the femoral anteversion was on the average 6° larger than in the normals, whereas no difference was revealed in the figures of acetabular anteversion.

The relationship between the degree of femoral and of acetabular anteversion was calculated. No correlation was found, neither in the normals, nor in the patients. Consequently, the relationship between the anteversion of the femoral neck and of the acetabulum was poor in the patients as compared to the controls, and it is concluded that this is a contributing factor to osteoarthritis due to poor adaptation of the femoral head to the acetabulum.

Key words: acetabulum; anteversion; femur; hip; osteoarthritis

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The adjustment of the acetabulum to the femoral neck and head influences the biomechanics of the hip joint. The erect posture makes demands on the joint because of the anteversion of both the femur and the acetabulum, and in the evaluation of pathological conditions of the hip knowledge of the anteversion should be valuable. Numerous research workers have dealt with the femoral anteversion in specimens and in living beings. But there have been fewer measurements of the acetabular anteversion. Specimen studies have been performed, but the position of the pelvis has not been standardized, and the available reports are not in agreement (McKibbin 1970).

In patients with idiopathic osteoarthritis of the hip increased anteversion of the femoral neck seems to be a predisposing factor for the disease (Reikerås & Høiseth 1982). In this respect the anteversion of the acetabulum is of interest.

The development of computed tomography has provided a method for assessment of the acetabular anteversion in living beings (Reikerås et al. 1982). The main aim of the present investigation in adults was to measure the normal anteversion of the acetabulum in the erect position, and to evaluate the relationship between the anteversion of the acetabulum and of the femoral neck in normals and in patients with osteoarthritis of the hip.

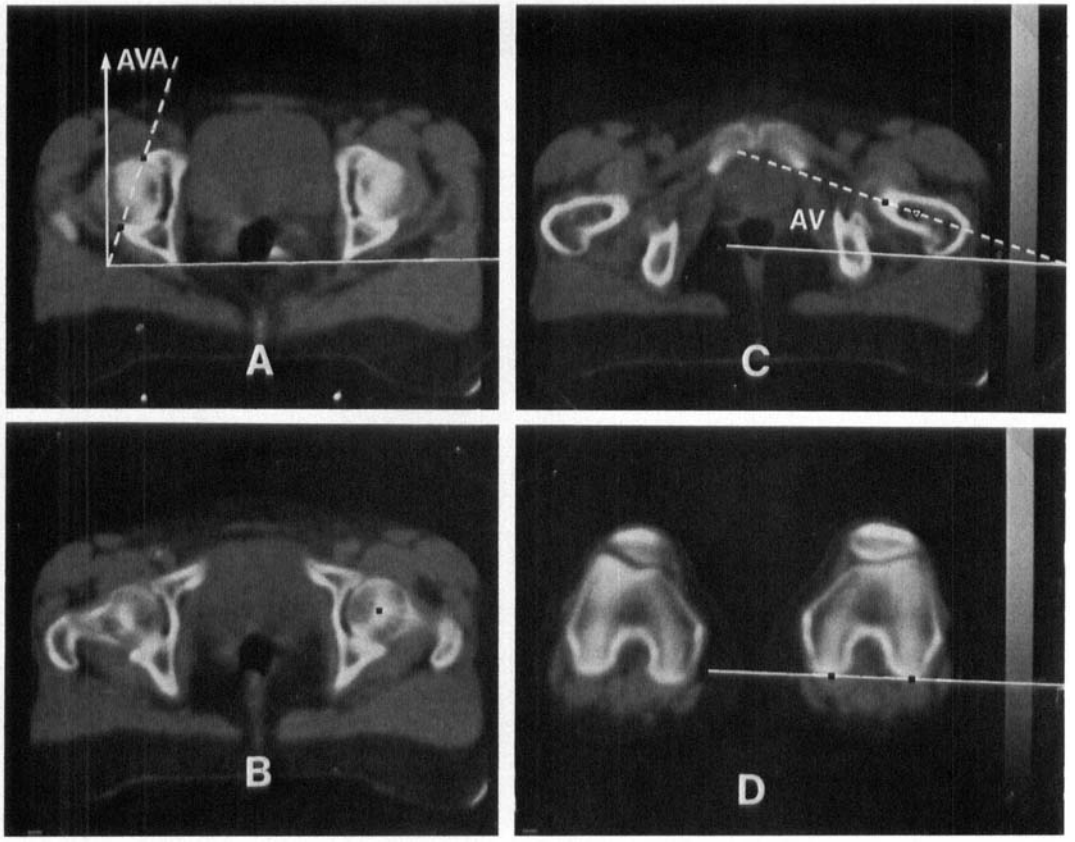

Figure 1. Computed tomograms viewed from below for determination of the anteversion of the acetabulum and of the femoral neck. A. Tomogram through the centres of the acetabulum. A measuring point is set at the anterior and at the posterior edge of the right acetabulum. The anteversion of the acetabulum (AVA) is determined as the angle between the line connecting these points (– – –) and the plane sagittal to the pelvis (→). B. Tomogram of the femoral heads. A measuring point is set in the centre of the left femoral head and projected on to image C, which is a section through the middle part of the femoral necks. A second measuring point (▽) is set centrally in the left femoral neck, and the anteversion of the femoral neck (AV) is constructed as the angle between the line connecting these points (– – –) and the reference plane (——). D. The reference plane is determined as the dorsal tangent (——) of the scanned femoral condyles.

PATIENTS AND METHODS

A prospective study of 86 individuals was carried out. The normal material includes 26 females and 21 males in whom computed tomography (CT) of the pelvic region was indicated for various disorders other than hip joint disease. The ages ranged from 23 to 74 years with a mean of 58.1 and 59.8 years for females and males respectively. A total of 39 patients (27 females and 12 males) suffering from idiopathic osteoarthritis of the hip were also investigated. The age of the patients ranged from 41 to 74 years (mean 65.2 years). They all were disabled to such a degree that operation was indicated, and either intertrochanteric osteotomy or total hip replacement was performed.

The anteversion angle of the acetabulum (AVA angle) and the anteversion angle of the femoral neck (AV angle) was determined by CT carried out by a Delta Scan 50 FS with exposure time of 18 seconds. The principles have been described by Aakhus et al. (1978). The patients were placed in supine position with hips extended and thighs horizontal and parallel. A sequential series of 13-mm-thick tomographic cross-sections obtained from the acetabulum and femoral head and neck were studied on the television monitor.

The tomogram through the centre of the acetabulum was selected for measurement of the AVA angle, which was defined as the ventral orientation of the acetabulum related to the sagittal plane. A measuring point was assigned at the anterior edge of the

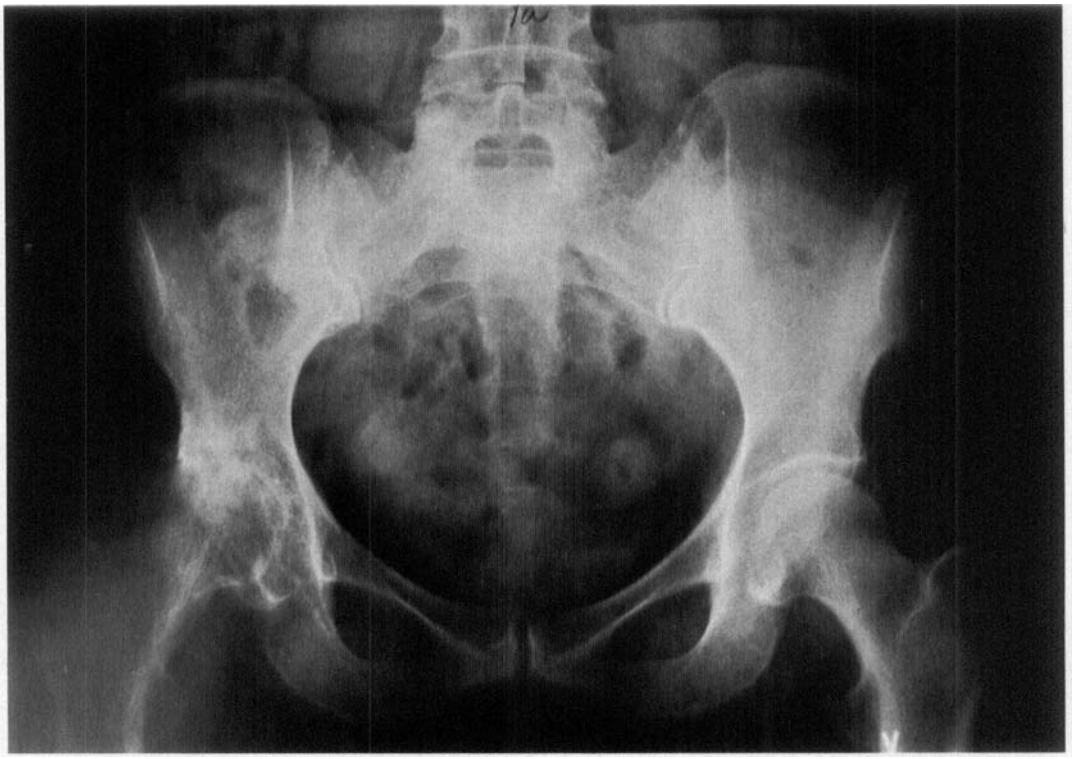

Figure 2. Conventional film of the pelvis and hip joints. The patient has osteoarthritis of the right hip.

acetabulum and a second at the posterior edge (Figure 1A). 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 AVA angle.

For determination of the AV angle the tomogram thorugh the centre of the femoral head was selected (Figure 1B). A measuring point was set in the centre of the head and projected on to the section through the middle part of the femoral neck (Figure 1C). The centre point of the neck was then identified, and the line connecting the two measuring points drawn. The angle formed by this line and the reference plane was determined as the AV angle. The reference plane was determined by scanning the femur condyles, and the dorsal tangent of the condyles (Figure 1D) served as the reference plane.

*Table 1. Anteversion of the acetabulum (AVA), anteversion of the femoral neck (AV) and the relationship between these angles (CFA collum femoris acetabulum) in 26 females and 21 males with normal hips and in 27 female and 12 male patients with idiopathic osteoarthritis of the hip. Mean (± standard deviation). NS = not significant. * = $P < 0.05$. ** = $P < 0.01$. *** = $P < 0.001$*

Normals	Degrees		
	AVA angle	AV angle	CFA angle
Females	18 (±6)*	14 (±7)*	58 (±10)**
Males	16 (±5)	11 (±7)	63 (± 9)
Total	17 (±6)	13 (±7)	60 (±10)
Patients	18 (±6) NS	19 (±9)***	53 (±11)***

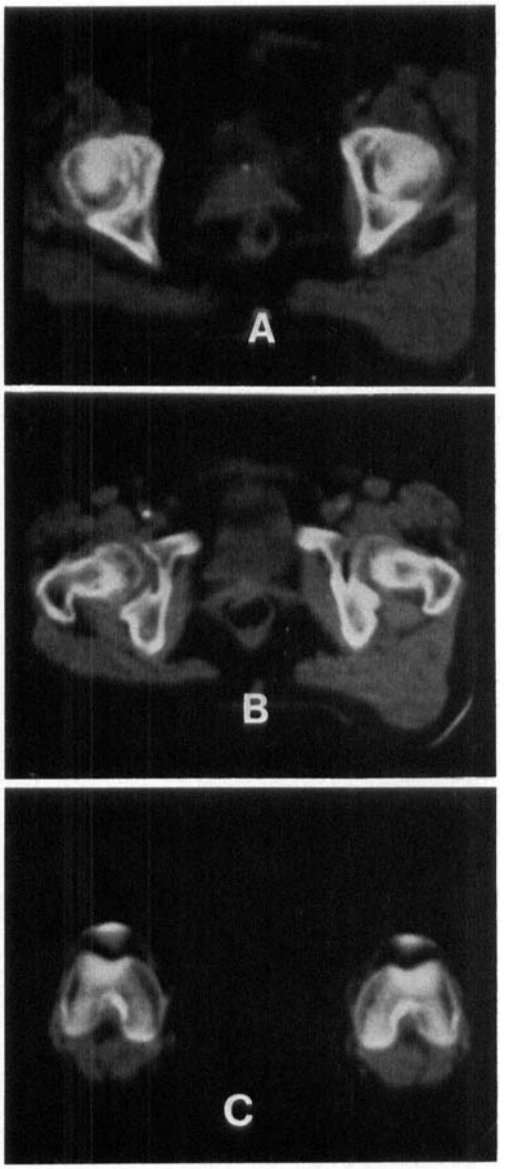

Figure 3. Computed tomograms viewed from below for determination of the anteversion of the acetabulum and of the femoral neck in the same patient as in Figure 2.

In 14 of the individuals with no hip joint disease the AVA angle was measured both in supine and in prone position. The mean difference between the calculations in the two positions was 0.6° (standard deviation 2.1°). Considering the standard deviations of the values of the AVA angle (Table 1), we assume that the measurements of the study are reliable for the acetabular anteversion in erect position.

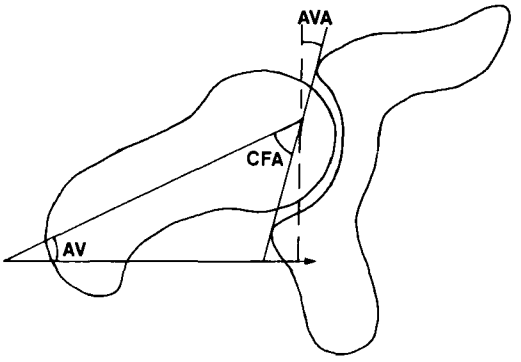

Figure 4. Unilateral cross-section of the pelvis with the hip joint demonstrating the anteversion angle of the femoral neck (AV) and of the acetabulum (AVA) and the relationship between the AV and AVA angle expressed by the angle CFA (collum femoris acetabulum). The reference plane of the AV angle (→) is the dorsal tangent of the femoral condyles. The reference plane of the AVA angle (– – –) is the plane sagittal to the pelvis.

To assure comparable position of the pelvis in the patients only those with no flexion contracture of the hips were examined. Also, in all the patients included in this study the original contours of the hip joint were distinguishable from bony spurs following osteoarthritis (Figures 2 and 3).

The relationship between the AV and AVA angles was expressed by the angle CFA (collum femoris acetabulum). As shown in Figure 4 this angle is 90°–(AV + AVA).

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

RESULTS

The results of the measurements are given in Table 1. No sex difference in the AVA, AV and CFA angles was revealed in the patient group. In the osteoarthritic patients the AV angle was significantly larger ($P<0.001$) and the CFA angle was significantly smaller ($P<0.001$) than in the normals. There was no significant difference in values of the AVA angle between the two groups.

In the normals no correlation was found between the values of the AVA and the corresponding AV angle (R = 0.09), nor was there any

correlation between the age and the values of the AVA and AV angle (R = 0.15 and –0.18 respectively).

In the patient group no correlation was found between the AVA and AV angles (R = 0.13). No difference of the angles was revealed between patients younger and those older than the mean age.

DISCUSSION

The orientation of the acetabulum has been studied in pelvic specimens (von Lanz 1951, Getz 1953, McKibbin 1970), and it has been documented that the acetabulum constantly faces forward relative to the sagittal plane. The anteversion depends on the tilting of the pelvis, and reported values vary. McKibbin oriented the pelvic specimens in the anatomical position and gave a mean figure of 16.5°, the anteversion of the female acetabulum being larger than that of the male. This is in agreement with our measurements, which were performed with the individuals in supine position. By measuring the acetabular anteversion also in prone position, no significant difference was found, so we are of the opinion that the values determined by CT are reliable for acetabular anteversion in the erect position.

According to von Lanz (1951) and McKibbin (1970) the anteversion of the acetabulum increases during growth. In a previous study in children with idiopathic increased anteversion of the femoral neck (Reikerås et al. 1982) the average AVA angle was found to be 14°. If this value is representative for the normal anteversion in children, the AVA angle seems to increase slightly during growth. In the present study no correlation was found between the age of the patients and the values of the AVA angle, and this would indicate that the acetabular anteversion does not change after completion of growth.

The CT method for determination of femoral anteversion was described by Weiner et al. (1978) and Hernandez et al. (1981). The accuracy of the method has been tested in femoral specimens (Høiseth et al. 1982), and it was concluded that the method is acceptable with a deviation of 0 ± 4.5° from the control values. The size of the normal anteversion of the femoral neck is well known from the literature (Kingsley & Olmsted 1948, von Lanz 1951, Hamacher 1974), and the findings of this study are in agreement with these reports. No correlation was found between the age of the patients and the values of the AV angle. This would indicate that the degree of femoral anteversion does not change after completion of growth.

The adjustment of the acetabulum to the femoral head depends upon the relationship between the anteversion of the acetabulum and of the femoral neck, and in the evaluation of hip instability special attention has been paid to this relationship (le Damany 1908, Getz 1955, McKibbin 1970). In cases of an unfavorable relationship the femoral head may subluxate laterally and forward in an outward rotation of the lower limb. In the present study no correlation was found between the values of the AVA and AV angles, and a large femoral anteversion was not compensated by a small acetabular anteversion. Judged from the values of the CFA angle the stability of the normal hip joint in many cases seems to be unfavorable, particularly in the females.

A poor relationship between the anteversion of the femoral neck and of the acetabulum with instability of the hip causes an abnormal biomechanical condition of the joint. It is well known that mechanical factors are of great importance in the pathogenesis of osteoarthritis (Trueta 1963, Benum 1977). In osteoarthritis of the hip disintegration of the cartilage has been most severe in areas of the femoral head which are not in continuous contact with the acetabulum (Harrison et al. 1953). In cases of excessive anteversion of the femoral neck, or when the acetabulum faces too far forward, the anterior segment of the femoral head will be uncovered. Dogs with enlarged femoral anteversion induced artificially by osteotomy showed deformation of the femoral head at autopsy (Schneider 1962).

In humans increased anteversion of the femoral neck has been assumed to predispose to osteoarthritis of the hip, and in a recent study (Reikerås & Høiseth 1982) such a causal re-

lationship was found. In this respect the corresponding anteversion of the acetabulum is of interest. In the present study increased femoral anteversion without a simultaneous decrease of the acetabular anteversion was found in the patient group. Consequently, the relationship between the anteversion of the femoral neck and of the acetabulum was unfavorable as compared to the normals. This is assumed to be a contributing factor in the pathogenesis of osteoarthritis due to poor adaptation of the femoral head to the acetabulum. In the normals the relationship was found to be more unfavorable in females than in males. Among other things this may explain why osteoarthritis of the hip is more frequent in females than in males.

Increased anteversion of the femoral neck may be secondary to the degenerative process of osteoarthritis. However, in all the patients of this study the original contours of the hip joint were distinguishable from degenerative changes. Also, the measurements of the oldest patients with a presumably longer duration of the disease did not differ from those of the younger patients. The sex distribution of the patient group differed from that of the normals, but correcting for this difference the fundamental results were not changed.

A poor congruity of the hip joint may also be provoked by increased anteversion of the acetabulum without a correspondingly reduced femoral anteversion. Thus, in the management of hip osteoarthritis the relationship between the anteversion of the femoral neck and of the acetabulum should be of importance, and if indicated femoral osteotomy should be considered to create optimal biomechanical conditions in the joint.

CONCLUSION

No correlation normally exists between the anteversion angle of the femoral neck and of the acetabulum. An unfavorable relationship between the two angles may contribute to osteoarthritis of the hip. The femoral anteversion is the important factor in this context.

REFERENCES

Benum, P. (1977) Artrose. *Tidsskr. Nor. Lægefor.* **25**, 1201–1210.

le Damany, P. (1908) Die angeborene Hüftgelenksverrenkung. *Z. Orthop. Chir.* **21**, 129–169.

McKibbin, B. (1970) Anatomical factors in the stability of the hip joint in the newborn. *J. Bone Joint Surg.* **48-A**, 148–159.

Getz, B. (1955) The hip joint and its bearing on the problem of congenital dislocation. *Acta Orthop. Scand.*, Suppl. 18.

Hamacher, P. (1974) Röntgenologische Normalwerte des Hüftgelenkes CCD-Winkel und AT-Winkel. *Orthop. Praxis* **10**, 23–28.

Harrison, M. H. M., Schajowitcz, F. & Trueta, J. (1953) Osteoarthritis of the hip. A study of the nature and evolution of the disease. *J. Bone Joint Surg.* **53-B**, 598–626.

Hernandez, R. J., Tachdjian, M. O., Poznanski, A. K. & Dias, L. S. (1981) CT determination of femoral anteversion. *Am. J. Rheum.* **137**, 97–101.

Høiseth, A., Reikerås, O. & Fønstelien, E. (1982) An evaluation of computerassisted tomography as a method for determination of the femoral neck anteversion. Submitted for publication.

Kingsley, P. C. & Olmsted, K. L. (1948) A study to determine the angle of the anteversion of the neck of femur. *J. Bone Joint Surg.* **30-A**, 745–751.

von Lanz, T. (1951) Über umwegige Entwicklungen am menschlichen Hüftgelenk. *Schweiz. Med. Wochenschr.* **81**, 1053–1056.

Reikerås, O., Bjerkreim, I. & Kolbenstvedt, A. (1982) Anteversion of the acetabulum in patients with idiopathic increased anteversion of the femoral neck. *Acta Orthop. Scand.* **53**, 847–852.

Reikerås, O. & Høiseth, A. (1982) Femoral neck angles in osteoarthritis of the hip. *Acta Orthop. Scand.* **53**, 781–784.

Schneider, P. (1962) Enlargement of the femoral anteversion. *Orthop. Praxis* **10**, 23–28.

Trueta, J. (1963) Osteoarthritis of the hip. *Clin. Orthop. Rel. Res.* **31**, 7–18.

Weiner, D., Cook, A., Hoyt, W. & Oravec, C. (1978) Computed tomography in the measurement of femoral anteversion. *Orthopedics* **1**, 229–306.

Aakhus, T., Lannto, L., Kollmannskog, F., Kolbenstvedt, A. & Skalpe, I. O. (1978) Computertomografi. Historikk, prinsipper og anvendelsse. *Tidsskr. Nor. Lægefor.* **27**, 1306–1310.

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