

# Lack of correlation between femoral neck anteversion and acetabular orientation

## Radiography and computed tomography in cadavers and in vivo

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Radiography and computed tomography measurements were made of femoral neck anteversion, femoral head cartilage distribution, and the orientation of the acetabulum. The measurements were made in elderly cadaver femurs and in patients. They failed to establish any correlation between the femoral neck anteversion and the orientation of the articulating surface of the femoral head, nor between the femoral neck anteversion and the angles of the acetabulum.

Excessive femoral neck anteversion is associated with coxarthrosis (Reikerås and Høiseth 1982, Terjesen et al. 1982); the uncovered cartilage at the anterior part of the femoral head is subjected to increased pressure. Increased femoral anteversion may, however, be compensated by an altered shape of the femoral head or acetabulum. A corresponding posterior rotation of the articulating surface of the femoral head or an altered shape of the acetabular socket may adjust the femoral head cartilage to that of the acetabulum. We have studied this hypothesis by radiographic measurements of the hip joint in cadavers and in healthy individuals.

### Materials and methods

The anteversion of the femoral neck and the cartilage angles on the femoral head were measured in 20 pairs of elderly cadaver specimens. The femurs were placed on a horizontal table with the long axis of the femoral shaft horizontal and with the dorsal aspect of the condyles resting on the table. Radiographs of the specimens were obtained with the central ray horizontal and centered on the femoral neck. To project the femoral neck free of the condyles, the shafts were abducted 5° to the central ray. The anteversion of the femoral neck was measured on the radiographs as described by Reikerås et al. (1985).

The cartilage angles of the femoral head were measured with the neck axis as the baseline (Figure 1). The

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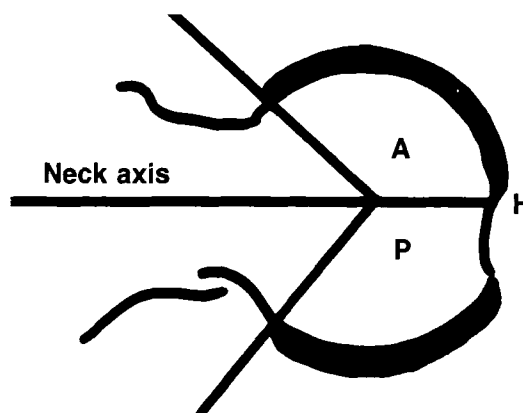


Figure 1. The lines and angles defining the cartilage angles of the femoral head. The neck axis is the line from the center of the femoral head. A is the Anterior cartilage angle formed by the neck axis and the line from the center of the femoral head to the edge of the cartilage anteriorly on the femoral head. P is the corresponding Posterior cartilage angle. H is the Head cartilage angle, which is the sum of the A and P angles.

neck axis was defined as the line connecting the center of the femoral head and the midpoint of the narrowest part of the femoral neck when the femoral neck was projected along the longitudinal axis of the femoral shaft.

The anterior cartilage angle is the angle between the femoral neck axis and the line from the center of the femoral head to the anterior edge of the femoral head cartilage. The posterior cartilage angle is the angle between the neck axis and the line from the head center to the posterior edge of the cartilage. The head cartil-

age angle is the sum of the anterior and posterior angles.

### Computed tomography of the acetabulum

The acetabular angles were determined in 23 males and 17 female patients, mean age 70 (25-87) years, without radiographic evidence of coxarthrosis. All of them were examined by computed tomography (CT) because of various intrapelvic diseases. CT was performed using the EMI 5005. Ten-millimeter-thick contiguous scans were performed transversely to the pelvis with the patients in the supine or prone position. The tomograms through the center of the femoral head were used for measuring the angles. The following landmarks were used (Figure 2):  $C_1$  and  $C_2$  are the centers of the femoral heads; and A and P are the anterior and posterior edges of the acetabulum.

The following angles were measured according to Anda et al. (1986):

AS, the anterior acetabular sector angle, which is the angle  $C_1C_2A$ .

PS, the posterior acetabular sector angle, which is the angle  $C_1C_2P$ .

HS, which is the horizontal acetabular sector angle (AS + PS).

AV, which is the acetabular anteversion, i.e., the angle between the line AP and a line perpendicular to  $C_1C_2$ .

### Computed tomography of femoral neck anteversion

In 11 female and 2 male patients the femoral neck ante-

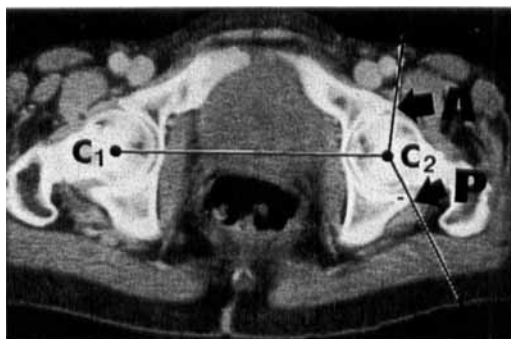


Figure 2. Transverse computer tomogram of the pelvis through the centers of the femoral head. The construction of the acetabular angles is shown.  $C_1$  and  $C_2$  are the centers in the femoral heads. A and P are the anterior and posterior edges of the acetabulum, respectively. Angle  $C_1C_2A$  is the anterior acetabular sector angle (AS). Angle  $C_1C_2P$  is the posterior acetabular sector angle (PS). Angle  $AC_1P$  is the horizontal acetabular sector angle (HS). The acetabular anteversion (AV) is the angle between the line AP and a line perpendicular to the line  $C_1C_2$ .

version was measured by means of CT as part of ordinary clinical evaluation of the anteversion. The mean age of the patients was 22 (16-31) years. The anteversion was measured on three superimposed tomograms, one through the center of the femoral head, one through the middle of the femoral neck, and one through the middle of the femoral condyles. The tomograms were made at a right angle to the long axis of the femoral shaft. The anteversion was measured as the angle between the line drawn from the center of the femoral head to the center of the femoral neck and the tangential line to the dorsal aspects of the femoral condyles.

### Statistics

Data were expressed as the mean, 1 SD, and range. Statistical evaluation was carried out using the paired or unpaired two-tailed *t*-test and by calculating the product moment correlation coefficient (*r*). When the bilateral difference of the femoral neck anteversion was significant, the right and left sides of the individuals were considered independent and pooled in the correlation analysis. When the bilateral difference was insignificant, the right and left sides were not considered independent, and the right side was used for correlation analysis. A *P*-value less than 0.05 was considered significant.

### Results

The 20 cadaver femurs had a mean anteversion of  $10.9^\circ$ , SD  $8.2^\circ$  ( $33^\circ-5^\circ$ ). The bilateral difference of femoral neck anteversion was not significant.

The bilateral differences of the P and H were significant ( $P < 0.01$  and  $0.02$ , respectively) and insignificant for A (Table 1). There was no correlation between the femoral anteversion and the cartilage parameters of the femoral head (Table 1). The correlation (*r*) between the femoral neck anteversion and A, P, H, and the ratio A/P was 0.05, 0.05,  $-0.03$ , and  $-0.12$ , respectively.

Males and females differed in the values for AS ( $P < 0.01$ ; Table 2). The other male/female differences were insignificant. The paired bilateral differences were insignificant for all the parameters.

The femoral neck anteversion of the 13 patients was  $25^\circ$ , SD  $10^\circ$  ( $6^\circ-50^\circ$ ). The bilateral differences were significant ( $P < 0.02$ ), and the right and left sides were therefore pooled in the further analysis (Table 3). The correlation (*r*) between the femoral neck anteversion and AS, PS, HS, and the ratio AS/PS and the AV was 0.14, 0.05, 0.11, 0.06, and 0.22, respectively.

Table 1. The cartilage angles degrees of the femoral head in 20 paired specimens (series I)

	Right side			Left side			Paired differences		
	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
A	115	7.7	97-125	116	10.1	85-130	-1.3	6.9	-12-12
P	107	9.3	90-125	112	8.8	94-128	-4.8	7.0	-16-6 <sup>a</sup>
H	222	13.3	187-250	228	14.5	179-253	-6.4	10.4	-26-12 <sup>b</sup>
Ratio	1.1	0.1	0.9-1.3	1.1	0.1	0.9-1.3	0	0.1	0

<sup>a</sup>  $P < 0.01$ , <sup>b</sup>  $P < 0.02$ . A anterior cartilage angle, H head cartilage angle, P posterior cartilage angle.

Table 2. The transverse angles of the right acetabulum in 17 females and 23 males with normal hips (series II)

	Right side			Left side			Paired differences		
	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
AS									
all	65.9	10.4	44-94	65.9	9.4	42-91	-0.1	8.6	-20-20
females	67.4	11.4	53-92	64.2	9.0	42-82	3.2	9.3	-20-20
males	64.8	9.5	44-94	67.3	9.5	54-91	-2.5	7.2	-16-12
PS									
all	107	11.0	82-130	107	12.4	78-145	-0.9	13.4	-31-38
females	109	11.7	94-130	109	12.9	92-145	0.1	15.8	-31-38
males	105	10.5	82-126	106	11.9	78-128	-1.6	11.3	-22-23
HS									
all	173	18.4	145-222	173	18.3	132-227	-0.9	20.8	-51-58
females	177	20.4	149-222	173	18.3	152-227	3.3	24.0	-51-58
males	169	16.2	145-209	173	18.3	132-210	-4.0	17.3	-37-33
AV									
all	19.0	4.7	10-28	19.8	5.7	7-30	-0.9	4.5	-10-12
females	19.8	4.9	11-28	21.6	5.4	10-30	-1.9	5.0	-10-12
males	18.4	4.5	10-25	18.5	5.6	7-30	-0.1	4.1	-9-6
RATIO AS/PS									
all	0.62	0.09	0.42-0.82	0.62	0.09	0.38-0.80	0	0.1	-0.1-0.2
females	0.62	0.08	0.48-0.77	0.59	0.09	0.38-0.75	0	0.1	-0.1-0.2
males	0.62	0.09	0.42-0.82	0.64	0.08	0.48-0.80	0	0.1	-0.1-0.1

AS anterior acetabular sector angle.

HS horizontal acetabular sector angle = AS + PS.

AS/PS is the acetabular ratio. The values are given in degrees. n40.

PS posterior acetabular sector angle.

AV the acetabular anteversion.

Table 3. The transverse angles of the acetabulum in 13 patients that were examined for suspected abnormal femoral neck anteversion (series III). Same denotations as in Table 2. Values given in degrees

	Mean	SD	Range
AS	76	9.5	55-95
PS	115	11.8	94-135
HS	191	18.9	149-226
AV	15	6.9	0-29
Ratio AS/PS	0.66	0.07	0.51-0.80

## Discussion

An objective of this work was to estimate whether there is a posterior rotation of the cartilaginous part of the femoral head or an altered shape of the acetabulum with increased femoral neck anteversion. Apart from the study by Reikerås et al. (1982, 1983), there are few data on these relationships.

The ratio between the anterior and posterior cartilage angles had a fairly small dispersion. This small individual variation indicates that the cartilage has a fairly constant relationship to the neck axis without adaptation to differences in the femoral neck anteversion. The same is shown by the lack of correlation of the an-

teversion to the cartilage angles or to the ratio between the angles.

The implications of the transverse acetabular anatomy has been given little attention because of difficulties in estimating this anatomy. Some radiographic methods have been designed for such an estimation (Broderick 1955, Chassard 1923, Lequesne 1971). CT offers a new and simple means of evaluating the transverse acetabular anatomy. The method has been used by Visser and Jonker (1980), Reikerås et al. (1982, 1983) and Browning et al. (1982) to determine the acetabular anteversion, which, however, does not take into account the depth of the acetabulum; a very shallow acetabulum may have a normal anteversion (Anda et al. 1986).

The tilt of the pelvis in relation to the plane through which the computer tomograms are made may influence the results. It may, however, be questioned whether more specified positioning than used in our work will give measurements that are more relevant. The tilt of the pelvis in the standing position probably varies and thus the axes of the forces acting on the hip joint. On the other hand, the normal values of the ace-

tabular angles found by us show very small variations from those obtained by Anda et al. (1986).

The patients had substantially larger than normal anteversion, and they had slightly larger acetabular angles. Browning et al. (1982) also found larger acetabular anteversion in the diseased hip than in the normal contralateral hip. However, we found no differences in the ratio AS/PS between the two groups. Therefore, although the angles may differ in magnitude, there is no inclination of the acetabular anatomy to adjust for variations of the femoral anteversion. Further, there was no correlation between the femoral anteversion and the acetabular angles. Consequently, increased femoral anteversion does not seem to be compensated for by an altered shape of the acetabulum. Our results accord with a previous study by Reikerås et al. (1983), who found no correlation between the acetabular anteversion and the femoral neck anteversion. These results thus support the hypothesis that an excessive anteversion may produce an unfavorable pressure distribution on the femoral head cartilage, particularly if a correction for toeing in is made by external rotation of the extremity.

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