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FEMORAL NECK ANGLES

A Specimen Study with Special Regard to Bilateral Differences

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The femoral neck angles were determined in 48 pairs of normal specimens from cadavers of elderly Norwegians, 24 males and 24 females. The anteversion angle was found to average 10.4° ± 6.7° and the neck-shaft angle 127.7° ± 7.6°. There were no significant differences between the sexes.
The bilateral differences were analysed. The 95 per cent confidence limits of the anteversion and head-neck-shaft angles were calculated to be 11.8 and 13.8 degrees, respectively.

Key words: angle; anteversion; femoral neck; inclination

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The proximal end of the femur has been the object of much attention. Knowledge of its anatomy is a prerequisite for a complete understanding of the mechanics of the hip joint and serves as a basis for the treatment of pathological conditions of the hip and femur. Extensive studies of normal neck angles have been carried out. The values differ considerably in the reports available. Differences in methods used, differing anatomical definitions and variations between populations may account for this.

In this paper a study performed on femoral specimens removed from the cadavers of elderly Norwegians is presented. All the specimens were taken from normal hip joints, as determined by radiograms of the hips and by inspection of the femoral specimens. The femoral neck angles were measured radiologically.

An assessment is made of the normal range of these values and the difference, if any, between the sexes. In addition, the possible correlation between the anteversion angle and the head-neck-shaft angle is investigated.

A principal objective is to evaluate the range of the normal bilateral difference of the angles. Limited data are available concerning this in a normal population. The purpose is to provide a basis for the evaluation of patients with known or assumed pathological conditions; for example, in the examination of rotational disorders after femoral fractures.

MATERIAL AND METHODS

The femoral neck angles are shown in Figure 1. The anteversion (AV) angle is defined as the angle formed by the projection of the neck axis and the knee axis on a plane perpendicular to the long axis of the femur. The neck axis is the line drawn from the centre of the femoral head to the centre of the femoral neck at the narrowest part of the neck. The knee axis is the tangent to the back of the femoral condyles. The long axis of the femur is defined as the line drawn from the middle of the femoral condyles to the middle of the greater trochanter in two planes. This corresponds to the "ideal axis" as defined by Billing (1954) and the long axis defined by Norman (1969). The head-neck-shaft (CCD caput collum diaphysis) angle is the angle formed by the neck axis and the long axis of the femur.

The material consists of 48 pairs of normal femora

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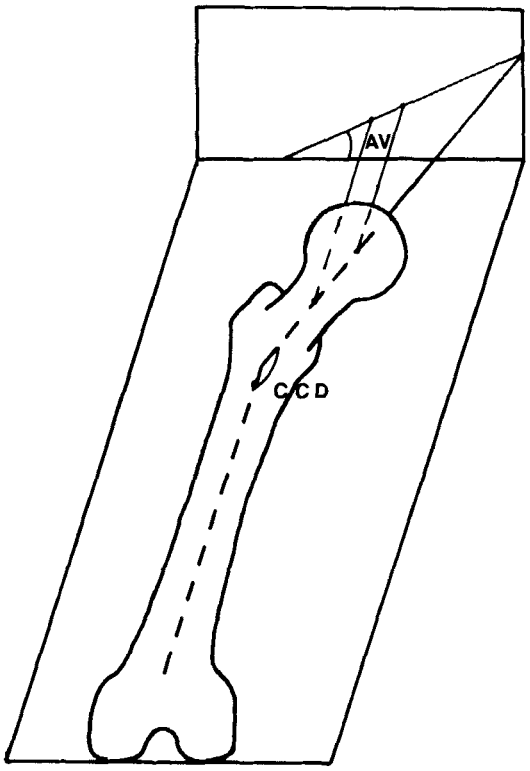

Figure 1. Definition of the anteversion (AV) angle and the head-neck-shaft angle (CCD caput collum diaphysis) angle.

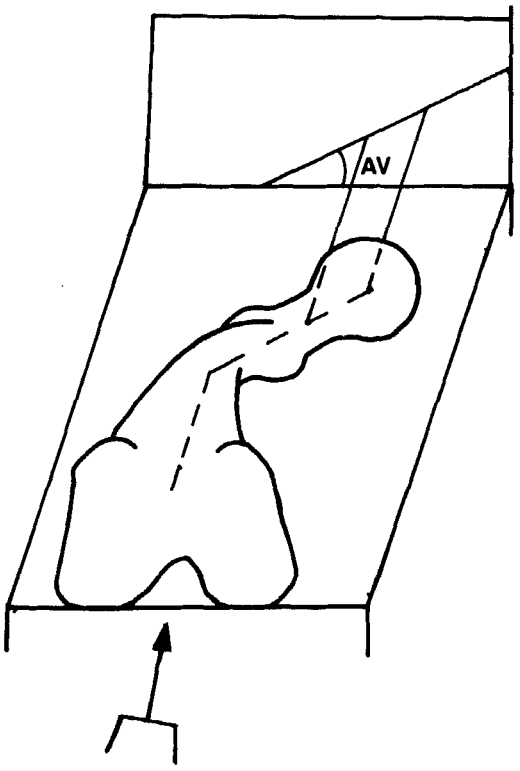

Figure 2. Projection of the femoral specimen for the radiogram to determine the anteversion angle (AV). The femur is abducted 5° from the central ray to allow projection of the neck without interference from the femoral condyles.

from elderly Norwegians, 24 males and 24 females. The AV angles were determined on radiograms taken by placing the femora on a horizontal plane. The long axis was placed parallel to the plane. The back of the femoral condyles rested on the plane. The femora were abducted 5° to the central X-ray (Figure 2). In this way the neck can be projected without interference from the condyles, and the AV angle projected can be determined. This abduction causes an error in the AV angle which is corrected by using the formula:

$$\tan AV = \tan AV' \cdot \frac{\cos (CCD' - 90 - 5)}{\cos (CCD' - 90)}$$

The AV′ and CCD′ are the projections of the AV and CCD angles.

The CCD angles were measured on radiograms of the femora taken with a vertical projection, compensating for the anteversion angle (Figure 3).

Statistical evaluation was carried out using the *t*-test and by calculating the product moment correlation coefficient. Differences were considered significant if $P \leqq 0.05$.

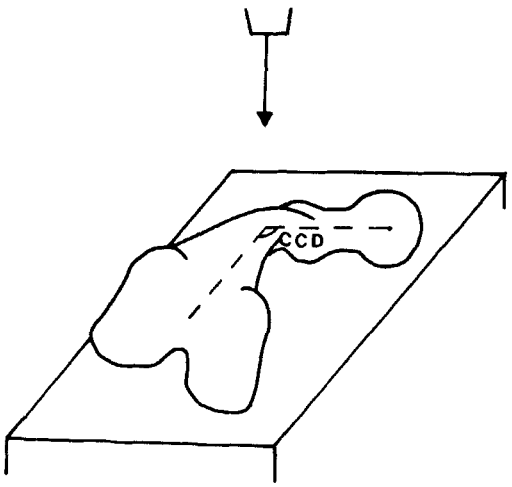

Figure 3. Projection of the femoral specimen for radiography for the head-neck-shaft angle (CCD) determination. The femur is tilted to compensate for the anteversion angle.

RESULTS

The neck angles measured are shown in Table 1. The difference between males and females was not significant.

The correlation between the AV angles and the CCD angles was poor, the coefficient being 0.26. Thus the two elements expressed by these angles are independent of each other.

In order to analyse the bilateral differences, the values from the right side were subtracted from those of the left side for each pair of specimens. This gave a close to normal distribution of the differences with the mean at 0°. To determine the absolute difference of the angles, the number of values was plotted against the difference of the angles in absolute values (Figures 4 and 5). The points do not show the S-shape which is characteristic of a normal distribution. However, the plots showed a very good correspondence with a logarithmic function, allowing the use of parameters pertinent to this function. The derivative of the function obtained in the plots was used to find a connection between the probability value and the absolute value for the difference in the AV angle and the CCD angle. This connection was expressed by the following equations:

$$|R\text{–}L|\ AV = -\frac{1n\ P}{0.25425}$$

$$|R\text{–}L|\ CCD = -\frac{1n\ P}{0.21695}$$

In these equations P is the level of significance or the probability value. $|R\text{–}L|$ AV and $|R\text{–}L|$ CCD are the bilateral differences of the AV angle and the CCD angle in absolute values. By substituting P for any level of significance, the absolute values of the difference can be determined for that level of significance (Colquhoun 1971).

Table 1. The femoral neck angles in 96 normal specimens from cadavers of elderly Norwegians. Mean (± standard deviation)

Specimens	*n*	Degrees	
		AV angle	CCD angle
Female	48	10.7 (±6.5)	127.0 (±7.2)
Male	48	10.2 (±6.9)	128.3 (±7.9)
Total	96	10.4 (±6.7)	127.7 (±7.6)

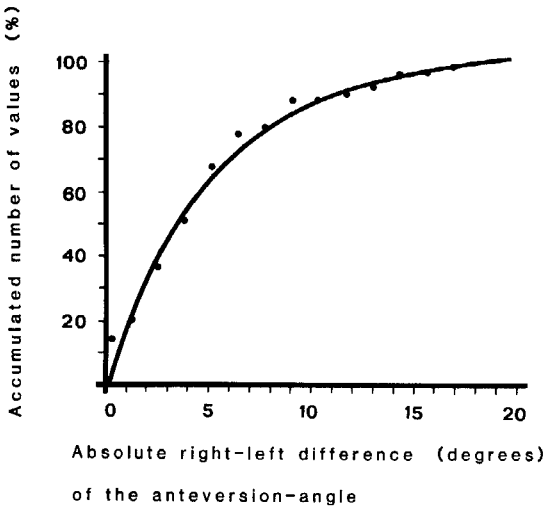

Figure 4. Cumulative frequency polygon to show the accumulated number of values plotted against the absolute value of the right-left difference of the anteversion angle. The total number of accumulated values is 48, the same as the total number of pairs of femora.

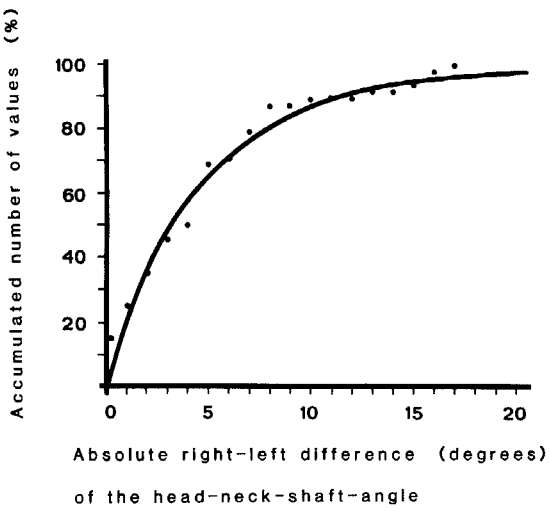

Figure 5. Cumulative frequency polygon to show the accumulated number of values plotted against the absolute value of the right-left difference of the head-neck-shaft angle. The total number of accumulated values is 48, the same as the total number of femora.

DISCUSSION

The lack of precise anatomical definitions of the femoral neck angles is often a problem in the literature. The nomenclature concerning the AV angle is not uniform (Henriksson 1980). Our definition agrees with several others. In our opinion the definition quoted is valuable for the understanding of the mechanics of the hip joint in relation to the functional anteversion of the femoral neck.

Numerous investigators have studied the AV angle. Most studies have been carried out on dried femora (Kingsley & Olmsted 1948, Lanz 1951, Getz 1955, Lofgren 1956). The AV angle in living persons has been determined by a variety of radiological methods (Henriksson 1980). It is a recognized fact that the angle decreases during growth to values of 8°–16° at maturity. Also the CCD angle shows a slight age-linked decrease to values of 126°–132° in the adult (Kingsley & Olmsted 1948, Lanz 1951, Shands & Steele 1958, Zippel 1971, Hamacher 1974).

Racial differences in angles have been described. In an anthropometric study of the hip joint in Norwegian Lapps, Getz (1955) found that the angles were greater in a normal Lapp material than in a normal Norwegian material. In the latter group the mean values of the AV and CCD angles were 10.1° and 125.1°, respectively. Our results agree well with the values reported.

Various observations have been made regarding sex differences in femoral neck angles. In children, Cyvin (1977) found that the AV angles were, on average, 3° larger in girls than in boys, but the difference in adult femoral specimens has been reported to be negligible (Kingsley & Olmsted 1948). The various studies do not indicate any difference in CCD angles, and the present investigation reveals that sex differences in femoral neck angles are of no practical importance.

Few reports deal with bilateral differences. Kingsley & Olmsted (1948) reported that the AV angle of the right femur was, on average, 1° greater than that of the left. According to Cyvin (1977) an asymmetry in AV angles of over 10° was found in 25 per cent of normal children. The mean values of the right side were higher than those of the left. In our study the average bilateral differences in femoral neck angles were not significant, but individual variations were considerable. Knowledge of this normal asymmetry of the right and left hip may be of great value in the evaluation of correctional osteotomies in cases of femoral fractures which have healed with rotational deformities. According to Benum et al. (1979) a bilateral difference of 5° in AV angle indicates a rotational disorder.

The formulae presented in this paper give the confidence limits of the normal asymmetry in femoral neck angles. A confidence interval of 95 per cent ($P = 0.05$) implies limits of the bilateral difference of 11.8° and 13.8° for the AV and CCD angles, respectively. This means that when 95 per cent of a normal population is included, the differences mentioned above must be expected.

The formulae and the accumulation curves presented are intended as an aid for future work on this subject, serving as a basis for comparison with pathological conditions. We also hope that this work may be helpful in clinical practice when treating pathological conditions of the hip joint.

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