Torsion of the leg determined by computed tomography

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Torsion of the leg was measured in 50 adults by computed tomography. The tangent to the dorsal aspect of the femoral condyles gave the proximal reference line. The distal reference line joined the centers of the medial and lateral malleoli. Tibial torsion was measured as the inclination between the dorsal tangent to the tibial condyles and the distal reference line, and torsion of the leg was measured as the inclination between the proximal and the distal reference lines. The anatomy of the dorsal aspects of the tibial condyles was more inconsistent than the anatomy of the dorsal aspects of the femoral condyles. In the females the external torsion of the leg was 38 ±9° on the right side and 37 ± 11° on the left side. In the males the values were 41 ± 6 ° and 40 ± 10°, respectively.

Tibial torsion is neutral at birth, i.e., the malleoli are about level. The medial malleolus rotates forwards during growth, causing tibial torsion in the adult of approximately 20° (Le Damany 1909, Hutter and Scott 1949, Staheli and Engel 1972).

Measurements of tibial torsion are difficult. Clinical measurements give only approximate values (Wynne-Davis 1964, Staheli and Engel 1972, Herold and Marcovich 1976, Turner and Smillie 1981). Conventional radiographic methods are complex and have only limited reliability (Herold and Marcovich 1976).

During recent years, different techniques based on computed tomography (CT) have been described (Jakob et al. 1980, Jend et al. 1981). In a critical analysis, it was concluded that they all had too wide variation to be clinically useful (Laasonen et al. 1984). However, Takai et al. (1985) measured torsional alignment of the lower limb in gonarthrosis by using reference lines to the dorsal aspects of the femoral and tibial condyles. We have evaluated this technique for measuring torsional alignment of the leg in a normal adult population.

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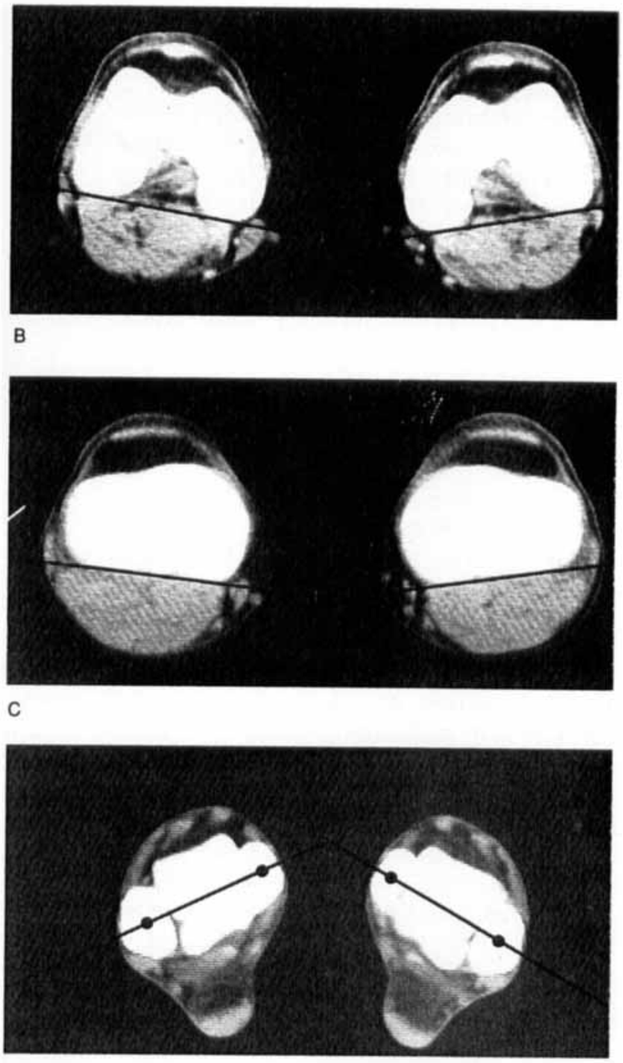
Methods

The study included 26 females and 24 males in whom CT was performed for disorders other than abnormalities of the lower extremities, and who all gave their informed consent for additional scanning of the knee region and distal end of the legs. The mean age was 39 and 35 (16–70) years for the females and males, respectively. A General Electric 8800 CT equipment was used. The patients were placed in the supine position with the hips and knees fully extended and the thighs and legs horizontal and parallel. A sequential series of 10-mm-thick tomograms were obtained through the femoral and tibial condyles (Figure 1). These gave proximal reference lines as the tangents to the dorsal aspects of the condyles. A tomogram just below the articular cartilage of the ankle joint was selected for the distal reference line, drawn from the center of the lateral malleolus to the center of the medial malleolus. Tibial torsion was measured as the inclination between the dorsal tangent to the tibial condyles and the distal reference line by superimposing the images. Torsion of the leg was measured as the inclination between the dorsal tangent to the femoral condyles and the distal reference line. The external torsion of the knee was measured as the inclination between the dorsal tangents to the femoral and tibial condyles.

In 33 patients, two slices of the right tibial condyle proximal to the fibular head were obtained, and the variability of the anatomy of the tibial condyles was expressed as the difference in inclination between the reference lines in the two tomograms. In 38 patients, two

A



B

C

D

Figure 1. Computed tomography for measurements of torsional alignment of the leg.
A. Sequential series of 10-mm-thick tomograms through the femoral and tibial condyles.
B. Proximal reference line determined as the dorsal tangent to the femoral condyles.
C. Proximal reference line determined as the dorsal tangent to the tibial condyles.
D. Tomogram just below the articular surface of the ankle joint. Distal reference line delineated from the center of the lateral malleolus to the center of the medial malleolus.

to three slices of the femoral condyles were obtained, and the variability of the anatomy of the femoral condyles was expressed as the difference in inclination between the reference lines in the tomograms.

In 20 randomly selected patients, the authors performed measurements of the right leg, with an intervening period of 6 months. The reproducibility of the measurements was determined as the standard deviation of the paired interpersonal and intrapersonal differences.

Data are expressed as mean ±SD of the mean, and the statistical evaluation was carried out by the paired and nonpaired, two-tailed *t*-test. $P < 0.05$ was considered significant.

Results

The anatomy of the dorsal aspects of the tibial condyles was more inconsistent than that of the femoral condyles. The difference in inclination between the dorsal tangents of the tibial condyle varied from +4° to –5°, i.e., more than that of the femoral values, which varied from +1° to –1°.

In the females the external rotation of the knee was 5.7 ± 4.6° and 6.4 ± 4.9° for the right and left sides, respectively. In the males the values were 5.3 ± 4.9° and 5.6 ± 4.1°, respectively.

Tibial torsion, determined as the inclination between the dorsal tangent to the tibial condyles and the distal reference line, was in the females 32.3 ± 8.5° and

30.7 ±10.4° for the right and left sides, respectively. In the males the values were 35.3 ±7.6° and 34.0 ±10.3°, respectively.

Torsion of the leg determined as the inclination between the dorsal tangent to the femoral condyles and the distal reference line is shown in Table 1. There was a greater range of values in the females than in the males, but the differences between the sexes were not significant.

The interpersonal variation of the measured values was 0.4 ±2.1 (–6 to +4)°. The intrapersonal variation of the values was 0.7 ±1.9 (–3 to + 6)°.

Discussion

Tibial torsion has been defined as the angle formed by the articular axes of the knee and ankle joint (Le Damany 1909). In the literature, there is, however, no standard for measurements. In anatomic studies, tibial torsion has been measured by anthropometric techniques (Le Damany 1909). Such methods cannot be used clinically, but similar devices have been used (Wynne-Davis 1964, Khermosh et al. 1971, Staheli and Engel 1972, Herold and Marcovich 1976, Turner and Smillie 1981). The various definitions make, however, these methods imprecise. There is also general agreement that pseudoaxial radiographic methods as described by Hutter and Scott (1949), Rosen and Sandick (1955), Wangarnez and Lababe (1975) are imprecise. Differences in measuring methods and in definitions explain why previous reports on tibial torsion in adults vary, on the average, from 14 to 24°.

During recent years, methods based on CT have been described. None of these have, however, reached a standard for measurements. Jacob et al. (1980) and Yagi and Sasaki (1986) determined the proximal reference line by the transverse axis of the tibia, whereas Jend et al. (1981) used the dorsal aspect of the tibia. Distally, Jacob et al. (1980) used the transverse axis of the tibia as the reference line, whereas Jend et al. (1981) and Yagi and Sasaki (1986) used the transmalleolar axis. These authors reported average values of external tibial torsion that varied from 24 to 40°. Such inconsistent results agree with the observation of Laasonen et al. (1984), confirmed by us, that it is difficult to determine precise reference lines on CT scans of the tibia, both proximally and distally, because of its rounded form. We therefore recommend the dorsal tangent to the femoral condyles as the proximal reference line for measurements of torsional alignment of the leg. Further, we selected a tomogram just below the articular cartilage of the ankle joint, which clearly visualized both malleoli. Our interpersonal and intrapersonal analyzes showed that this method for measuring torsion of the leg has a high degree of precision. It may be argued that a femoral reference line for measuring tibial torsion only gives indirect estimations. However, the extended knee does not allow rotation except in patients with joint instability. In such cases and in cases with other rotational abnormalities between the femur an tibia, measurements of knee-joint derangements and tibial torsion might be evaluated by using the dorsal tangent to the tibial condyles.

It has been claimed that patients with increased femoral anteversion have a compensatory external torsion of the legs. In these patients the degree of femoral neck anteversion can be determined by CT using the dorsal tangent of the femoral condyles. By the present method, this line can simultaneously be used for evaluation of tibial/leg torsion.

Takai et al. (1985) found an external torsion of the leg of about 20–25°. This difference from our results may be explained by possible instability due to arthrosis. Differences between populations and races should, however, also be considered.

In cases with rotational malalignment after a tibial fracture and in cases with unilateral abnormalities of the lower limb, it is natural to make comparisons with the unaffected side. In our series, there were no significant differences between the right and left legs. There were, however, individual variations, so a bilateral difference up to 10° can normally be expected.

Table 1. Measurement (°) of external torsion of the leg in 26 female and 24 male Norwegian adults

	Mean	*SD*	Range	95% confidence limits
Females				
right leg	38	*9.2*	14–59	20–56
left leg	37	*11.6*	9–63	14–60
Males				
right leg	41	*6.1*	31–51	29–53
left leg	40	*9.8*	25–57	21–59

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