Varus inclination of the distal femur and high tibial osteotomy
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We have analysed retrospectively the relationship between the axial parameters of alignment of the lower limb and the recurrence of varus deformity after high tibial osteotomy. We studied 29 patients (37 knees) with a mean age at surgery of 66 years. The mean follow-up was for 7.4 years (5 to 10.5). Recurrence of varus deformity was defined as an increase in the femorotibial angle of 3° or more, compared with that obtained six months after the operation. There were four patients (four knees) with recurrence of varus deformity. They had a greater varus inclination of the distal femur than those without varus recurrence.

An association between varus inclination of the distal femur and horizontal obliquity of the joint surface was observed. Excessive obliquity prevents the shift of weight-bearing to the lateral compartment, and may cause a recurrence of varus deformity after high tibial osteotomy.

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High tibial osteotomy has long been used as surgical treatment for medial osteoarthritis of the knee. The importance of accurate realignment of the femorotibial axis has been recognised1-16 and that a slight overcorrection gives the best results. It is therefore important to obtain precise alignment of the lower limb at the time of operation. Recurrence of varus over a period of years has been reported and loss of the correction may lead to a poor result.7-9,17

We have previously analysed how axial alignment influences femorotibial alignment after high tibial osteotomy and have shown an association between a varus inclination of the distal femur, in relation to the femoral shaft, and a tilt of the tibial articular surface towards the horizontal plane.18 Even although the femorotibial angle (FT) of these knees was within the optimal range, they showed an unfavourable tendency towards increased tilting.

In this study, we have considered the influence of the axial alignment of the distal femur on the alignment of the lower limb after corrective surgery and attempted to determine the factors which influence the recurrence of varus deformity.

Patients and Methods

Between 1988 and 1993, we performed a high tibial osteotomy on 43 consecutive patients (53 knees) with osteoarthritis of the medial compartment of the knee. Of these, eight patients (nine knees) could not be traced and/or refused to undergo a follow-up examination. Two (three knees) had suffered a cerebrovascular accident, two (two knees) had died, and two (two knees) had a replacement arthroplasty. All 14 patients (16 knees) were excluded from the study. The remaining 29 patients (6 men and 23 women; 37 knees) had a mean age of 66 years (46 to 76) at the time of osteotomy. The mean follow-up was 7.4 years (5 to 10.5). In all cases we used the dome osteotomy technique described by Maquet.13

All patients were assessed before surgery and at follow-up, using the 100-point rating scale of the Hospital for Special Surgery (HSS).19

Standing anteroposterior radiographs were taken using 35 × 43 cm films before the operation, immediately after operation, at six months, one year, and then annually. A plumb line was hung on the film cassette to show the vertical axis.20 Care was taken to ensure that the patella was facing directly forwards. The five angles were measured from the preoperative and postoperative radiographs as shown in Figure 1.

Intra- and interobserver reproducibility of the five angles was assessed by reading 20 selected films, twice in two weeks. In order to determine the most likely sources of radiographic error in the positioning of the patients, five
patients (10 knees) had radiography twice in one week. We have defined recurrence of varus deformity as an increase of more than 3° in the FT angle compared with that obtained six months after the operation.

Statistical analysis. Statistical differences between the pre-operative and postoperative mean values were analysed using Student’s t-test and among groups by the unpaired t-test. The Mann-Whitney U test was used for comparisons of clinical scores. We used a linear regression model to evaluate the association between the axial angular parameters. P values of less than 0.05 were considered to be statistically significant.

Results

Table I gives the normal values for the six measurements. The intra- and interobserver variation was one degree or less for the five angles. Table II gives the mean differences in measurement between the two radiographs taken in one week. The difference in measurement in one FC-TP, one

![Diagram showing the angular measurements used. F₁ and F₂ were bicortical centres located 7 cm and 15 cm above the surface of the knee and T₁ and T₂ were bicortical centres located 7 cm and 15 cm below the surface of the knee, respectively. F₁ F₂ is the anatomical axis of the distal femur and T₁ T₂ the anatomical axis of the proximal tibia. HL is a line tangential to the distal femoral condyles connecting the distal aspects of the medial and lateral condyles. FT is the femorotibial angle, FC-FS the femoral condyle-femoral shaft angle, FC-TP the femoral condyle-tibial plateau angle, TP-TS the tibial plateau-tibial shaft angle and TP-H, the tibial plateau-horizontal angle. The FT angle is the angle between the anatomical axis of the femur and that of the tibia. The FC-FS angle is the angle between the anatomical axis of the femur and the tangent to the subchondral plates of both femoral condyles. The FC-TP angle is the angle between the tangent to the subchondral plates of the femoral condyles and the tangent to the subchondral plate of the tibia. The TP-TS angle is the angle between the tangent to the subchondral plate of the tibia and the anatomical axis of the tibia. The TP-H angle is the angle between the tangent to the subchondral plate of the tibia and the horizontal axis in the standing position. A positive TP-H angle represents an inferolateral slope of the joint surface. The medial joint space (MJS) was measured between the tip of the medial femoral condyle and the tangent to the subchondral plate of the tibia. All measurements were made using a pencil and ruler. Normal values were established by measuring the angles in 20 male volunteers (40 knees) of mean age 30 years (25 to 45).
TP-TS and two TP-H angles was 2°; the other differences were 1° or less, confirming reproducibility. Table III gives the mean preoperative and postoperative axial parameters for 37 knees. Four patients (four knees) had a recurrent varus deformity. The magnitude of recurrence was 4° in one knee, 5° in one and 7° in two knees. There was no difference between the four knees with recurrence and those without with regard to the preoperative FT angle, the FC-TP angle, the TP-TS angle or the FT angle six months after operation. The knees with recurrence, however, had significantly greater FC-FS angles (Table III); they were 83° or more. These results indicate that the group with recurrent varus had significant varus inclination of the distal femur. Twelve knees with a substantial varus inclination of the distal femur had an FC-FS angle of 83° or more, but eight did not show varus recurrence. Of these eight, two had an FT angle of 167°; the other six were overcorrected with an FT angle of less than 165°.

The preoperative FC-FS angle correlated with the postoperative TP-H angle (R = 0.56, p < 0.01), and also with the postoperative MJS (R = -0.52, p < 0.01). These results show that the knees with a large FC-FS angle had a greater tilt of the tibial articular surface from the horizontal and a small opening of the MJS.

The mean preoperative HSS score was 60 points (51 to 76). The mean postoperative score had been significantly improved to 84 points (55 to 98). The postoperative score in the knees with recurrence of varus was 65 points (55 to 75) and in those without recurrence 88 points (65 to 98). The difference is significant (p < 0.01).

Discussion

The cause of recurrence of varus deformity after high tibial osteotomy remains uncertain. In our study, recurrence was identified in four of 38 knees (11%) at a mean of seven years after surgery. These knees showed notable varus inclination of the distal femur and a greater horizontal obliquity of the tibial joint surface. Our findings suggest that the varus inclination of the distal femur is responsible for recurrence of varus deformity after high tibial osteotomy. Previous studies have suggested that this excessive obliquity of the tibial joint surface from the horizontal prevents the shift of weight-bearing to the lateral compartment, and causes the recurrence of varus deformity after high tibial osteotomy. Our study indicates that we can predict a postoperative tilt of the tibial articular surface relative to the horizontal and the postoperative opening of the medial joint space, by measuring the FC-FS angle.

Rinonapoli et al. evaluated 58 high tibial osteotomies at a mean follow-up of 15 years. Their study showed no significant correlation between recurrent varus and unsatisfactory results. By contrast, recurrence of varus was associated with poor results in our cases. This conflict could be explained by the differing stages at which the recurrence occurred. In the patients of Rinonapoli et al, recurrence took place gradually and seemed to be due to progressive degeneration. In our patients, there was recurrence at a relatively early stage after operation. The initial correction of these knees had been deemed acceptable; the recurrence of deformity was thought to be due to mechanical failure.

Jackson and Waugh stated that proximal tibial osteotomy is a reliable procedure for osteoarthritis of the knee when varus angulation occurs in the proximal aspect of the tibia. It is generally agreed that this is usually the case. However, a wide variation in angles between the tangent of the condyles and the femoral shaft has been reported. Our findings suggest that there are some varus knees in which the deformity partly lies in the distal femur. Since these knees tend to have recurrent varus in the early postoperative phase after high tibial osteotomy, it is important to consider the slope of the distal femur, described as the FC-FS angle in our study. There were 12 knees in our series which showed a significant inclination of the distal femur, eight of which did not develop a recurrent varus deformity; six knees had an FT angle of less than 165°, which is a large overcorrection.

When encountering the varus knee with a substantial varus inclination in the distal femur, we recommend overcorrection to an FT angle of less than 165°, i.e., a distinctly valgus knee. Cosmetic considerations are important for patients, however, and the limit of appropriate overcorrection is thought to be 164°. Otherwise, total joint replacement or unicompartmental knee arthroplasty should be performed. Double osteotomy about the knee is a very invasive procedure and we do not recommend it.

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References


