A total of 30 patients who underwent endoscopic reconstruction of the anterior cruciate ligament using quadrupled hamstring tendons, through a single drill hole in the femur, had MRI 24 to 28 months after operation. In 18 patients the scans revealed that both the anterior and posterior portions of the graft ran in parallel from the inside of the femoral to the tibial tunnel. In 12, the posterior bundle had moved anteriorly and the anterior bundle could not be identified at the anterodistal border of the femoral tunnel. The mean difference in the anterior laxity, when compared with the contralateral knee, was 2.0 ± 1.7 mm and 4.3 ± 2.8 mm for the two types, respectively. Damage to the anterior bundle may occur when using the endoscopic technique because of biomechanical disadvantages, including concentration of loading and repetitive bending stress in the anterior bundle at the opening of the femoral tunnel.

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After endoscopic reconstruction of the ACL using quadrupled hamstring tendons there is inevitably a significant change in the angle of the graft at the intra-articular opening of the femoral tunnel during flexion and extension. Since this angle is smallest at full extension, when the graft is subjected to the highest tension, some local damage may occur with the passage of time, leading potentially to abnormal laxity (Fig. 1).

MRI is a useful method of evaluating the soft-tissue structures of the knee. Previous studies assessing ACL grafts have concentrated on the signal intensity. Recent reports have shown conflicting results, since the change in signal intensity may involve many biological factors, including the water content, neovascularisation and synovial infiltration. We have recorded the direction of the anterior bundle of the graft, and correlated damage to this part of the graft, as seen on MRI, with restored stability after endoscopic reconstruction of the ACL using quadrupled hamstring tendons.

Patients and Methods

We selected randomly from our cases of reconstruction of the ACL carried out between June 1995 and March 1997, 30 patients (30 knees), with a mean age of 26 years (15 to 45), who had undergone endoscopic repair using quadrupled hamstring tendons through a single femoral tunnel and meniscal repair or partial meniscectomy. In all, lengthening of the graft by 1 to 3 mm in extension was confirmed using the Isometric Positioner with a folded No. 2 suture (Acufex Microsurgical Inc, Mansfield, Massachusetts). Impingement of the graft was avoided by careful arthroscopic observation and by notch and roof plasty when required. The graft was fixed with an Endobutton (Smith & Nephew Endoscopy,
Andover, Massachusetts) on the femoral side and sutured around a screw on the tibial side, after the anterior edge of the femoral tunnel had been chamfered. All operations were performed by the senior author (KS). Postoperatively, all patients followed the same rehabilitation programme. Movement and exercises to strengthen the thigh muscles were started on the seventh day after operation and full weight-bearing without crutches was usually achieved within five weeks. In 20 patients, who underwent concomitant meniscal repair, rehabilitation was delayed by one week. Jogging was allowed at four months, and return to contact sports at eight to nine months.

**MRI evaluation.** Each patient underwent MRI to evaluate the repaired menisci at a mean of 24.4 months (24 to 28) after surgery. The studies were performed with a dedicated knee coil on a 0.2-T Magnetom (MRP20EX; Hitachi, Tokyo, Japan). The knee was positioned in 20° external rotation. T1- (TR = 700, TE = 20) and T2-weighted (TR = 600, TE = 15) sagittal oblique imaging was obtained using 4 mm slices, four signal acquisitions and a 160 mm field of view. The entire length of the ACL graft, including the femoral and tibial tunnels, was imaged. The patients were classified into two types based on the appearance of the graft on the T1-weighted image, on which we relied to achieve maximum anatomical definition. In type 1, both the anterior and posterior portions of the graft ran in parallel from inside the femoral to the tibial tunnel. In type 2, the posterior bundle had moved anteriorly and the anterior bundle could not be seen at the intra-articular opening of the femoral tunnel, suggesting damage to the anterior bundle at this site (Fig. 2). All images were evaluated by an independent observer who was blinded to the restored stability of the knee.

**Knee stability.** Measurements of both knees were made simultaneously using a KT-1000 Knee Arthrometer (Med-Metric Inc, San Diego, California) combined with MRI. The difference in the anterior laxity, compared with the contralateral knee, was used to determine restored stability of the knee.

**Activity level.** At follow-up at two years the activities of each patient who had undergone MRI were categorised into four levels according to the International Knee Documentation Committee Knee Ligament Evaluation Form. Level I comprised patients undertaking jumping, pivoting and/or such sports as basketball, football or judo. Level II included those who undertook heavy manual work, ski-ing or tennis. Level III included patients who undertook light manual work or who jogged, and level IV, those in sedentary employment.

**Analysis of data.** The Student’s unpaired t-test was used to assess the stability of the knee. The Mann-Whitney and chi-squared tests were used, respectively, to compare levels of activity and combined meniscal injury between the two types. Significance was based on p < 0.05 and one standard deviation was used to describe the variability of the means.

**Results**

The entire length of the graft, from the femoral tunnel to its tibial insertion, could be demonstrated on all MR scans; no significant impingement was seen. In 18 of 30 patients (60%) the appearance of the graft was classified as type 1 and in 12 (40%) it was type 2. The mean values for the difference in anterior laxity between the two knees were 2.0 ± 1.7 mm and 4.3 ± 2.8 mm, respectively, for type 1 and type 2; this difference was statistically significant (Fig. 3; p = 0.0090).

The activity levels of the type-1 and type-2 patients at the follow-up at two years are shown in Table I. Associated
meniscal injuries are shown in Table II. There was no significant difference in the activity level of patients (p = 0.64) or the type of meniscal injury (p = 0.53) between the two groups although the numbers were small.

Discussion

While previous investigators have concentrated on the signal intensity in the MRI appearance of the ACL graft for its evaluation, they did not record which portion of the graft was responsible for the restored stability.  

Our study has shown that damage to the anterior portion of the graft at the femoral tunnel could be one of the factors responsible for residual laxity after this type of reconstruction. A well-recognised cause for an abnormal appearance on MRI is impingement of the graft at the intercondylar notch, but this is unlikely to explain our observations since the damage to the anterior bundle extended from the intra-articular opening of the femoral tunnel. Moreover, we saw no impingement of the graft either on MRI or at arthroscopic examination during reconstruction. Another possible cause is excessive loading on the anterior bundle at the anterior edge of the intra-articular opening of the femoral tunnel on extension of the knee. The concentration of stress in this portion could also be exacerbated by flexion and extension (the windshield wiper effect) and an anteriorly directed compressive force produced by the tightened posterior bundle in extension. Such biomechanical stresses are inevitable when using a multistranded hamstring graft in a single femoral tunnel particularly with the endoscopic technique.

We were not able to perform a second-look arthroscopy in all the patients. We did, however, record second-look arthroscopic findings in five patients of type 1 and six of type 2 which accorded with the MRI findings. Moreover, we did not observe impingement of the graft in any cases.

Although all the patients in our study underwent the same operative procedure and rehabilitation programme, some had damage to the anterior elements of the graft, as seen on MRI, and others did not. There was no correlation between levels of activity and abnormality on MRI. Although the exact mechanism by which the biomechanical problems are induced remains uncertain, we propose several methods for minimising them. First, we advise using the graft with a bone plug, since the bone-tendon junction can be located at the opening of the femoral tunnel. Secondly, aggressive rehabilitation should not start until bone-tendon healing at the femoral tunnel is secure, since movement of the graft within the femoral tunnel can damage it at the opening. Recent studies have also shown the deleterious effect of early aggressive rehabilitation on healing of the ACL graft.  

Finally, a two-tunnel technique can be used on the femoral side, since the posterior bundle which compresses the anterior bundle against the anterior wall of the femoral tunnel can be placed postero-distally, leading to reduced stress at the graft-tunnel junction by increasing the contact area.

We have shown, on MRI, that damage to the anterior elements of the graft, could be one of the factors responsible for residual instability after ACL reconstruction by endoscopy with autografts of quadrupled hamstring tendon. This may be associated with biomechanical problems when using a single femoral tunnel.

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References


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