Endoscopically-assisted single-bundle posterior cruciate ligament reconstruction
RESULTS AT MINIMUM TEN-YEAR FOLLOW-UP

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We evaluated the long-term outcome of isolated endoscopically-assisted posterior cruciate ligament reconstruction in 26 patients using hamstring tendon autografts after failure of conservative management. At ten years after surgery the mean International Knee Documentation Committee subjective knee score was 87 (SD 14) of a possible 100 points. Regular participation in moderate to strenuous activities was possible for only seven patients pre-operatively; this increased to 23 patients post-operatively. The mean Lysholm score improved from 64 (SD 15) to 90 (SD 14) at ten years (p = 0.001).

At ten years endoscopic reconstruction of the posterior cruciate ligament with hamstring tendon autograft is effective in reducing knee symptoms. Of the series, 22 patients underwent radiological assessment for the development of osteoarthritis using the Kellgren-Lawrence grading scale. In four patients, grade 2 changes with loss of joint space was observed and another four patients showed osteophyte formation with moderate joint space narrowing (grade 3). These findings compared favourably with non-operatively managed injuries of the posterior cruciate ligament.

This procedure for symptomatic patients with posterior cruciate ligament laxity who have failed conservative management offers good results.

The short-term results of arthroscopic reconstruction of the posterior cruciate ligament (PCL) are well documented. Yet, many studies show inconsistencies in operating techniques using multiple grafts, lack homogeneity of the patient group with some reports including combined injuries of the anterior cruciate ligament (ACL), or posterolateral instability. Nevertheless, most studies on PCL reconstruction show improvement of knee function with fewer symptoms than in patients treated conservatively. No studies have evaluated the long-term results of endoscopic PCL-reconstruction. Although data about radiological degenerative changes are available in the mid-term, the development of osteoarthritis in the long-term is still unknown.

We prospectively studied a group of 30 patients with isolated PCL laxity who had failed conservative treatment, at a minimum of ten years after operation.

Patients and Methods

Between June 1994 and December 1996, 30 patients underwent arthroscopic reconstruction for isolated PCL laxity, of not less than three months duration, under the care of the senior author (LAP). All patients had failed conservative treatment which had consisted of physiotherapy and quadriceps strengthening exercises for at least 14 weeks. There remained, however, pain or instability which prevented them from returning to such activities as sprinting, running downhill and deceleration. Before surgery all patients had at least grade 2 laxity on posterior drawer testing. Radiographs were used to find and exclude patients with bony avulsion fractures. Patients with injuries to the posterolateral corner combined with PCL injuries, as defined by an increased dial test of at least 20° at both 30° and 90° of knee flexion were also excluded as were patients receiving compensation for their injury.

Surgical technique. All the operations were performed by the senior author (LAP). The surgical technique used has been described previously. The patient is positioned supine with a thigh support and a footrest to hold the knee at 80° of flexion. Intravenous antibiotics are administered before inflation of a high thigh tourniquet. A standard arthroscopic examination of the joint is performed using low anterolateral and high anteromedial portals. Only the anterolateral remnants of the PCL are removed. Postero-
The femoral tunnel is placed 8 mm to 10 mm from the anterior or distal medial femoral articular margin on a line continuous with the junction of the roof and medial wall of the intercondylar notch. The femoral tunnel is initially drilled with a 4.5 mm AO drill (Synthes Inc, Ontario, Canada) using the anterolateral portal. Through a separate longitudinal proximal tibial incision, the semitendinosus and gracilis tendons are harvested and fashioned to form a three- or four-strand graft with a minimum length of 13 cm. The tendons at the proximal and distal ends of graft are sutured using a whipstitch. The central, intra-articular, 4 cm of the graft remains free of suture material. The diameter of the graft is ascertained using a sizer demarcated in 0.5 mm increments. A mark is made 30 mm from the free end of graft with a methylene blue pen, allowing for confirmation of complete docking of the graft into the femoral tunnel at final insertion. Then a 2.4 mm Beath pin (Smith and Nephew, Andover, Massachusetts) is passed through the femoral tunnel, and over this a cannulated drill reamers the distal portion of the tunnel to a depth of 30 mm at the pre-determined diameter of the hamstring graft. A posteromedial portal is created under direct vision, and the most distal insertion of the PCL on the proximal tibia is elevated with a curette through this portal. A ‘C-arm’ AO drill guide is inserted through the posteromedial portal and a tibial hole, made using a 4.5 mm drill directed from anterior to posterior. A 2.4 mm Beath pin is then advanced through this hole with the blunt end leading, to which a clip is attached at its end via the posteromedial portal to act as a stop for subsequent reaming. This tunnel is then reamed according to the diameter of the graft. A pull out suture is threaded in a retrograde fashion. Using this, the 4-strand hamstring graft is pulled through the tibial tunnel and then docked into the femoral tunnel. Proximal femoral fixation is obtained using a 7 mm × 25 mm titanium round-head cannulated interference screw (RCI; Smith and Nephew, Andover, Massachusetts) inserted over a guide pin. The graft is then tensioned, the knee taken through at least ten range-of-motion cycles, and a 7 mm × 25 mm RCI screw inserted partially at 90° of knee flexion. After the first threads of the screw have engaged, the knee is extended and the screw fully introduced and seated at the most posterior part of the tibial hole. In the event of a short graft ending inside the tibial tunnel, graft sutures are tied over the neck of a cortical post screw (Smith and Nephew) which is inserted into the tibial bone. If the graft is overlong or found to protrude from the anterior tibial tunnel, supplementary fixation is obtained with the use of a staple. The patient is allowed to commence full weight-bearing as tolerated without a brace and intensive physiotherapy is started on the day of surgery using closed-chain exercises focusing on quadriceps strengthening. Resisted hamstring exercises are contraindicated for six weeks.

Review. At ten years follow-up symptoms and signs of knee function were assessed according to the guidelines of the International Knee Documentation Committee (IKDC). The level of sporting activity was assessed according to the IKDC levels 1 to 4, which correspond respectively to strenuous (rugby, basketball), moderate (skiing, tennis, heavy manual labour), light (jogging), and sedentary activities. The subjective symptoms were evaluated using the Lysholm knee score. It evaluates specific symptoms such as limp, lack of support, locking, instability, pain, swelling and difficulty in stair-climbing and squatting. The highest obtainable score is 100. Lachman’s test, posterior drawer and reverse pivot-shift tests were used to assess posterior translation and side-to-side difference. A reverse pivot shift is positive if a sensation of reduction is appreciated when the flexed externally rotated knee is extended with a valgus stress. The results of posterior drawer tests were classified in accordance with Clancy’s classification. The KT-1000 arthrometer (MedMetric, San Diego, California) was used for objective laxity testing. The quadriceps neutral angle was found for the uninvolved knee using the arthrometer and the PCL Pro (MedMetric). This is the angle at which displacement of the tibia occurs with the contraction of quadriceps musculature. At this angle the amount of anteroposterior (AP) laxity for both knees was recorded with a force of 9.1 kg (20 lb). Side-to-side differences were recorded. The patient was also asked to perform a single leg hop for the maximum possible distance on the index and normal side. Three trials for each leg were conducted and the mean recorded. A ratio of the operated index to the normal knee was calculated.

Radiographs of the treated knees were taken at a minimum of ten years after operation with a series of exposures including AP, 30° flexion weight-bearing posteroanterior, 30° lateral and Merchant views. Examination of the radiographs was undertaken by an author (WFMJ) according to the Kellgren-Lawrence grading scale to score degenerative changes and posterior displacement. This scale has good inter- and intra-rater reliability as well as good validity when compared with arthroscopic findings.

Statistical analysis. SPSS 11.0 for Windows (SPSS Science Inc., Chicago, Illinois) was used for all statistical analysis. Results are presented as means, ranges and SD as appropriate. The Wilcoxon signed ranked test was used to assess change over time. Statistical significance was set at p < 0.05.

Results

Of the original 30 patients, one suffered a fatal pulmonary embolism 11 days after operation and one patient died of unrelated causes seven years after operation. A total of 26 of the remaining 28 patients (93%) were reviewed at a minimum of ten years (10 to 11.7) after operation with two lost to follow-up. One had moved overseas and one could not be located. All data presented refer to the 26 patients reviewed at ten years. All patients had been assessed pre-operatively.
and reviewed at a medium term follow-up at two to four years from surgery which has been previously reported. Geographical limitations of living interstate prevented objective review in four patients at ten years but these patients completed the subjective review.

**Demographic data.** There were 25 males and one female. The mean age at surgery was 28 years (18 to 57). The mean time from injury to reconstruction was 24 months (4 to 120), with 14 patients undergoing surgery between four and 12 months after injury.

**Mechanism of injury.** In 21 patients the injury had occurred during sport, 16 by a direct tackle during football. Motor vehicle accidents accounted for three injuries, and a fall from a bicycle for two injuries. Hyperextension injuries during baseball, hockey and skiing resulted in one PCL injury each. One patient was kicked by a bull and the other fell from a 4 m height landing on a flexed knee.

**Previous surgery.** Seven patients had undergone previous surgery to the index limb, in five arthroscopy examination with meniscectomy and two had undergone ipsilateral surgery to the index limb, in five arthroscopy examination.

**Operative findings.** At operation, the site of rupture of the PCL was found to be mid-substance in 18 patients; distal in three and ill defined in five. A four-strand hamstring graft was used in 21 patients and a three-strand graft in five. The proximal femoral fixation of the graft was performed in all patients using a standard 7 mm × 25 mm RCI screw. Graft fixation at the tibial end was achieved using an RCI screw and staple fixation in 14 patients, RCI screw alone was used in eight and in four an RCI screw was combined with tying the leading graft sutures over a post screw.

**Meniscal injury and treatment.** At initial arthroscopy, 23 patients had normal medial menisci. In the two patients who had undergone a previous medial meniscectomy there was a stable remnant. One patient had a posterior horn tear which required subtotal medial meniscectomy. In 22 patients no abnormality was found in the lateral meniscus but four required a partial lateral meniscectomy for tears.

**Collateral ligament injury.** Three patients had a medial collateral ligament injury at presentation (grade II/III). One was treated successfully with a range of movement brace from 30° to 90° for a period of four weeks. Two underwent open repair at the time of PCL reconstruction. No patient had significant lateral ligament laxity or significant (> 1+) posterolateral corner instability.

The mean Lysholm knee score for the 26 patients was 64 (SD 15) pre-operatively and 90 (SD 14) at ten years post-operatively (p = 0.001).

**IKDC subjective knee evaluation.** The IKDC 2000 subjective knee assessment was introduced after the four-year assessment period therefore the results are available for the ten-year review only, at which time the mean IKDC subjective knee score was 87 (SD 14) of a possible 100. The number of patients out of 26, able to participate in moderate to strenuous activities without symptoms at ten years is shown in Figure 2. Regular participation in moderate to strenuous activities improved from seven of 26 pre-operatively to 23 of 26 patients at ten years after surgery. The number of patients reporting no or minimal difficulty with various tasks at ten years is shown in Figure 3.

**Ligament testing.** Before surgery, posterior drawer testing at 90° of knee flexion revealed that 15 of 26 patients had grade 2 laxity (displacement of anterior tibia flush with femoral condyles) and 11 patients had grade 3 laxity (anterior tibia subluxable posterior to the femoral condyles). At ten years, eight of 22 patients had grade 0 laxity, 12 patients had grade 1 laxity (increased posterior tibial displacement but with the tibia not flush with the femoral condyles) and two patients had grade 2 laxity.

Instrumented knee testing was not performed in patients pre-operatively and two patients were not assessed with the KT1000 at ten years. One suffered a contralateral ACL injury during the follow-up period and was therefore excluded from the analysis which assumes a normal contralateral knee, and the other was reviewed at a peripheral clinic without access to a KT1000 arthrometer. At ten years after surgery the mean side to side difference in total anterior and posterior translation was 1.1 mm (SD 1.9) and 17 of 20 patients had < 3 mm side to side difference at the quads neutral angle.
Range of movement. When compared with the contralateral limb, 21 of 22 patients available for physical examination had less than 3° of loss of extension and 20 of 22 patients had less than 5° of loss of flexion at ten years follow-up.

Single-legged hop test. At ten years, 18 of 22 patients were able to achieve > 90% of their contralateral knee distance on their treated leg.

Radiological assessment. At ten years after surgery, of the 22 patients available for re-examination, 14 had no or minimal degenerative change, four had osteophytes with a normal joint space and four had moderate joint space narrowing (Table I).

Patients who had undergone a meniscectomy had a significantly higher rate of radiological degenerative change (p = 0.008). Grade 2 or 3 changes were seen in all four patients who had undergone meniscectomy compared with four of the 18 who had no meniscal resection.

Complications. Among the original cohort of 30 patients a 39-year-old, non-smoker, with no previous risk factors sustained a fatal pulmonary embolus despite having a normal operative and early post-operative course. The operative time was 75 minutes. One patient required removal of a tibial staple 19 months after operation. One patient ruptured his graft 24 months after reconstruction in a hyperextension injury during a football tackle. He was reviewed ten years from initial reconstruction and subsequently underwent revision reconstruction. Two patients suffered a contralateral ACL rupture at 12 and 72 months post surgery and underwent ACL reconstruction.

Discussion
Management of PCL injuries remains controversial. It is agreed that displaced acute bony avulsion injuries are best managed surgically. Current opinion recommends surgical reconstruction when PCL injuries occur in association with other ligamentous damage. The management of isolated PCL injuries is more contentious.

Some authors have argued that isolated PCL ruptures can be successfully managed non-operatively with physiotherapy aimed principally at strengthening the quadriceps, so that they may better resist the tendency for posterior subluxation of the tibia. Others have shown that a subgroup of these patients will fail to respond to conservative treatment and continue to have symptomatic knees, commonly complaining of difficulty with running, decelerating or pain with exercise and on stairs. Reconstruction of the PCL for this subgroup of patients has shown good short-term results with minimum follow-up periods of two years, three years, four years or five years. However, the long-term results of endoscopic PCL reconstruction are currently unknown.

This study on the outcome of 26 patients shows excellent function can be achieved and maintained at ten-year follow-up following endoscopic PCL reconstruction using a hamstring tendon autograft. IKDC scores showed that 24 patients had normal or nearly normal knee function, and improvement of the mean Lysholm score from 64 (SD 15) pre-operatively to 90 (SD 14) at final follow-up. Of the 26 patients 25 reported no pain or giving way with moderate to strenuous activity. At ten years following reconstruction, 23 of 26 patients continued to participate in regular moderate to strenuous activity.

It is thought that chronic PCL deficiency leads to increased rates of osteoarthritis particularly in the patellofemoral and medial compartments. Chronic PCL deficiency allows subluxation of the tibia posteriorly and this needs to be counteracted by increased quadriceps tone. Experimental studies have shown that injury to the PCL alters knee kinematics with increased patellofemoral contact pressures, reduced lever arm of the quadriceps mechanism, and ‘fixed’ anterior subluxation of the medial femoral condyle. Over the medium term, Shelbourne et al. found evidence of osteoarthritis in the injured knee in ten of 67 (15%) of non-operatively treated patients at a mean of 5.4 years. More recently an arthroscopic evaluation of 181 patients with symptomatic, isolated PCL-deficient knees after five years showed that nearly 80% had degenerative lesions on the medial femoral condyle, with another 50% showing degenerative lesions involving the patella.
tively-treated isolated PCL-deficient knees, Boynton and Tietjens41 showed radiographic degenerative changes, after a mean follow-up of 13.4 years, in 88% of patients with meniscal surgery and 60% without meniscal surgery.

Successful reconstruction may protect the knee from degenerative change by both reducing patellofemoral contact pressures as well as preventing further episodes of instability and possible meniscal or chondral injuries. Following arthroscopic PCL reconstruction, others have reported evidence of degenerative changes in between 10% to 18% of patients up to five years after reconstruction.7,12,13 In this study at ten-year follow-up, of the 22 patients available for radiological assessment 14 had no or minimal degenerative changes, 4 had grade 2 and another 4 had grade 3 osteoarthritis according to the Kellgren and Lawrence radiological grading system.26 We found that PCL reconstruction without meniscectomy resulted in lower rates of radiologically-identified degenerative change compared with patients who had undergone meniscal resection. These rates of degenerative change compare favourably with the long-term results of conservatively-treated patients.41,48

As with all PCL reconstruction series the number of patients we report are relatively small and represent less than 50% of the total number of isolated PCL injuries seen by the principal investigator (LAP) during the study period. For those who remained symptomatic after three months of treatment. At ten years post-operatively they can expect a well functioning stable knee that allows them to participate in moderate to strenuous activities. Osteoarthritis is shown some loss of joint space but the rates were better than those previously observed in non-operatively managed isolated PCL injuries,41 and reconstruction may protect these knees in the even longer term.

### Table I. Radiological assessment at ten years according to the Kellgren and Lawrence26 radiological grading system (n = 22)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
<th>Patellofemoral compartment</th>
<th>Medial compartment</th>
<th>Lateral compartment</th>
<th>Overall</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>No radiographic osteoarthritis</td>
<td>11</td>
<td>12</td>
<td>14</td>
<td>8</td>
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<tr>
<td>1</td>
<td>Minute osteophytes of doubtful clinical significance</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>6</td>
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<tr>
<td>2</td>
<td>Definite osteophytes with unimpaired joint space</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Definite osteophytes with moderate joint space narrowing</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Definite osteophytes with severe joint space narrowing and subchondral sclerosis</td>
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### References

ETIOLOGY AND MANAGEMENT OF ISOLATED POSTERIOR CRUCIATE LIGAMENT INJURIES