Medium-Term (5-Year) Comparison of the Functional Outcomes of Combined Anterior Cruciate Ligament and Posterolateral Corner Reconstruction Compared With Isolated Anterior Cruciate Ligament Reconstruction

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**Purpose:** To present a 5-year comparison of the functional outcomes of combined anterior cruciate ligament (ACL) and posterolateral corner (PLC) reconstruction with those of isolated ACL reconstruction.

**Methods:** All patients were reviewed clinically and completed knee function questionnaires prospectively, by use of the International Knee Documentation Committee (IKDC) 2000, Knee Injury and Osteoarthritis Outcome Score (KOOS), and Lysholm scoring systems, preoperatively and at 1, 2, and 5 years postoperatively. Patients who underwent combined ACL-PLC reconstruction were identified and reviewed. These patients had intact lateral collateral ligaments. A comparison group was created from a group of patients who underwent isolated ACL reconstruction. The ACL group was selected to have the same profile with regard to age, sex, and meniscal procedure.

**Results:** There were 25 patients in the ACL-PLC group and 100 in the ACL group. All patients underwent restoration of their PLC function as shown on dial testing. The preoperative values for all KOOS measures and the Lysholm score were significantly lower in the ACL-PLC group than in the ACL group ($P < .001$). The IKDC score was not significantly different. All knee scores showed a significant improvement in both groups postoperatively at 1, 2, and 5 years ($P < .001$). At 5 years, the KOOS symptoms subscore ($P < .001$), KOOS pain subscore ($P < .001$), KOOS sports subscore ($P < .001$), KOOS quality-of-life subscore ($P < .05$), KOOS activities of daily living subscore ($P < .001$), aggregate score for all KOOS parameters ($P < .001$), and Lysholm score ($P < .001$) were significantly lower in the ACL-PLC group than in the ACL group. At 5 years, the IKDC scores were not significantly different. All patients in the ACL-PLC group resumed preinjury employment, and 23 of 25 had resumed sports.

**Conclusions:** Combined ACL-PLC injuries have greater morbidity than isolated ACL injuries. However, return to work and sporting activity is possible in most cases after combined ACL-PLC reconstruction. The KOOS for sport outcomes suggests that sports were resumed at lower functional levels.

**Level of Evidence:** Level III, case-control study.

Ligamentous injuries to the knee are common, accounting for 34% to 48% of all knee injuries. Sports-related injuries to the knee and knee ligaments are increasing in incidence, as more persons are participating in sports. Posterolateral rotatory instability (PLRI) was first described in 1976, but the posterolateral corner (PLC) of the knee has become appreciated in recent years. The incidence of PLC injury seen on magnetic resonance imaging has been reported to be apparent in 16% of all knee ligament injuries.

PLC injury is usually the result of high-energy trauma, by either direct or indirect mechanisms. PLRI is rare in isolation but occurs most frequently in association with injury to the anterior cruciate ligament (ACL) and/or the posterior cruciate ligament. These injuries result in severe functional disability, with pain,
instability, and deterioration of the articular cartilage if left untreated, which has also been replicated in an animal model. Unrecognized PLC injury can affect the integrity and results of cruciate ligament reconstructions. Therefore it is recommended that the PLC be repaired or reconstructed at the time of cruciate ligament reconstruction to decrease the risk of cruciate reconstruction failure. Similarly, PLC reconstruction alone is at great risk of attenuation and failure if the integrity of the ACL is not restored at the same time.

Despite increasing awareness of ACL-PLC injuries, there is little published information on the outcome of ACL-PLC reconstruction and patients’ prognoses. We are aware of only a single article comparing the outcome of these patients with an isolated ACL injury group. The article had 24 months’ follow-up and was from a South Korean cohort. There may be considerable differences between these patients and our predominantly white patient population.

The purpose of this study is to present a 5-year comparison of the functional outcomes of combined ACL and PLC reconstruction with isolated ACL reconstruction. Our hypothesis is that patients with ACL-PLC reconstruction will have similar outcomes to patients with isolated ACL reconstruction up to 5 years postoperatively.

**Methods**

All patients undergoing soft-tissue knee surgery in our unit were assessed clinically preoperatively and at 3 and 6 months and 1, 2, and 5 years postoperatively. All patients also completed questionnaires prospectively at these times using the Lysholm Knee Scoring Scale, International Knee Documentation Committee (IKDC) 2000 Ligament Subjective Knee Evaluation Form, and Knee Injury and Osteoarthritis Outcome Score (KOOS). All data were prospectively recorded in our secure knee injury database. We complied with the hospital trust’s requirements, and all patients consented to be involved in this study. Because this was an observational study from data collected as part of routine follow-up, ethical approval was not required.

A database search identified patients who underwent ACL-PLC reconstruction between October 2001 and December 2006. Excluded from the study were patients with acute repairs (<3 weeks after injury); injuries to the medial collateral ligament, posterior cruciate ligament, or posteromedial corner; isolated PLC injuries; associated fractures; concomitant high tibial osteotomy with the ligament reconstruction; abnormal contralateral limb examination findings (in the clinic or under anesthesia); or abnormal contralateral knee function. Data were also collected from the operative records and hospital case notes. Thirty-six patients made up this cohort, but because there were several techniques used in reconstruction of the PLC, we decided to include patients who underwent only 1 technique (split biceps tenodesis) to reduce heterogeneity. The largest group of ACL-PLC reconstructions comprised patients who had split biceps tenodesis. Patients were only deemed eligible for split biceps tenodesis if the lateral collateral ligament (LCL) was intact and the bicipital aponeurosis was of satisfactory quality with an intact insertion into the fibula head.

The database is a continuous series of knee ligament reconstructions and was used to create a comparison group of patients who had undergone isolated ACL reconstruction. The group was matched to the ACL-PLC cohort for age, sex, and any meniscal procedures carried out. This group was kept as large as possible to reduce the possibility of statistical error.

The correction of anteroposterior (AP) tibial translation achieved by cruciate ligament reconstruction was measured intraoperatively in both groups, just before the first skin incision was made, as well as after wound closure and at each follow-up appointment, with a Rolimeter (Aircast, Vista, NJ). The Rolimeter is a device used to measure AP translation and has been shown to be equally as effective as the KT-1000 (MEDmetric, San Diego, CA). The dial test was performed with the knee at 30° and 90° of flexion, and the amount of external rotation was recorded for the uninjured knee preoperatively and for the operated knee preoperatively, postoperatively, and at each follow-up visit. An abnormal dial test finding (increased external rotation >10°) preoperatively was an indication of PLRI and therefore required reconstruction of the PLC concomitantly with the ACL reconstruction. The results of the dial test were compared to assess the effectiveness of the PLC reconstruction. Varus laxity was evaluated and was not present in any of our patients (exclusion criterion). It was also not present when assessed in all patients at each postoperative follow-up visit.

**Surgical Technique and Rehabilitation Program**

The senior author (M.J.M.) carried out all surgical procedures. Patients were assessed in the clinic by use of the dial test to determine whether PLC reconstruction was required; if the LCL was intact and the bicipital aponeurosis was of satisfactory quality with an intact insertion into the fibula head, the patient was selected to undergo split biceps tenodesis. This was confirmed with the patient under anesthesia before surgery. Any meniscal pathology that required surgical treatment was addressed during the same anesthesia period. Split biceps tenodesis is the preferred technique of the senior author, and patients undergoing this technique make up our cohort. ACL reconstruction was performed arthroscopically with a 55° tibial tunnel, and the femoral tunnel was drilled by the transtibial technique. The grafts used were 18 hamstring grafts and 7
bone–patellar tendon–bone grafts in the ACL-PLC patients and 66 hamstring grafts and 34 bone–patellar tendon–bone grafts in the ACL patients. During the tightening of an ACL graft, there is a significant increase in tibial external rotation in knees with a PLC injury compared with knees in which the PLC is intact. It is therefore recommended that in cases of combined ACL-PLC injury, the PLC structures should be reconstructed before tensioning the ACL graft. These procedures were followed in this study. When isolated popliteofibular ligament reconstruction was required and the bicipital aponeurosis was of satisfactory quality with an intact insertion into the aponeurosis was harvested. The common peroneal nerve was first identified at the fibula neck and traced proximally to ensure that it was protected throughout the procedure. All of the aponeurosis except for the anterior and posterior 2-mm edges was used, taking a graft of up to 10 cm from the fibula head. It then underwent tubularization by No. 5 Ethibond (Ethicon, Somerville, NJ) whipstitch, with care taken to “cinch” this by pulling in the line of its intended action, that is, toward the hip. This was passed deep to the muscle belly of the biceps femoris and the LCL and was then fixed into a 7-mm-diameter bone tunnel, which was 50 mm in length in the most anterior part of the popliteus fovea. The graft was pulled into the tunnel, held under tension, and fixed with the knee in 30° of flexion with the foot held in neutral rotation, by use of a 7 × 25-mm RCL screw (Smith & Nephew Endoscopy, Andover, MA). Before 2004, patients underwent PLC fixation with the tibia at 30° of flexion with internal rotation. After oral communication with La Prade (2004) discussing over-constraint of the knee, our technique changed, with fixation of the PLC in neutral rotation. None of our patients had over-constraint.

All patients followed the unit’s standard rehabilitation program under the close supervision of senior physiotherapists, which commenced with preoperative muscle strengthening. Patients who underwent isolated ACL reconstruction had physiotherapy postoperatively to ensure return of full range of motion initially and then proprioception, strength, endurance, and ultimately, sports-specific training before being allowed to return to contact sports. Patients who underwent ACL-PLC reconstructions were placed into a long lever brace with motion limited between 10° and 90° for 6 weeks and were kept non-weight bearing; from 6 to 12 weeks, the motion was 0° to 120° with partial weight bearing, increasing to full weight bearing as comfortable, and from 12 weeks, patients were weaned off the brace. Patients were not allowed to return to sports training/conditioning (noncontact) until after 6 months in the ACL group and 9 months in the ACL-PLC group and were not allowed to return to competitive sports until after 9 months in the ACL group and 12 months in the ACL-PLC group.

The preoperative and postoperative Lysholm, KOOS, and IKDC 2000 scores were compared in the ACL-PLC and ACL groups. The scores and the Rolimeter data were analyzed with the Mann-Whitney U test, by use of Salstat software, version 2 (Salstat, Cardiff, Wales). The level of significance was taken as P < .05.

## Results

Twenty-five patients were identified as having undergone ACL-PLC reconstructions. No patients were lost to follow-up. Three patients were women. The mean age was 34.0 years (range, 23 to 50 years). The right knee was injured in 20 patients and left knee in 5. The mean duration of follow-up was 84.5 months (range, 70 to 129 months). The mean time from injury to surgery was 27 months (range, 1 to 121 months). Reasons for delay in surgery included patients who did not present for many months and patients who presented as tertiary referrals and had already been assessed and treated at other hospitals. The mechanisms of injury were as follows: sports in 22 patients, road traffic incidents in 2, and a fall in 1.

The ACL group consisted of 100 patients, 92 men and 8 women. The mean age was 36.0 years (range, 20 to 52 years). Sixty-three patients had right knee injuries, and 37 patients had left knee injuries.

A number of patients in both groups had meniscal injuries that required surgical treatment. In the ACL-PLC group these included 7 medial meniscus procedures (5 underwent debridement and 2 were repaired) and 13 lateral meniscus procedures (10 underwent debridement and 3 were repaired). The ACL group included 49 medial meniscus procedures (3 were repaired) and 31 lateral meniscus procedures (2 were

### Table 1. Intraoperative AP Rolimeter Measurements in ACL and ACL-PLC Groups at 30°

<table>
<thead>
<tr>
<th>Injured Side</th>
<th>Contralateral Knee</th>
<th>Preoperatively</th>
<th>1 yr</th>
<th>2 yr</th>
<th>5 yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACL (mm)</td>
<td>9.4 (2.6)</td>
<td>13.8 (3.7)</td>
<td>11.9 (2.1)</td>
<td>11.8 (2.1)</td>
<td>10.1 (1.8)</td>
</tr>
<tr>
<td>ACL-PLC (mm)</td>
<td>9.7 (2.7)</td>
<td>14.0 (4.4)</td>
<td>13.2 (3.0)</td>
<td>12.2 (2.2)</td>
<td>11.3 (2.0)</td>
</tr>
<tr>
<td>Mann-Whitney P value</td>
<td>.20</td>
<td>.50</td>
<td>.14</td>
<td>.44</td>
<td>.50</td>
</tr>
</tbody>
</table>

*NOTE. Standard deviations are shown in parentheses.*
repaired). (The groups had the same proportion of
patients with meniscal injuries; however, 4 patients in the
ACL-PLC group and 17 patients in the ACL group had
both medial and lateral meniscal injuries.) There was
no statistical difference between the groups.

Rolimeter measurements were recorded in 23 pa-
tients in the ACL-PLC group and 77 in the ACL group,
as shown in Tables 1 and 2. Ligamentous recon-
structions in both groups had similar outcomes at all
time points. The difference in tibial external rotation
between the 2 knees as measured by the dial test is
shown in Figs 1 and 2. There was a clear improvement
in rotational testing at 30° and 90° after PLC recon-
struction and, therefore, correction of PLRI. Measure-
ments of the rotation of the knees were assessed at all
time points, and only 1 patient had a positive dial test
finding at further follow-up, at 5 years, which occurred
as a result of a contact injury while playing football. No
patients in the ACL-PLC group showed evidence of
varus laxity.

The results and analyses of the functional outcome
scores for both groups are shown in Table 3 and in Figs
3 to 5. Patients in the ACL-PLC group had statistically
worse scores than those in the ACL group for the KOOS
symptoms subscore, KOOS activities-of-daily living
subscore, KOOS sports subscore, and aggregate score
for all KOOS parameters at all time points and in the
KOOS sports subscore and KOOS quality-of-life sub-
score at most time points. The Lysholm scores were
worse for the ACL-PLC group at all points, but the
IKDC scores only showed a difference at the 2-year
review.

**Complications**

One patient in the ACL-PLC group, early in the series,
had prominence of the screw and washer/soft-tissue
washer at the femoral tunnel used for PLC recon-
struction, which were removed after 12 months. The
senior author’s method of fixation was changed to an
RCI screw. None of these patients (23 patients) have
required removal. One patient (already mentioned)
had a reinjury to the PLC after 5 years and awaits
revision reconstruction. Other complications included 2
superficial infections: 1 in the ACL anterior wound,
treated with oral antibiotics, and 1 stitch abscess at the
site of inside-out medial meniscal repair, requiring
surgical debridement. The senior author’s method of
meniscal repair has changed to an all-inside technique
using Fast-Fix (Smith & Nephew Endoscopy). One

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**Table 2. Intraoperative AP Rolimeter Measurements in ACL and ACL-PLC Groups at 90°**

<table>
<thead>
<tr>
<th></th>
<th>Contralateral Knee</th>
<th>Preoperatively</th>
<th>1 yr</th>
<th>2 yr</th>
<th>5 yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACL (mm)</td>
<td>7.2 (1.9)</td>
<td>7.2 (2.9)</td>
<td>8.4 (1.8)</td>
<td>8.0 (2.1)</td>
<td>7.0 (1.2)</td>
</tr>
<tr>
<td>ACL-PLC (mm)</td>
<td>7.4 (2.0)</td>
<td>7.6 (2.7)</td>
<td>7.9 (1.5)</td>
<td>8.2 (1.2)</td>
<td>6.3 (1.1)</td>
</tr>
<tr>
<td>Mann-Whitney P value</td>
<td>.18</td>
<td>.49</td>
<td>.35</td>
<td>.26</td>
<td>.16</td>
</tr>
</tbody>
</table>

*NOTE. Standard deviations are shown in parentheses.*

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**Fig 1.** Preoperative dial test findings in patients undergoing combined ACL-PLC reconstruction at 30° and 90°. The IKDC examination form classifies these values as follows: 5° or less, normal; 6° to 10°, nearly normal; 11° to 19°, abnormal; and 20° or greater, severely abnormal.

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**Fig 2.** Dial test findings at 1 year postoperatively in patients undergoing combined ACL-PLC reconstruction at 30° and 90°. The measurement taken is the increased external rotation seen in the injured limb compared with the uninjured limb. The IKDC examination form classifies these values as follows: 5° or less, normal; 6° to 10°, nearly normal; 11° to 19°, abnormal; and 20° or greater, severely abnormal. There is a clear improvement in the test results. The 2-year and 5-year results are the same other than in 1 patient who showed increased external rotation at 5-year follow-up.
patient had failure of the meniscal repair because of a new injury during sports participation 18 months postoperatively. In the ACL group there were 3 complications: 2 patients had rerupture of the ACL grafts, both of which were successfully revised, and 1 patient had arthrofibrosis, which responded to intensive physiotherapy.

At the time of latest follow-up, all patients in both the ACL-PLC and ACL groups had resumed their preinjury employment. Twenty-three of the patients in the ACL-PLC group and all patients in the comparison group had resumed sports.

**Discussion**

Patients in the ACL-PLC group had statistically and clinically worse scores than those in the ACL group for the KOOS symptoms subscore, KOOS activities—
of—daily living subscore, KOOS sports subscore, and aggregate score for all KOOS parameters at all time points and in the KOOS sports subscore and KOOS quality-of-life subscore at most time points. Clinical significance in all the KOOS values is defined as a difference greater than 8 points. The Lysholm scores were worse for the ACL-PLC group at all points, but the IKDC scores only showed a difference at the 2-year review. All of the lower functional scores in the ACL-PLC group were found despite correction of PLRI as shown by results of the dial test. Therefore the presence of a PLC injury does cause significantly increased morbidity in patients with an ACL injury, contrary to the findings of Kim et al.

Preoperatively, there was no difference in the groups in AP translation at 30° or at 90° (Tables 1 and 2). Though incomplete, these follow-up proportions are comparable with the Swedish registry experience. The groups had similar results throughout follow-up. Comparison of the contralateral knees in the 2 groups showed no difference in AP translation, suggesting that no constitutional laxity difference between the groups existed. There was no difference in AP translational instability between the 2 groups, although Kim et al. found slightly less AP motion in patients who had undergone ACL-PLC reconstruction. Both groups had a reduction in their AP motion at 30° at the 5-year point, which was unexpected. Reconstruction of the PLC has been shown to restore rotatory instability, which was confirmed in our postoperative patients by restoration of normal rotation on dial testing.

PLC injuries treated nonoperatively have not shown any major difference in IKDC scores up to 2 years. Our IKDC scores did not show major differences either, whereas the other scoring systems did. Perhaps the IKDC score is not sufficiently sensitive to show the difference.

Several procedures have been proposed to reconstruct the PLC, but to date, no single technique has been universally accepted. However, a recent comparison of
anatomic reconstruction of the PLC versus the modified biceps rerouting technique has shown that the anatomic technique yielded slightly better outcomes.\textsuperscript{20} An increased risk of over-correction using the modified biceps technique was noted (20\% vs 5\%), but we have not experienced this in our patients. Surgical treatment of PLRI must address all components of the injury, including injuries to the cruciate ligaments, menisci, medial knee ligaments, and articular cartilage, as well as associated fractures, as indicated.\textsuperscript{23} We recommend the use of split biceps tenodesis only when the LCL is intact and functioning properly.

Limitations

Our study is a retrospective study. Although there were similar proportions of meniscal injury in both groups, there was a greater proportion of medial meniscal tears in the ACL group. The medial meniscus acts as a secondary stabilizer to AP translation of the tibia relative to the femur. However, recent cadaveric work has shown no difference in AP motion in the presence of increasing severity of meniscal tears with a functioning ACL or ACL reconstruction until the root of the meniscus is transected.\textsuperscript{24} There was a modification of the rotational position of the tibia during fixation of the biceps tenodesis early in our series. However, there were no cases in which the graft was either too tight or too lax.

Conclusions

Combined ACL-PLC injuries have greater morbidity than isolated ACL injuries. However, return to work and sporting activity is possible in most cases after combined ACL-PLC reconstruction. The KOOS for sport outcomes suggests that sports were resumed at lower functional levels.

References


