Outcomes of Arthroscopic Double-bundle PCL Reconstruction Using the LARS Artificial Ligament

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abstract

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The purpose of this study was to assess the outcomes of posterior cruciate ligament (PCL) reconstruction using the Ligament Augmentation and Reconstruction System (LARS) (JK Orthomedic Ltd, Dollard-des-Ormeaux, Quebec, Canada) artificial ligament. Compared with older artificial ligaments, the LARS, which has been used in Europe for 15 years, is more resistant to wear and tear, has satisfactory torsional fatigue resistance, and has good biocompatibility. The current study included 38 double-bundle PCL reconstructions using the LARS artificial ligament in 38 patients. Mean patient age was 32.6 years, and mean time from injury to surgery was 6 months. Mean follow-up was 37 months (range, 30-68 months). The study endpoint was 2-year follow-up. Mean Tegner score improved from 3.4±0.6 preoperatively to 6.0±1.4 postoperatively (P<.001), and mean Lysholm score improved from 70.0±11.0 preoperatively to 91.7±5.5 postoperatively (P<.001). Knee laxity decreased significantly postoperatively (P<.001), and no differences existed at 1- and 2-year follow-up. After surgery using the Y-type LARS artificial ligament, knee function and stability improved. Using the LARS artificial ligament for double-bundle reconstruction of the PCL avoids donor-site morbidity and disease transmission. The complication rate is low, and the results appear to be stable with time and comparable with those obtained with other grafts. Double-bundle PCL reconstruction with the LARS artificial ligament may be an alternative treatment option.

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Drs Chen, Lin, Chiu, Wu, Lee, Tong, and Huang have no relevant financial relationships to disclose.

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The management of posterior cruciate ligament (PCL) injuries remains a challenging clinical problem. Single-bundle PCL reconstruction is popular and often recommended; however, the clinical results of single-bundle PCL reconstruction are unpredictable and not as good as those obtained after anterior cruciate ligament (ACL) reconstruction. A recent systematic review that included 10 studies of arthroscopic single-bundle transtibial PCL reconstruction found that this technique, like other reconstruction techniques, is not reliable for restoring normal knee stability.\(^1\)

Functionally, the PCL can be regarded as comprising 2 bundles.\(^2,4\) Reconstruction of the PCL varies among surgeons with respect to ligament graft selection and fixation technique. Autografts (patellar tendon, hamstrings, quadriceps tendon) and allografts (Achilles tendon, patellar tendon) have been preferred.\(^5-11\) However, the disadvantages of autografts and allografts, as well as the success of ACL reconstruction with the Ligament Augmentation and Reconstruction System (LARS; JK Orthomedic Ltd, Dollard-des-Ormeaux, Quebec, Canada), prompted interest in the use of Y-type LARS artificial ligaments to reconstruct the PCL (Figure 1).\(^12,13\) Compared with older artificial ligaments, the LARS, which has been used in Europe for 15 years, is more resistant to wear and tear, has satisfactory torsional fatigue resistance, and has good biocompatibility.\(^14\)

In studies in which the Y-type LARS artificial ligament has been used for PCL reconstruction, the short-term clinical outcomes were promising.\(^15,15\) However, longer-term studies are needed. The current authors used the Y-type LARS artificial ligament for PCL reconstruction because the patients refused to harvest their own tendons, and not all patients can use an allograft. The purpose of this study was to evaluate the 2-year postoperative results of using the Y-type LARS artificial ligament for PCL reconstruction.

### Materials and Methods

Between July 2003 and July 2008, thirty-eight consecutive PCL reconstruction procedures using a LARS ligament in 38 patients were performed at the authors’ institution. The diagnosis of PCL rupture was made on the basis of the posterior drawer test, the posterolateral instability test, and magnetic resonance imaging (MRI). Surgical indications for PCL reconstruction were symptomatic PCL rupture with posterior translation of grade III or more according to the posterior drawer test and >10 mm by the KT-1000 arthrometer (Medmetric Ltd, San Diego, California). A patient who experienced the posterolateral instability was excluded. Each patient was fully informed of the disease details and the surgical procedures, including the advantages and disadvantages of the procedures. The patients then selected their procedure. Written informed consent was obtained from each patient. All surgeries were performed by 1 orthopedic surgeon (C.-P.C.).

The retrospective series comprised 38 patients (23 men and 15 women). Mean patient age was 32.6 years (range, 19-59 years), mean time from injury to surgery was 6 months (range, 1-48 months), and mean follow-up was 37 months (range, 30-68 months). The mechanism of injury was traffic accident for 32 (84.2%) patients. The other 6 (15.8%) patients were injured in falls or during sports. The left knee was involved in 16 patients. The PCL tear was isolated in 33 patients. Six patients had osteoarthritis; 3 had Ahlbäck stage I osteoarthritis and 3 had stage II. Among patients older than 50 years, 1 had stage I and 2 had stage II osteoarthritis. Two patients had associated injuries. One had an old acetabular posterior wall fracture without displacement that had healed (interval, 7 months), and the other had an old patellar fracture that had healed (interval, 9 months). One patient had a medial meniscal tear. The diagnosis of PCL rupture was made 6 months after the injury. The lesion was confirmed on MRI. One patient had a concomitant biceps tear.

### Table 1

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age at surgery, y</td>
<td>32.6±11.6</td>
<td>19-59</td>
</tr>
<tr>
<td>Median interval between injury and surgery (IR), mo</td>
<td>6 (3-11.25)</td>
<td>1-48</td>
</tr>
<tr>
<td>Mean tibial tunnel widening, mm</td>
<td>1.0±0.1</td>
<td>0.9-1.42</td>
</tr>
<tr>
<td>Mean Tegner score</td>
<td>3.4±0.6</td>
<td>2-4</td>
</tr>
<tr>
<td>Mean Lysholm score</td>
<td>70.0±11.0</td>
<td>15-81</td>
</tr>
<tr>
<td>Mean KT-1000 knee laxity measurement, mm</td>
<td>11.5±0.5</td>
<td>11-12</td>
</tr>
<tr>
<td>IKDC grade, No.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>No. right/left injuries</td>
<td>22/16</td>
<td></td>
</tr>
<tr>
<td>No. injuries caused by traffic accidents</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>No. female/male patients</td>
<td>15/23</td>
<td></td>
</tr>
<tr>
<td>Median follow-up (IR), mo</td>
<td>37 (31-54)</td>
<td>30-68</td>
</tr>
</tbody>
</table>

Abbreviations: IKDC, International Knee Documentation Committee; IR, interquartile range. \(^N=38.\)
meniscus tear, and 2 had a lateral meniscus tear. All patients received preoperative physical therapy. Patient characteristics are summarized in Table 1.

**Surgical Technique**

All PCL reconstructions were performed arthroscopically using the anterolateral, anteromedial, and posteromedial portals. Preliminary diagnostic arthroscopy was performed, and any meniscal lesions found were treated. The remnant of the PCL was preserved. The tibial tunnel was made by a LARS device (Figure 2). The tibia guide pin was placed on the medial aspect of the proximal tibia below the medial joint line and exited posterior at approximately 1.2 cm below the articular surface and just lateral to the midline at the PCL insertion site. The proper position of tibial tunnel was checked by C-arm image intensifier, and the tunnel size was 7.5 mm. The femoral tunnels were located within the PCL footprint on the medial femoral condyle and were placed 1.0 cm apart (measured from the edge of the tunnel) between the 2 tunnels in an anteroposterior fashion. The anterolateral tunnel was located 2 to 3 mm and the posteromedial tunnel was 4 to 5 mm posterior to the articular junction. The size of each femoral tunnel was 6.0 mm.

The distal end of the graft was delivered through the parapatellar anteromedial portal into the knee joint and tibial tunnel with a carrying wire. The double end of the graft was then pulled out through the same portal into the femoral tunnels with carrying wires. The distal end of the graft was first secured from the outside to the inside of the tibial tunnel at the desired location with a 30-mm-long metal interference screw 8 to 9 mm in diameter. Tension was applied on the double ends of the graft and secured outside-in with a 25-mm metal interference screw 8 to 9 mm in diameter with the knee at 90° flexion to reconstruct the anterolateral bundle and at 20° flexion to reconstruct the posteromedial bundle. The adequacy of graft fixation was confirmed with direct arthroscopic visualization (Figure 3).

**Postoperative Rehabilitation**

For 3 days postoperatively, the knee was immobilized with a soft splint. Quadriceps isometric exercises and straight-leg raising exercises were initiated from postoperative day 1. Immediate mobilization of knee was authorized from 45° flexion and increased gradually to complete flexion within 1 month. Patients usually walked with crutches from postoperative day 1. The crutches were discarded after 2 weeks. Resumption of jogging could be undertaken after 3 months, and general exercise was allowed after 6 months. No patient used a knee brace.

**Evaluation**

Preoperative assessment included clinical examination and MRI; posterior drawer and KT-1000 arthrometer testing for stability measurements; and modified International Knee Documentation Committee (IKDC), Tegner, and Lysholm scoring for functional evaluation. The patients were assessed postoperatively at least 3, 6, 12, and 24 months postoperatively and annually thereafter. The assessments were performed by the first author (C.-P.C.). All patients were followed for >2 years postoperatively. The study endpoint for analysis was 2-year follow-up. The diameter of osteolysis of the tibial tunnel was measured on radiographs.

**Statistical Methods**

Mean±SD was calculated for continuous variables, and frequencies and percentages were calculated for categorical variables unless otherwise stated. Pre- and postoperative scores were compared using the Wilcoxon signed rank test. Simple and regression analysis were used to explore the relationships between scores and factors; simple linear regression was applied first to eliminate the covariates in the multiple regression model. Preoperative values of age, sex, side of the injured knee, and injury caused by traffic accident were used to predict the postoperative values at 2 years. Data were analyzed using SAS version 9.0 software (SAS Institute Inc, Cary, North Carolina). All statistical tests were 2-sided, and P<.05 was considered statistically significant.

**RESULTS**

**Imaging**

Figures 4 through 6 show radiographic and MRI results of surgery.

**Clinical Laxity**

Pre- and postoperative assessments of knee stability are summarized in Tables 1 and 2, respectively. Preoperatively, all patients had a grade 3 posterior drawer test. The KT-1000 examination (90° flexion and 30 lb) showed that the side-to-side difference in anteroposterior translation was 11.5±0.5 mm (range, 11-12 mm). At 2-year follow-up, 2 patients had a grade 2 and 2 patients had a grade 3 posterior drawer test. On KT-1000 examination,
the side-to-side difference was 4.2±1.1 mm at 2-year follow-up. Significant improvement in the posterior drawer test and KT-1000 examination was achieved (P<.001).

**Whole Function of Knee**

As shown in Tables 1 and 2, Tegner and Lysholm scores improved significantly between the pre- and postoperative assessment (P<.001). The final IKDC evaluation also significantly improved between the pre- and postoperative assessment. Preoperatively, function was graded as abnormal or severely abnormal in all patients. At 2-year follow-up, function was graded as normal in 7 (18.4%) patients and nearly normal in 31 (81.6%). Overall IKDC scores were: grade A=7, grade B=27, grade C=2, and grade D=2.

**Range of Motion**

At 2-year follow-up, 1 patient lost the normal 5° hyperextension, and the others had normal knee extension. Three patients had 5° flexion limitation, and the others had normal flexion. The range of motion distribution among the 38 patients was: 120°=1, 125°=4, 130°=1, 135°=3, and 140°=29.

**Complications**

Three patients developed ≥1 complications. One patient had symptoms of synovitis that required arthroscopic debridement. One patient had a superficial wound infection of the tibial side, which was resolved after oral administration of antibiotics. One patient had a deep infection that was resolved after intravenous antibiotics, but then rupture of the artificial ligament and excess laxity resulted. The deep infection developed after the patient caught a cold. The patient was only treated with antibiotics because the patient refused to undergo another operation.

**Regression Analysis**

Regression models were used to predict the Tegner score (Table 3), Lysholm score (Table 4), and KT-1000 values (Table 5). The models evaluated the effects of age, sex, side of the injured knee, preoperative score, and whether the injury was caused by a traffic accident.

**Tegner Score**

The results in Tables 1 and 2 were used to construct a model to predict the patients’ Tegner scores (Table 3). In the multivariate model, age and preoperative score were found to be significant. Older patients on average had a significantly lower Tegner score (P<.001); and the higher the preoperative score, the higher the Tegner score (P=.001).

**Lysholm Score**

The results in Tables 1 and 2 were used to develop a model to predict the patients’ Lysholm scores (Table 4). No factor was found to be significantly associated with Lysholm score.

**Knee Laxity**

A model was developed to predict knee laxity (KT-1000 arthrometer measurements) (Table 5). This score was the sum of anterior and posterior translation. Magnetic resonance images showed that no patient had combined posterolateral injury. In the multivariate analysis, age was found to be significantly positively associated with KT-1000 score (P<.001).

**Discussion**

Several promising methods and techniques for PCL double-bundle reconstruction have been reported with various graft selections.1-11 Because the allograft has disadvantages, including tissue reaction, risk of disease transmission, and delayed revascularization, and because the autograft involves donor-site morbidity, interest was piqued in the use of synthetic material for ligament reconstruction. In the 1980s, the enthusiasm for synthetic materials gradually waned because this therapeutic option produced disappointing results, including many failures and complications.19-22
The LARS ligament was regarded as a new generation of artificial ligament due to its special design and material. It is made of polyester. The Y-type LARS artificial ligament consists of 2 bundles, both containing 60 fibers. The overall tear resistance is 2500 N for the single 60-fiber. Harner et al reported that the ultimate tensile strength of the intact PCL was estimated to be approximately 1800 N for the entire ligament. It appears that the initial strength of the LARS ligament is adequate for double-bundle PCL reconstruction.

A few studies have reported the outcome of ACL or PCL reconstruction using the LARS ligament. In single-bundle PCL reconstruction with the LARS ligament, Brunet et al reported that 58% of the patients were assessed as normal or nearly normal in IKDC scoring. However, using the double-bundle LARS ligament for PCL reconstruction has not been previously reported in the English literature, and few Chinese studies have reported encouraging short-term (<2 years) results. The results of the current study with a synthetic ligament are similar to those obtained with autografting or allografting. This study showed that the technique yielded normal results in 18.4% of patients and nearly normal results in 81.6% at 2-year follow-up. Furthermore, the majority of patients achieved full range of motion in 1 month and return to preinjury sports at 3 months.

Using the LARS ligament for double-bundle PCL reconstruction is not technically demanding. Due to the special material and technique design, the LARS ligament can be easily passed into the proper tunnels without encountering the trouble of the killer angle. The total operation time was approximately 50 minutes, including the proper positioning of the tibial tunnel checked by a C-arm image intensifier.

Synovitis and ligament rupture are serious problems associated with artificial ligaments. No patient reported clinically evident synovitis or obvious ligament rupture in several studies using the LARS artificial ligament for cruciate ligament reconstruction. Use of the LARS ligament for ligament reconstruction has been reported to avoid complications of a material-related nature that can occur with autologous and allogeneic grafts. High biocompatibility of the LARS ligament has been demonstrated in vitro and in vivo, with the observation of fibroblast growth into the artificial ligament after 6 months; in addition, osteoblast-like cells have been observed growing into the LARS ligament in vitro.

In the current study, 1 patient had repeat synovitis and needed arthroscopic debridement. Most evidence of osteolysis was noted at the tibial tunnel near the site of articulation; evidence of femoral osteolysis was relatively rare. No significant correlation between tunnel widening and the level of activity, KT-1000 results, and IKDC scores was found in our study. One patient had a deep infection, which was resolved after intravenous antibiotics were administered, but then resulted in rupture of the artificial ligament and excess laxity. Knee laxity decreased significantly postoperatively, and the comparison of knee laxity at 1- and 2-year follow-up showed no significant difference.

### Table 2

**Postoperative Measures**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Value (SE)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean tibial tunnel widening, mm</td>
<td>1.3 ± 0.2</td>
<td>0.9-1.42</td>
</tr>
<tr>
<td>Mean Tegner score</td>
<td>6.0 ± 1.4</td>
<td>3-8</td>
</tr>
<tr>
<td>Mean Lysholm score</td>
<td>91.7 ± 5.5</td>
<td>72-100</td>
</tr>
<tr>
<td>Mean KT-1000 knee laxity</td>
<td>4.2 ± 1.1</td>
<td>1-12</td>
</tr>
<tr>
<td>Mean ROM, deg</td>
<td>137.2 ± 5.7</td>
<td>120-140</td>
</tr>
<tr>
<td>IKDC grade, No.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

*Abbreviations: deg, degree; IKDC, International Knee Documentation Committee; ROM, range of motion. *P<.05 compared with preoperative score (Wilcoxon signed rank test).}

### Table 3

**Summary of Regression Analysis Examining Influence of Predictor Variables on Tegner Score**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Univariate Analysis</th>
<th>Multivariate Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \beta ) (SE)</td>
<td>( P )</td>
</tr>
<tr>
<td>Age, y</td>
<td>-0.09 (0.01)</td>
<td>&lt;.0001*</td>
</tr>
<tr>
<td>Sex, female vs male</td>
<td>1.03 (0.45)</td>
<td>.264*</td>
</tr>
<tr>
<td>Injured side, left vs right</td>
<td>-0.59 (0.46)</td>
<td>.2153</td>
</tr>
<tr>
<td>Preop score</td>
<td>1.46 (0.31)</td>
<td>&lt;.0001*</td>
</tr>
<tr>
<td>Traffic accident, no vs yes</td>
<td>-0.96 (0.62)</td>
<td>.1320</td>
</tr>
<tr>
<td>Associated injuries, no vs yes</td>
<td>-0.09 (0.01)</td>
<td>&lt;.0001*</td>
</tr>
</tbody>
</table>

*Abbreviations: Preop, preoperative; SE, standard error. *P<.05; effect is significant.
current study’s patients had a significant improvement in activities of daily living, as represented by the Lysholm scores. The patients were mainly injured in traffic accidents, and most were not engaging in competitive sports activities. The long-term results with regard to knee laxity and knee function when the LARS artificial ligament is used for double-bundle PCL reconstruction remains to be determined by future randomized, controlled trials with a significant number of patients and a long-term follow-up.

Conclusion

Using the LARS ligament for double-bundle reconstruction of the PCL avoids donor-site morbidity and disease transmission. The complication rate is low, and the results appear to be stable with time and comparable with those obtained with other grafts. The authors suggest that double-bundle PCL reconstruction with the LARS artificial ligament may be an alternative treatment option for reconstructing an anatomic PCL. A randomized, controlled study should be performed to further assess the value of using the LARS artificial ligament for double-bundle PCL reconstruction.

References


