Isolated posterior cruciate ligament reconstruction:
Is non-aggressive rehabilitation the right protocol?

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Posterior cruciate ligament; Rehabilitation; Quadriceps tendon; Co-contraction exercises

Summary
Introduction: Reconstruction Surgery of the posterior cruciate ligament (PCL) has not yet been fully standardized, and associated rehabilitation protocols have not been clearly defined. The aim of this study is to report the results of a consecutive series of patients who underwent the same surgical technique for isolated PCL reconstruction and were submitted to the same specific rehabilitation protocol. A non-aggressive rehabilitation protocol which protects the graft from excess mechanical stress produces satisfying and reproducible clinical and laxity results in the knee.

Materials and methods: Our series included 17 patients who underwent single bundle arthroscopic reconstruction of the PCL with an autologous quadriceps tendon graft and who followed the same non-aggressive rehabilitation protocol. All patients were followed up for an average of 30 months (range 12–60 months). The preoperative evaluation and the last follow-up included objective and subjective IKDC scores as well as the Tegner & Lysholm knee scales. The side to side laxity was measured radiologically with the Telos stress testing device. A statistical analysis was performed to compare preoperative and postoperative results.

Results: Preoperatively, no patients were classified as A or B on the IKDC objective score. At last follow-up visit, 88.2% of patients were classified as A or B. Average side to side anteroposterior laxity was 11.9 mm (range 8–18) in the preoperative evaluation and 3.8 mm (range 1–7) in the final follow-up (p = 0.01) The average subjective IKDC score was 37.7 before surgery and 74.7 at last follow-up (p < 0.01). The Tegner & Lysholm scores were significantly improved by surgery.
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Discussion: Although the results are still less successful than ACL reconstruction, successful PCL reconstruction results were obtained with a standardized single bundle reconstruction technique and an adapted specific postoperative rehabilitation protocol. A non-aggressive rehabilitation protocol can limit postoperative mechanical stress on the graft.

Type of study: Retrospective Level IV.

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Introduction

Although the frequency of this surgical intervention has been on the increase since the year 2000, reconstruction of the posterior cruciate ligament (PCL) remains relatively rare. In 1999, it represented 2.6% of all knee ligamentoplasties in our rehabilitation center and 11% in 2007. During this same period, reconstruction techniques have been simplified and double bundle ligamentoplasties by arthrotomy have been replaced by single bundle arthroscopic reconstructions.

Preserving reduction of the posterior draw obtained at the end of surgery is the main difficulty of this surgical technique. Results of a retrospective multicentric study [1] by the French Association of Arthroscopy (Société française d’arthroscopie [SF A]) in a series of 103 isolated PCL reconstructions with an average follow-up of 48 months, showed that residual differential posterior laxity was more than 5 mm in 55% of reconstructions and more than 10 mm in 25%. Paradoxically, very few studies describe optimal rehabilitation protocols after PCL reconstruction [2, 3]. The aim of our study was to analyze the results after 30 months of follow-up in 17 patients who underwent isolated, single bundle arthroscopic PCL reconstruction with the quadriceps tendon and who followed the rehabilitation protocol described in this paper. Our hypothesis is that careful rehabilitation in terms of delay and gradual recovery, provides satisfactory and reproducible clinical and laxity results.

Materials and methods

Between 2005 and 2008, 47 patients underwent surgery in our unit for posterior laxity. There were 17 isolated injuries of the PCL and 30 cases of combined laxity. Surgery was performed jointly by two senior surgeons using the same technique (BSC and PC). Only the 17 reconstructions of the isolated PCL were included in this study. The surgical indication was based on a symptomatic isolated tear of the PCL revealed by laxity and/or pain with a side to side laxity of at least 8 mm. The population included 15 patients in whom conservative treatment had failed and two high-level athletes with significant differential laxity (18 mm) whose goal was to begin practicing sports again as soon as possible. Rehabilitation was always performed in the same center according to the same protocol. All patients were seen at the consultation for an average follow-up of 30 months (range 12–60 months) by the same observer who was independent from the surgeons (ZR).

The clinical results of this series are presented in Table 1.

The pre- and postoperative evaluation included a complete radiological evaluation, radiological measurement of differential laxity with a Telos stress device as well as an objective and subjective IKDC form and Tegner & Lysholm scores.

Surgical technique

The surgical technique was identical for all patients. It included isolated arthroscopic reconstruction of the anterolateral bundle of the PCL by autologous graft of the ipsilateral quadriceps tendon, with double fixation on the tibia (interference screw + press fit) and femur (interference screw + cortical fixation) (Fig. 1).

Table 1  Clinical data.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>17</td>
</tr>
<tr>
<td>Men and women</td>
<td>15 and 2</td>
</tr>
<tr>
<td>Age at surgery</td>
<td>29.25 (18–46)</td>
</tr>
<tr>
<td>Mechanism of injury</td>
<td></td>
</tr>
<tr>
<td>Sport</td>
<td>9 (53%)</td>
</tr>
<tr>
<td>Road accident</td>
<td>7 (41.1%)</td>
</tr>
<tr>
<td>Fall</td>
<td>1 (5.88%)</td>
</tr>
<tr>
<td>Delay accident - surgery</td>
<td></td>
</tr>
<tr>
<td>&lt; 3 weeks</td>
<td>2 (11.7%)</td>
</tr>
<tr>
<td>&gt; 3 months</td>
<td>15 (88.3%)</td>
</tr>
<tr>
<td>Follow-up (months)</td>
<td>29 (12–60)</td>
</tr>
</tbody>
</table>

Figure 1  Surgical technique: the bone block of the quadriceps graft to 11 mm in diameter is blocked by “press-fit” into the tibial tunnel whose proximal end is drilled to 9 mm in diameter. The tibial “press-fit” is secured by an interference screw. Femoral fixation by interference screw and attachment by traction suture on a cortical screw.
Table 2  Summary of the goals for recovery and protecting the PCL graft in relation to the postoperative delay.

<table>
<thead>
<tr>
<th>Period</th>
<th>Objective</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1 — D45</td>
<td>Teach the person not to use the hamstring Recover quadriceps function</td>
<td>0° active and passive extension Passive flexion 90°/95° Full weight bearing Knee brace in extension + small foam cushion on the posterior side of the upper end of the tibia day and night</td>
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<td></td>
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<tr>
<td>D45 — D90</td>
<td>Increase all types of weight bearing on the quadriceps and gastrocnemius: closed kinetic chain exercises</td>
<td>Passive flexion 120° Removal of brace then crutches and recovery of normal gait Muscle control and balance with destabilizing exercises on two legs Strengthening the hamstrings is only possible with the knee in extension and with a contraction of the quadriceps (no classic strengthening with the flexed knee) Avoid anterior instability during proprioceptive exercises</td>
</tr>
<tr>
<td>D90 — D150</td>
<td>Begin controlled physical activity</td>
<td>Continue recovery of flexion Continue recovery of muscular strength Proprioceptive training on one leg No classic strengthening of the hamstrings Avoid anterior instability during proprioceptive exercises</td>
</tr>
<tr>
<td>After J150</td>
<td>Begin normal physical and sports activities</td>
<td>Maximal flexion necessary for physical activities Strengthening the hamstrings Continue strengthening the quadriceps and reinforcing muscular control Training can begin when range of motion and muscular strength permit</td>
</tr>
</tbody>
</table>

Postoperative follow-up and rehabilitation

All patients followed the same postoperative rehabilitation protocol based on:

- temporary reduction of shear forces that cause posterior drawer induced by gravity and hamstring contraction;
- stimulation and strengthening of the quadriceps and triceps, to protect the reconstruction graft;
- early and progressive increase in weight-bearing.

Rehabilitation, which was begun in the surgical unit the day after surgery, was continued in our center after D + 4. The goals for recovery and protection of the graft in relation to the postoperative delay are summarized in Table 2.

Brace in extension

Immediately following surgery and until D45, the knee was immobilized in a brace locked in extension (Fig. 2). A counter pressure in the form of a small foam cushion placed behind the upper end of the tibia (Fig. 2) was added to the brace to prevent any shear force on the reconstruction graft [4,5]. The cushion and brace were worn day and night except for rehabilitation sessions.

Weight bearing

Walking and placing the foot on the ground while wearing the brace and using crutches was begun the day after surgery [6]. Progressive weight bearing did not really begin until D10.
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Exercises performed in flexion

After D21, the patient began exercises for flexion which only worked on the "braking" action of the quadriceps, and extension was gradually recovered in this same group of muscles.

Strengthening the quadriceps and the gastrocnemius

The quadriceps, which was nearly completely blocked in the first postoperative days was reactivated with electrostimulation and biofeedback. From D15 to D21, active locking of the knee in extension was obtained with open kinetic chain exercises (OKCE) which helped specific and overall strengthening of the quadriceps and gastrocnemius in a closed kinetic chain [7]. After D45, half-squats, stair-step exercises that emphasize pushing towards extension with the upper body in a vertical position, as well as exercises on a horizontal leg press (double leg push, single leg return) were begun within an ROM of 0°/60°.

Strengthening the hamstrings

In the first 5 postoperative months, there was no strengthening of the hamstrings in open kinetic chain exercises, at any angle. Classic strengthening of the hamstrings began during the 6th postoperative month. After D45, strengthening of this muscular group began, with the knee in extension and by contraction of the quadriceps and strapping (Fig. 5). Active spontaneous flexion without resistance was permitted on the 4th postoperative month within the free ROM.

Neuromuscular reprogramming

Proprioceptive training with weight bearing and the upper body in the vertical position was begun around D90, with the usual progression (weight on two legs → weight on one leg, stable ground → unstable ground, unmoving feet → moving feet).

Returning to physical activity

An exercise bicycle without a toe-clip, the foot with heel support, an upright stepper and kicking in a pool with the...
Figure 5  Working the hamstrings in the ventral decubitus position, with the knee in extension by contraction of the quadriceps plus a strap (co-contractions of the hamstring-quadriceps).

knee locked in extension by the quadriceps were allowed on D45. Until D90 these activities were performed without resistance while the amount of time was increased. From D90 to D150, activities were diversified by introducing an upright elliptic bicycle without using the upper limbs, a road bike without a foot cage, jogging, and swimming the crawl without flippers. The amount of time for each of these exercises and the amount of resistance were very gradually increased. After D150 running, bicycling and swimming were possible without restriction. Athletes could begin training again 8 months after surgery.

Statistical analysis

A descriptive analysis with a calculation of the frequencies, distributions, means and standard deviations was performed. For comparative analyses, we used Fisher’s Exact test and Wilcoxon’s test. The Mann-Whitney and the Kruskal-Wallis tests were used to study correlations. Five percent was considered to be significant.

Results

The results are summarized in Table 3.

Complications

Two patients developed algoneurodystrophy which resolved with medical treatment. At the last follow-up, two patients out of 17 (12%) presented with a flexion deficiency of 6° and 15°. Four patients (24%) presented with moderate pain (equivalent to discomfort or postoperative tendinitis) where the graft had been harvested. Three patients presented with moderate radiological narrowing of the medial joint space.

Activity level

Before the initial injury, all patients had been practicing moderate to intensive physical activity with 94% performing pivot-contact sports; this rate was 23.5% after the injury. At the last follow-up after surgery, 82% of patients were practicing moderate to intensive physical activity, 71% including pivot-contact sports. The level of physical activity of the 17 patients in the last follow was comparable to their level before the accident ($p = 1$ with Fisher’s Exact test).

Subjective evaluation of the knee by the patient

Eleven patients out of 17 (65%) evaluated their knee as normal or nearly normal in the last follow-up. The average subjective preoperative IKDC score was 37.7 while it was 74.5 in the last follow-up ($p < 0.01$).

Six patients out of 17 (35%) had the same amount of pain during physical activity as before surgery and four patients (23%) had moderate effusion during intense physical activity. The average Lysholm scores in the preoperative evaluation and at the last follow-up were 40 (range 5–69) and 82 (range 54–95) points respectively ($p = 0.0002$). The average pre-

| Table 3  Results of the series. |
|-----------------|-----------------|-----------------|---|
| Before the Accident | Preoperative | Postoperative | $P$ |
| IKDC | | | |
| Subjective (points) | 37.7 (21.4)$^a$ | 74.5 (17.8) | < 0.01 |
| Objective (patients) | | | > 5% |
| A | 0 | 5 | |
| B | 0 | 10 | |
| C | 10 | 2 | |
| D | 7 | 0 | |
| Lysholm Score (points) | 40.5 (18.9) | 82.3 (10.9) | < 5% |
| Tegner Score | 3 (2.1) | 7 (1.8) | < 5% |
| Level of activity (patients) | | | |
| Intensive | 9 | 1 | 7 |
| Moderate | 8 | 3 | 7 |
| Light | 0 | 8 | 1 |
| Sedentary | 0 | 5 | 2 |
| Posterior drawer (mm) | 11.9 (4.4) | 3.8 (2.3) | < 0.01 |

$^a$ Average (standard deviation).
operative and postoperative Tegner scores were 3 and 7 \((p = 0.003)\).

**Objective evaluation**

- Preoperatively, there were no patients classified A or B at the objective IKDC score whereas 88.2% of patients in the series was A or B at the postoperative evaluations.
- Side to side postoperative laxity was 11.9 mm (range 8—18) in the preoperative evaluation and 3.8 mm (1—7) in the last follow-up \((p = 0.01)\).

**Correlations**

The delay between the accident and surgery did not affect the objective or subjective IKDC scores \((p = 0.112\) and \(p = 0.251\) respectively), or the residual side to side laxity \((p = 0.829)\). At the last follow-up, the subjective and objective scores were not correlated \((p = 0.335)\). However, there was a correlation between the level of preoperative activity and the subjective IKDC score \((p < 0.01)\).

**Discussion**

Management of PCL injuries remains controversial. The results of surgical studies in the literature are difficult to analyze. Clinical series are often heterogeneous, both for the type of injuries treated and the methods of evaluating posterior laxity. Nevertheless, several published series have evaluated surgery for isolated PCL injuries. Wu et al. [8] prospectively studied 22 arthroscopic reconstructions of isolated PCL injuries using an autologous graft of the quadriceps tendon. This study found a significant improvement in differential laxity, IKDC scores and Tegner and Lysholm scores after an average follow-up of 5 years. Sekiya et al. [9] retrospectively studied the clinical results of 21 single AL bundle arthroscopic reconstructions of the isolated PCL with an autologous graft of the Achilles tendon. Results showed a significant difference in relation to the delay between the accident and surgery. In a retrospective study of 25 patients with an average follow up of 9 years, Hermans et al. [10] found a significant difference in patients who underwent surgery within one year after the accident and the others. We did not find any correlation between the delay between the accident and surgery and the final results.

Although the results are encouraging in all of these series, there is very little information provided about postoperative rehabilitation protocols. While for Boileau and Shelbourne [11,12] accelerated rehabilitation protocols are possible after reconstruction of the anterior cruciate ligament, in our opinion, rehabilitation protocols following posterior cruciate ligament reconstruction should be non-aggressive [2]. In all cases, these protocols must respect the delays for recovery of range of motion in flexion, and the principle of not using/and of early strengthening of the hamstrings. Practically speaking, the latter is the main difficulty of rehabilitation because if an exercise is not performed correctly, whatever it is, the use of the hamstring exerts excess shear on the ligamentoplasty which may cause the graft to slip into the bone tunnels or cause elongation of the transplant.

Therefore, during the postoperative period, it is important to make the patient aware of the dangers of active flexion of the knee by the hamstrings and to teach them the correct movements and confirm that this group of muscles is not being used during any of the exercises. The rehabilitation protocol should obviously be adapted to any associated injuries or movements.

The results of our series of reconstruction of 17 isolated PCL with an average follow-up of 30 months also shows a significant improvement in the subjective scores and satisfactory results in the control of the posterior drawer. This study only included isolated ruptures of the PCL which were operated on with the same surgical technique and which received the same postoperative rehabilitation protocol. Nevertheless, our study has certain weaknesses. It is a retrospective study with a fairly short follow-up and a small cohort. The clinical results of this series should therefore be interpreted with caution.

**Conflict of interest statement**

None.

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**References**


