Arthroscopic reconstruction of the posterior cruciate ligament with a quadruple hamstring tendon graft

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Background
This study prospectively evaluated 21 patients treated consecutively to determine patient outcomes, efficacy, and possible complications of arthroscopically assisted posterior cruciate ligament (PCL) reconstruction performed with hamstring tendon grafts.

Patients and methods
Twenty-one patients (18 men and three women), each with an isolated PCL injury, underwent PCL reconstruction with a hamstring tendon autograft and were enrolled in this prospective study. The average age of the patients at the time of surgery was 26 years (range, 21–30 years). The average follow-up period was 21 months (range, 12–30 months). Patients underwent regular follow-up after clinical and radiographic preoperative and postoperative evaluation. Follow-up examinations included the International Knee Documentation Committee score, thigh muscle assessment, and radiographic evaluation.

Results
In the final International Knee Documentation Committee ratings, 85.7% of patients (18 of 21) were assessed as normal or near normal (grade A or B). A statistically significant improvement was observed in thigh girth difference, extensor strength ratio, and flexor strength ratio before and after reconstruction.

Conclusion
Analytical results showed satisfactory function after PCL reconstruction with the use of hamstring tendon autografts. We suggest that the hamstring tendon autograft is a safe, effective, and acceptable choice for PCL reconstruction, and that it affords good ligament reconstruction.

Keywords:
posterior cruciate ligament, knee reconstruction, hamstring tendon

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Introduction

Posterior cruciate ligament (PCL) injuries are more common than considered previously. Injuries to the PCL have been reported to compose ~3% of all knee injuries in the general population and as much as 37% in trauma patients with acute hemarthrosis. Furthermore, the setting in which the injury occurred has diagnostic and therapeutic implications because 95% of PCL injuries in the trauma setting have associated ligamentous injuries as well. In contrast, athletes suffer mainly isolated PCL injuries, although the overall incidence in this population remains unknown [1–3].

In contrast to the anterior cruciate ligament (ACL), the indications for PCL surgery are not well established. PCL injuries occur less frequently than ACL injuries and many isolated PCL injuries may be undetected [1].

PCL injuries have historically been underdiagnosed because of their frequent asymptomatic nature. Natural history studies have suggested that that the PCL-deficient knee lags behind that of the ACL-deficient one and at short or intermediate follow-up, PCL-deficient athletes functioned well despite obvious clinical laxities [2,3].

In the past decade, many changes have occurred in the basic science knowledge, available techniques, and the graft used. Graft selection, graft placement, fixation method, knee position at fixation, period of immobilization, position of immobilization, and rehabilitation are among the many factors that contribute toward the variables affecting PCL surgical results. In addition, most knee ligament surgeons, many of whom perform more than 100 ACL reconstructions annually, are relatively inexperienced with PCL reconstructive surgery [4].

Patients and methods

Between February 2008 and December 2009, 21 patients (18 men and three women) underwent arthroscopic reconstruction for isolated PCL laxity at Tanta University hospitals of not less than 3 months' duration. Fifteen patients had laxity in the left side and six in the right side. 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 that prevented them from returning to ordinary daily activities.

Before surgery, all patients had at least grade II 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 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 author (Abdou). Spinal anesthesia was administered and the patient was placed in the supine position. The foot of the operating table was lowered so that the affected knee could be hung free at the edge of the table in a 90° flexion position. The opposite limb was placed in a well-leg support with the knee flexed and hip flexed, abducted, and externally rotated to facilitate the work of C-Arm on the affected knee (Fig. 1).

Routine diagnostic arthroscopy was then performed and associated meniscal chondral lesions were managed. Arthroscopic portals utilized for the procedure included a high anteromedial portal, a low anterolateral portal, and a high posteromedial portal. While viewing through the anterolateral portal, the remnant of ruptured PCL on the medial femoral condyle was removed using a shaver through the anteromedial portal (Fig. 2). The remaining fibers of the PCL on the tibia were then removed using a shaver through the high posteromedial portal, while viewing through the anteromedial portal (Fig. 3).

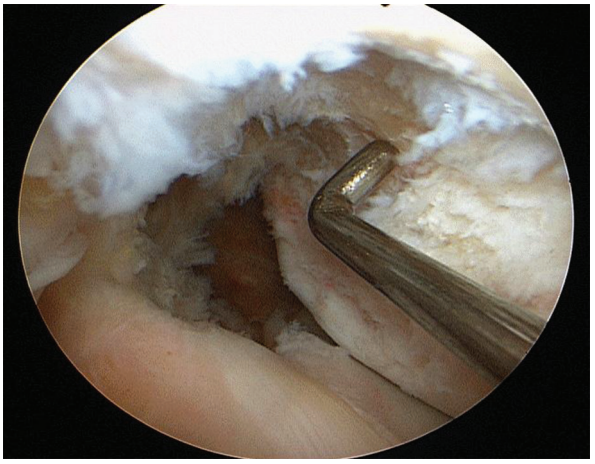
Through a separate longitudinal proximal tibial incision, the semitendinosus and gracilis tendons were harvested and fashioned to form a four-strand graft with a minimum length of 13 cm. The tendons at the proximal and distal ends of graft were sutured using a whipstitch. The central, intra-articular, 4 cm of the graft remained free of suture material.

Using fluoroscopy, the tibial tunnel was prepared using the PCL Tibial Drill Guide (Arthrex Inc., Naples, Florida, USA) and a 10 mm cannulated reamer (Fig. 4). A looped wire was used to pass No. 5 nonabsorbable suture through the tibial tunnel. The anterolateral area of the PCL footprint was chosen for single-bundle PCL reconstruction. Through the low anterolateral portal, a 10 mm femoral tunnel was created using a cannulated reamer to a depth of 40 mm.

Figure 1

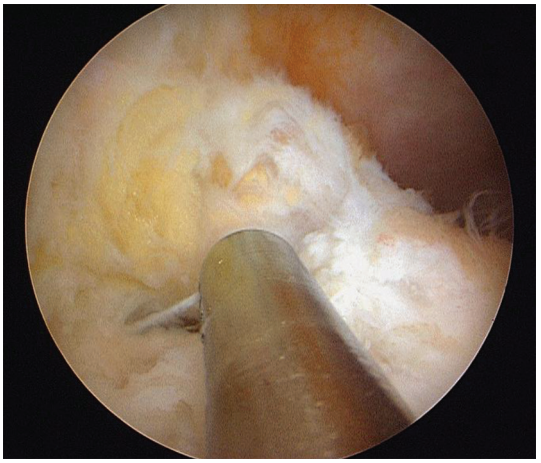
Patient position.

Figure 2



Preparation of femoral insertion.

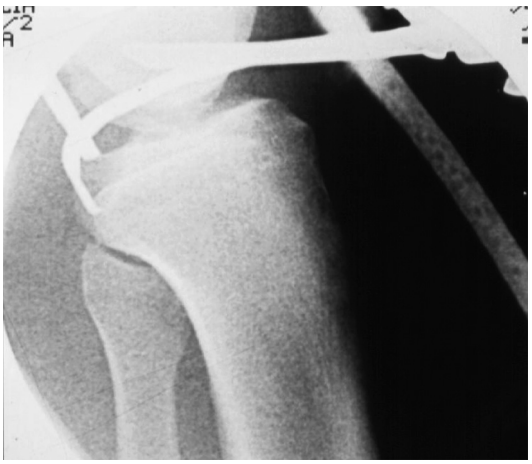
Figure 3



Preparation of tibial insertion through the posteromedial portal.

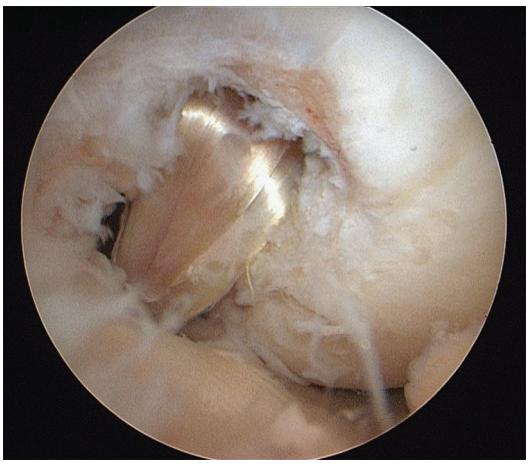
A pull-out suture was threaded in a retrograde manner. Using this, a four-strand hamstring graft was pulled

Figure 4



Tibial guide under fluoroscopy.

Figure 5



Graft insertion.

through the tibial tunnel and then docked into the femoral tunnel. Proximal femoral fixation was achieved using a bioabsorbable interference screw inserted over a guide pin. The graft was then tensioned, the knee taken through at least 10 range-of-movement cycles. With a maximal anterior drawer tension of the proximal tibial in 90° knee flexion, a bioabsorbable interference screw was inserted over a guide pin for tibial fixation.

Finally, using a probe, the graft was tested for tension (Fig. 5). The good tension of the graft must be associated with good tension of ACL. The patient was allowed to commence full weight-bearing as tolerated without a brace and intensive physiotherapy was started on the week of surgery using closed-chain exercises focusing on quadriceps strengthening. Resisted hamstring exercises were contraindicated for 6 weeks.

Review

At the 2-year follow-up, the 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 1–4, which correspond, respectively, to strenuous (rugby, basketball), moderate (skiing, tennis, heavy manual labor), 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 results of posterior drawer tests were classified according to Clancy's classification.

Statistical analysis

SPSS 11.0 for windows was used for all statistical analyses. Results were 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 a P value less than 0.05.

Results

The highest incidence of PCL rupture was found to be in the age group from 21 to 30 years. The younger the patient, the better the results. The clinical results were better in the left side than in the right side. The end results were found to be better in men than in women.

The duration of operative intervention ranged from 1.5 to 3 h, with a mean of 2 h. In isolated PCL reconstruction, the operative time ranged from 1.5 to 2 h, with a mean of 1.7 h. With associated meniscal suturing, the operative time ranged from 2 to 2.5 h, with a mean of 2.1 h.

In all cases, a hinged knee brace and immediate continuous passive motion over a range of 0–90° were initiated. The patients were encouraged to use the ice therapy unit as much as tolerable.

The patients were evaluated after PCL reconstruction periodically every 3 weeks for 6 weeks, and then every 3 months until the end of the first year. The shortest period of follow-up was 12 months and the longest period was 30 months, with a mean of 21 months.

One year after reconstruction, 15 patients (71.4%) could return back to their previous activities. Six patients (28.6%) did not return back to their previous activities as before injury because of lack of confidence of stability of the knee. The difference in the activity level before injury, preoperative, and after reconstruction was statistically significant ($P < 0.001$).

The total end results of the preoperative IKDC score were graded into almost normal in five patients (23.8%), abnormal in 10 patients (47.6%), and severely abnormal in six patients (28.6%).

The total end results of postoperative IKDC score were graded as follows: normal 10 patients (47.6%), almost normal in eight patients (38.1%), abnormal in two patients (9.5%), and severely abnormal in one patient (4.8%).

The difference between the preoperative and the postoperative IKDC score end results was statistically significant ($P < 0.001$) Table 1.

Patient subjective assessment

The patient was asked to rate the involved knee compared with the normal knee or what was perceived as normal. Ten patients (47.6%) stated that the knee became normal; eight patients (38.1%) stated that it was almost normal; two patients (9.5%) stated that it was abnormal; and one patient (4.8%) stated that it was severely abnormal.

Symptom evaluation

Pain

Ten patients (47.6%) had no pain during athletic activities, whereas eight patients (38.1%) had mild inconstant pain during strenuous activities. two patients (9.5%) had mild inconstant pain during moderate activities; and one patient (4.8%) had mild inconstant pain with light activities.

Knee swelling

Eighteen patients (85.7%) did not complain of any knee swelling. However, two patients (9.5%) had mild swelling that occurs with strenuous activities. One patient (4.8%) had swelling that occurs with moderate activities. No patient had constant or tense swelling.

Sense of instability

Eighteen patients (85.7%) had no episodes of giving way during their activities, whereas two patients (9.5%) had partial giving way on strenuous activities, one patient (4.8%) on moderate activities, and none with light activities.

Table 1 Relation between preoperative and postoperative IKDC score end results

End results	IKDC score (final evaluation) [*n* (%)]	
	Preoperative	Postoperative
Normal	0 (0.0)	10 (47.6)
Almost normal	5 (23.8)	8 (38.1)
Abnormal	10 (47.6)	2 (9.5)
Severely abnormal	6 (28.6)	1 (4.8)
Total	21 (100.0)	21 (100.0)

Wilcoxon signed ranks test; $Z = 9.22$; IKDC, International Knee Documentation Committee; $P < 0.001$ (significant).

Range of knee motion

Extension range

Twenty patients (95.2%) had loss of less than 5° of extension compared with the healthy side, whereas one patient (4.8%) had loss of 6–10° of extension.

Flexion range

Nineteen patients (90.5%) had no lack of flexion compared with the healthy side, whereas two patients (9.5%) had lack of flexion up to 15°.

Radiological evaluation

Seventeen patients (80.9%) were graded with a radiologically normal knee, two patients (9.5%) with an almost normal knee, one patient (4.8%) with an abnormal knee, and one patient (4.8%) with a severely abnormal knee.

All bone tunnels into which the graft had incorporated were benign. The graft position as well as the tunnel length were clearly demarcated by a line of higher bone density.

Functional hopping test

On comparing the hop distance of the operated limb with the sound one, 16 patients (76.2%) could hop more than 90% of the normal limb. Four patients (19%) could hop from 76 to 89% and one patient (4.8%) from 50 to 75%.

IKDC score end results

The total end results of the IKDC score were graded as normal in 10 patients (47.6%), almost normal in eight patients (38.1%), abnormal in two patients (9.5%), and severely abnormal in one patient (4.8%).

All except one of these patients had normal or almost normal objective findings. The lower rating was because of subjective complaints.

Complications of PCL reconstruction

Early complications

Hemarthrosis: Four patients (19%) developed postoperative moderate hemarthrosis. Aspiration, cold therapy, and medication were administrated. One patient (4.8%) developed tense hemarthrosis. Arthroscopic lavage and partial synovectomy were performed. All patients with postoperative

hemarthrosis recovered completely without any sequel.

Infection: One patient (4.8%) developed moderate effusion and fever for 2 days that did not improve with medication. Arthroscopic lavage and partial synovectomy were performed on the third day. Culture and sensitivity test showed a streptococcal infection. Medication was administered and the infection cleared, but there was delayed recovery of the knee in range of motion and the patient was graded as having an abnormal knee.

Late complications

Donor site morbidity: One patient (4.8%) developed mild pain and tenderness in the posteromedial aspect of the knee in line with the donor site. The pain disappeared gradually after 9 months.

Knee motion deficit: One patient (4.8%) had loss of 6–10° of extension after 4 months of postoperative rehabilitation. Two patients (9.5%) developed lack of up to 15° of flexion after 6 months of postoperative rehabilitation.

Fixation site morbidity: Two patients (9.5%) developed tenderness over the post tibial fixation with no signs of infection. One patient (4.8%) developed radiologically a cyst in the site of the bioabsorbable interference screw without any complaint from the patient.

Knee osteoarthritis: Diminution of the medial joint space was detected in two patients (9.5%) of larger than 4 mm and in one patient (4.8%) of 2–4 mm. A change in the lateral joint space was detected in two patients (8%) of larger than 4 mm and in one patient (4.8%) of 2–4 mm.

A reduction in the patellofemoral joint space was detected in four patients (19%) of larger than 4 mm, in two patients (9.5%) of 2–4 mm, and in one patient (9.5%) of less than 2 mm.

Discussion

Most PCL ruptures may be managed successfully with supervised conservative treatment [2,5,6]. Shelbourne *et al.* [5] studied 133 patients with isolated PCL injury who were treated through an unsupervised rehabilitation program and found that 42% consistently rated the knee as good or excellent. Shino *et al.* [6] studied 15 patients with PCL injury and reported that 53% had an overall IKDC of A or B, and 73% were participating in moderate to strenuous activities.

Arthroscopic PCL reconstruction has increased in frequency recently, and satisfactory results with an IKDC of A or B (range 68–82%) have been documented for most patients in whom surgical principles and techniques were adequate [7–10]. The following controversies continue: choice of graft tissue, use of one-bundle or two-bundle reconstruction, location of tunnel placements, knee flexion angle when a graft is secured, and methods of fixation.

A patellar tendon–bone autograft is considered the preferred procedure for reconstruction of the ACL [11,12] and is used widely as a graft for PCL reconstruction [13,14]. This graft technique has several shortcomings. The patellar tendon autograft may be too weak to adequately substitute for the PCL and can be difficult to pass through the tunnel when the transtibial tunnel procedure is used. The quadriceps tendon autograft is thicker and wider than the patellar tendon, thereby providing an ample source of tendons for ligament reconstruction purposes. The quadriceps tendon–bone construction may be a versatile alternative graft for use in primary and revision ACL and PCL reconstruction [8,15,16]. However, a high incidence of donor-site pain and graft-site morbidity has been reported when both tendon grafts are used [17–19]. Hamstring tendon autograft has gained popularity recently. The quadrupled graft of double loops of semitendinosus and gracilis tendons has greater mechanical strength than the bone–patellar tendon–bone complex commonly used in ACL reconstruction [20,21]. The hamstring tendon graft method provides greater initial fixation strength than the patellar tendon graft method, [22] allowing for accelerated rehabilitation protocols. Moreover, because a hamstring tendon graft is multistranded and has a larger surface area, it can be advantageous in promoting revascularization [23].

Considering the availability of tissue and the surgical simplicity of the technique, hamstring tendon autografts were used in this series for arthroscopic reconstruction of the isolated PCL. This study identified significant improvement in knee function, activity level, and IKDC classification. No morbidity was associated with harvesting of the hamstring tendon. The total end results of IKDC score were graded as normal in 10 patients (47.2%), almost normal in eight patients (38.1%), abnormal in two patients (9.5%), and severely abnormal in one patient (4.8%).

However, Chan *et al.* [24] reported that the IKDC evaluation system showed that only 25% (n = 5) of patients were classified as normal and 60% (n = 12) were rated as almost normal at the final follow-up. Many studies have also reported a lower percentage

of normal or almost normal results when the IKDC system is used than with other rating systems. It seems, however, that most patients lowered their activity level between reconstruction and follow-up, likely reflecting the realization that complete restoration of knee function after reconstructive surgery is extremely rare.

In this series, one patient (4.8%) developed loss of 6–10° of extension after 4 months of postoperative rehabilitation. Two patients (9.5%) developed lack of up to 15° of flexion after 6 months of postoperative rehabilitation.

However, Chan *et al.* [24] reported that three patients (15%) had problems with range of motion after surgery. One patient (5%) showed a 3–5° difference in extension and two patients (10%) showed a 16–25° deficit in flexion compared with a normal limb. They considered that postoperative limitation in range of motion may be a problem when hamstring tendon graft is used for PCL reconstruction. They recommended more aggressive training for knee flexion and squatting ability so that this problem can be avoided. They observed that extensor muscle strength in the reconstructed knee recovered to at least 90% that of the normal knee in 18 (90%) patients. Flexor muscle strength in the reconstructed knee recovered to at least 90% that of the normal knee in 17 (85%) patients. Recovery of extensor strength and flexor strength as assessed preoperatively and postoperatively was statistically significant. They recommended that thigh muscle training may be more effective when hamstring tendon reconstruction is used and we also recommended this.

Numerous studies [6,25,26] have reported that PCL injury is associated with an increased incidence of degenerative changes in the knee, primarily involving the medial, patellofemoral, and lateral compartments, in that order. This rate increased with duration of injury, severity of ligament laxity, and length of follow-up [27].

This prospective study is unique for two reasons:

(a) All patients had an isolated PCL injury; those with associated injuries were excluded to control for confounding factors that may have affected outcome; and
(b) The arthroscopic surgical technique was identical in terms of autograft type, performing surgeon, graft placement, graft fixation, and rehabilitation program.

Furthermore, all 21 patients received complete follow-up and outcome assessment. However, the limitations of this work must be acknowledged. No control group was studied. The principal disadvantages were the small case number and the limited observation period.

Conclusion

After follow-up for longer than 30 months, analytical results showed that patients achieved satisfactory function after PCL reconstruction was performed with the hamstring tendon autograft. We suggest that the hamstring tendon autograft is a safe, effective, and acceptable choice for PCL reconstruction with good outcomes.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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