Original Article

A Study on the Results of Reconstructing Posterior Cruciate Ligament Using Graft from Quadriceps Muscle Tendon

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Abstract

Background: Many of the knees affected by rupture of the posterior cruciate ligament (PCL) lack their desirable function. Researchers are currently seeking surgical procedures for treating PCL rupture, which can offer a reliable degree of objective and subjective knee stability after surgery. This study assesses the results of anatomical reconstruction of PCL using graft from the tendon of the quadriceps muscle.

Methods: This is a descriptive prospective study involving 14 patients with clinical diagnosis of PCL rupture. The patients complained of knee discomfort in spite of conservative treatment and many sessions of physiotherapy. Subjective symptoms of knee instability, i.e. giving way, pain after long walks and pain during climbing, as well as objective knee instability symptoms as assessed by posterior drawer test at 30° and 90° knee flexion, and neutral rotation were recorded and compared prior to and after surgery. The procedure entailed anatomical reconstruction of PCL using grafts taken from the tendon of quadriceps muscle and part of proximal patella.

Results: Two patients were excluded from the study due to their failure to refer for follow-up. The patients included 11 men and 1 woman with a mean age of 23 years. The patients displayed statistically significant improvement after surgery as regards subjective symptoms, i.e. giving way, pain after long walks and pain in climbing. Objective knee instability symptoms as evaluated by posterior drawer test at 30° and 90° knee flexion and neutral rotation also showed significant improvement compared to pre-operation findings.

Conclusion: Reconstruction of PCL is aimed at achieving normal knee kinematics and stability. The procedure used in this study entailed anatomical reconstruction of PCL. Given the objective and subjective results obtained, the use of this procedure is recommended by authors as the method of choice for reconstructing PCL.

Keywords: Posterior Cruciate Ligament, Knee Instability, Quadriceps Tendon

Lesions of the posterior cruciate ligament (PCL) of the knee constitute between 3-20% of all knee ligament lesions[1]. Surgical treatment of PCL lesions of the knee is surrounded by much controversy[2]. Many authors recommend conservative treatment for PCL rupture[2]. However, it is obvious that not all knee with PCL rupture regain a desirable level of function and long-term studies have shown that knee function deteriorates over time, especially in the presence of severe knee instability (i.e. grade III of knee joint function)[3, 4, 5]. Studies on the natural trend of PCL lesions without surgical treatment have revealed that between 52% to 70% of patients had knee pain in walking and standing, 20% experienced giving way and 36% displayed long term changes characteristic of osteoarthritis[3]. Osteoarthritic changes in affected knee correlate directly with the duration of time since the development of lesion[4]. In one study on patients who underwent surgical reconstruction of knee ligaments, four years after sustaining the lesion, osteoarthritic changes of the medial compartment were seen in 90% of patients at the time of operation[6]. Hence, surgical correction of PCL lesions is recommended in young individuals in order to prevent osteoarthritis and instability of the knee[7, 8]. Presently, researchers are seeking surgical procedures, which result in better objective stability of the knee, to eliminate or delay the development of osteoarthritic changes[6].

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Different procedures have been described for reconstructing PCL. Most studies have described the use of the gastrocnemius muscle, or the meniscus as replacement for PCL[6]. Presently, considerable controversies remain on the graft choice and fixation methods in PCL reconstruction[9]. Despite the functional improvement, current surgical techniques only have modest success in restoration of ligament stability in knees[8]. Investigators hypothesized that double-bundle grafts reconstruction of PCL demonstrates a mechanical advantage compared to single bundle grafts[10, 11] and restoring normal knee laxity compared to the conventional single bundle isometric reconstruction[12]. Some surgeons have recently used other types of grafts, such as the middle third of patellar tendon and hamstring tendon auto graft, or the Achilles tendon and patellar tendon allograft. These procedures entail partial anatomical reconstruction of PCL[7, 9, 10] (usually the anterolateral section), or the use of graft from different locations (e.g. hamstring and patellar ligaments) for reconstruction of both, anterolateral and posteromedial sections of PCL[7]. Disadvantages of the latter procedure include:

a) the need for obtaining grafts from two sites,
b) the need for longer grafts (because the grafts must be passed through the tibial canal, hence the need for surgeons to determine the precise length of the graft prior to surgery), and
c) the acute angle of the grafts at the tibial tunnel, has been implicated as a cause of graft failure[13, 14].

In this study, we described a modification of a PCL reconstruction technique using a single double – bundle quadriceps tendon graft and the outcome of this procedure was determined as related to subjective and objective knee symptoms.

Materials and Methods

Our study was descriptive and prospective, involving patients with the clinical diagnosis of severe chronic PCL tearing who had referred to the orthopedics clinic of Al-Zahra hospital. These patients continued to complain of knee instability in spite of receiving conservative treatments such as physiotherapy and underwent arthroscopy for treatment of meniscal tearing and other problems of the knee. None of the patients suffered from malalignment of the lower limbs.

The patients were adequately briefed on the surgical procedure and their written consent was obtained.

Patients' data such as age, sex and type of trauma, as well as signs and symptoms of knee instability were collected using questionnaires. Symptoms of knee instability such as giving way, knee pain after long walks (>1000 meters) were recorded. Pain in climbing (15 to 20 stairs) before and after the surgery was recorded as no pain, mild, moderate to severe and disabling pain.

Signs of knee instability were examined and graded by an attending professor of orthopedics using posterior drawer test at 90° flexion, neutral knee rotation and posterior drawer test at 30° flexion and neutral rotation (grade I: posterior displacement less than 5 mm, grade II: posterior displacement of 5-10 mm, grade III: Posterior displacement more than 10 mm). These data were entered in the questionnaires.

Surgical technique

The patients were placed in the decubitus position, with the affected lower limb facing upwards. Prep and drape were applied to the lower limb in 45° abduction, external hip rotation, and 90° knee flexion. Grafts were taken from the tendon of quadriceps muscle and part of proximal patella. The bony portion of graft was 10-12 mm wide and 4-5 cm long. The tendinous section of the graft was 16 mm wide and had the full length of the quadriceps muscle tendon. The tendinous part of the graft was divided into two separate sections from the middle. Each of the two ends of the tendon were sutured with Vicryl thread # 1 using the Krackow method, leaving free the two ends of the thread to pass through the femoral tunnel. Drill # 2.7 mm was used to bore two holes in the bony portion of the graft for fixation. The remnants of PCL on the lateral surface of the medial condyle of femur in the intercondylar notch were exposed. There is a rounded ridge in this location with no PCL fibers originating from its posterior aspect. This ridge offers a very useful landmark for ascertaining the site of femoral tunnels. Two tunnels were bored in the intercondylar notch on the anterior aspect of the ridge. They were separated from each other with a 1-3 mm bony edge. The site of making the tunnels was determined using guide wire and was rimmed using an 8 mm rimmer. The tunnels' were bored at 10:30 and 1:30

o'clock position of the intercondylar notch in the left and right knees respectively, posterior to the articular surface of the medial condyle of femur. The posterior tunnel should lay distal and posterior to the anterior tunnel. Care was taken to create the tunnel at the anatomical site of PCL exactly opposite to the ridge of the medial condyle of femur. In the next stage the knee was extended and the patient's bed was tilted towards the prone position. The popliteal fossa was then explored using the standard approach, exposing the anatomical site of PCL insertion on the posterior surface of the tibial plateau. The site was prepared for fixation of the bony section of the graft. Fixation of the graft was then conducted using two 4 mm cancellous screws of appropriate length. The site of incision was washed and the anatomical layers were repaired. The patient was returned to the lateral position. The tendinous part of the graft was passed through the femoral tunnels and the two ends of the threads were knotted to each other outside the tunnels at 30-40 flexion, neutral rotation, and anterior drawer position of proximal tibia.

In the next stage, graft tension was tested at 90° flexion by neutral rotation and posterior drawer test. The surgical wound was cleaned and closed using the routine method. Posterior splint was then applied in complete knee extension. The knee remained in complete extension for two weeks and the patients were allowed partial weight bearing using crutch. Rehabilitation continued similar to the other techniques for PCL reconstruction.

Signs and symptoms of knee instability were compared before and one year after the operation using MC Nemar and Wilcoxon statistical test. P values less than 0.05 were considered as statistically significant. Data were analyzed using SPSS 10.0.

Results

Fourteen patients (13 men and 1 woman) were studied. Two patients were excluded from the study due to failure to refer for follow-up. The patients had a mean age of 23 ± 8 years. Mechanism of injury in all cases was due to trauma.

Frequencies of patients with different degrees of symptoms of knee instability are summarized in table 1. Before surgery, one patient felt slight pain, 9 had severe pain and two patients complained of debilitating pain after long walks. One year after surgery, 10 patients had no complaints and 2 patients had slight pain after long walks, showing a significant difference from their pre-operation state ($P < 0.05$).

Before surgery, 7 patients had slight pain, 4 patients had severe pain and 1 patient complained of debilitating pain in climbing. One year after surgery, 9 patients had no pain and 3 patients had slight pain in climbing, showing a significant difference from their pre-operation state ($P < 0.05$).

Before surgery, the giving way symptom was experienced by 9 patients and 3 patients did not have the symptom. Neither of the patients experienced giving way after surgery, showing a significant difference to the pre-operation state ($P < 0.05$).

Results of assessing objective stability of knee before and one year after surgery were as follows:

Posterior drawer test in 90° flexion and neutral rotation: Before surgery, all patients fell in grade III (>10 mm) posterior instability. After surgery, 5 patients fell in grade I, and 7 in grad II posterior instability, showing a significant improvement from their pre-operation state ($P<0.05$). All of patients had full range of motion after one year follow-up. We did not have any complications such as patellar fracture, decreased rang of motion and quadriceps tendon rupture.

Discussion

Theoretically, the posterior cruciate ligament functions as two separate bundles. The anterolateral bundle of the ligament works essentially in knee flexion and the largest part of the posteromedial bundle serves in knee extension[7, 15 – 17]. When a single graft is used, only one of the two bundles (principally the anterolateral bundle) can be reconstructed. Since most knee activity occurs below 70° of flexion, mere reconstruction of the anterolateral bundle of PCL places the graft under stress when the knee is flexed below the degrees in which the graft is under tension, ultimately resulting in its cyclic fatigue and lengthening[7]. Hence, both bundles of the ligaments must be reconstructed to activate dynamic stability of the knee in all degrees of flexion. The function of the posteromedial and anterolateral bundles of PCL is assessed by conducting the posterior drawer test at 30° and 90° knee flexion, respectively[13]. Presently, considerable controversies remain on the graft choice and fixation

methods[9]. Most studies have reported procedures involving the use of graft from the gastrocnemius and hamstring muscles[7]. These procedures do not enable the anatomical reconstruction of PCL and the prepared graft is significantly weaker than graft taken from the middle third of the quadriceps tendon. In a study by Kennedy and Galpin, graft was taken from the gastrocnemius muscle[7]. Excellent and good results were obtained in this study in 80% of patients; however, posterior drawer test was positive for all patients after surgery. In general, the degree of objective stability achieved in these studies has been far less than that of a normal PCL[7]. In another study with single-bundle reconstruction of PCL the results were 68% satisfactory and 32% unsatisfactory and complete restoration of ligament stability was observed in only 44% of the knees[8]. Despite the functional improvement, the currently devised surgical techniques show only moderate success in restoration of ligament stability in knees[8]. The investigators hypothesized that double-bundle graft demonstrates a mechanical advantage over single-bundle graft[10, 11].

In the new procedures, attempt has been made at achieving the anatomical reconstruction of PCL using multiple femoral tunnels and more than a single graft. These procedures meet biomechanical and clinical objectives; nevertheless, the obtained results come from the preliminary stages of the study.

The procedure used in the current study is different from the latter described procedure in three major ways:

1) anatomical reconstruction of PCL is achieved without the need for taking graft from two sites.

2) since this procedure disposes of the need for passing the graft through the tibial canal, the length of graft required is less than that needed in other procedures, hence dispensing the need to conduct an accurate measurement of the length of graft prior to surgery.

3) with this procedure, the acute angle of the graft at tibial tunnel improved. This acute angle has been implicated as a cause of graft failure.

As previously noted, all 12 patients in this study achieved considerable subjective relief after surgery; i.e. giving way and pain after long walks or in climbing decreased notably compared to before surgery. Results of posterior drawer test at 30° and 90° knee flexion and neutral rotation also improved remarkably. Improvement in knee function at 90° flexion was nevertheless more prominent. Better objective posterior drawer test results may be achieved if each of the aforementioned PCL bundles can be fixed separately at 90° and 30° flexion. Disadvantage of this procedure only was making two separate incisions.

Table 1. Frequency of patients with different signs and symptoms of knee instability before and after operation.

		BO	AO*
Pain in long walking	No Pain	0	10
	Mild	1	2
	Moderate to Severe	9	0
	Disabling	2	0
Pain in Climbing	No Pain	0	9
	Mild	7	3
	Moderate to Severe	4	0
	Disabling	1	0
Posterior Drawer Test			
At 90° flexion	Grade I	0	10
	Grade II	0	2
	Grade III	12	0
At 30° flexion	Grade I	0	5
	Grade II	0	7
	Grade III	12	0
Giving way	Positive	9	0
	Negative	3	12

BO = Before Operation, AO = After Operation

*$P < 0.05$ compared to the frequencies before operation

References

1. Shenck RC Jr. Injuries of the knee. Beaty JH. Kasser JR. In: Fractures in adults. From: Philadelphia, LIPPINCOTT WILLAMS & WILKINS; 2001, Vol. 2,5th edition, 1843 1937.
2. Miller RH. Knee Injuries. Canale ST. IN: Campbell's operative orthopaedics. Frome: Pennsylvania, Mosby, 2003, Vol. 3, Tenth edition, 2199- 2300.
3. Parolie JM, Bregfeld JA: Long term results of nonoperative treatment of isolated posterior cruciate ligament injuries in athlete, Am J Sports Med 14:35, 1986.
4. Dandy DJ, Pusey RJ: The long-term results of unrepaired tears of the posterior cruciate ligament, J Bone Joint surg 64B: 92, 1982.
5. Keller PM, Shelbourne D, MC Carroll JR, Retting AC: Nonoperatively treated isolated posterior cruciate ligament injuries, AMJ Sports Med 21: 132, 1993.
6. Bisson LJ, Clancy WG. Posterior cruciate ligament injuries. Insall JN. Scott WN. Surgery of the knee. Frome: Pennsylvania, CHURCHILL LIVINGSTONE; 2001, Vol. 1; 3th edition, 879-910.
7. Clancy WG Jr. Shelbourne KD, Zoellner GB, et al: Treatment of knee joint instability secondary to rupture of posterior cruciate ligament, report of new procedure, J Bone Joint surg 65A: 310, 1983.
8. Ching JW. Han SH. Outcome of surgical reconstruction for posterior cruciate and poserolateral instabilities of the knee, Injury 2002; 33: 815-821.
9. Chen Ch. Chen WJ. Shin CH. Arthroscopic reconstraction of posterior craciate ligament a comprasion of quadriceps tendon autograft and quadriple hamstring tendon graft. Arthroscopy 2002; 18(6): 603-612.
10. Nyland JH. Cabron DN. Double- bundle posterior cruciate ligament reconstruction with allograft tissure: 2 year postoperative outcomes, knee surgery, sport traumatology, Arthroscopy, 2002; 10(5): 274-279.
11. Valldevit A. Kambic H.Lilly D. Graham S. Parker R. Bregfield J: nonlinear fitting of mechanical data for efficacy determination of single versus double bundle Achilles tendon grafts for PCL reconstruction. Bio-medical and Engineering 2002; 12(3): 309-317.
12. Andreas C. Stahelin MD, Nober P: Anatomical double boundle PCL ligament reconstruction using hamstring tendons, Arthroscopy, the journal of arthroscopy 2001; 17(1): 88-97.
13. Ohkoshi Y. Nagasaki S. Yamamato K. et al: A new endoscopic posterior cruciate ligament reconstraction: minimizing graft angulation, Arthroscopy 2001; 17(3): 258-263.
14. Dunlop DG, Woodnutt DJ, Nutton RW: A new method of determine graft angles after knee ligament reconstruction, Journal of orthopedic research 2003; 21(1): 177-182.
15. Amis AA. Anatomy and biomechanics of the PCL Sports Med. Arthroscop Rev 1997; 7: 225-234.
16. Race A, Amis AA. PCL recounstration: In vitro biomechanical comprasion of isometric vs. single and double- bundled anatomic grafts. J Bone Jt Surg 1998; 80B: 1733-1739.
17. Racc A, Amis AA. Loading of the two bundles of the PCL: analysis of bundle function in A.P drawer test. J Biomech 1996; 29; 873-879.