Outcomes of the All Inside Single Bundle Posterior Cruciate Ligament Reconstruction Using Quadrupled Semitendinosus Tendon Graft

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Abstract

Background
PCL is the main knee restraint to posterior tibial translation. PCL tear is not a common knee injury. There are several techniques for PCL reconstruction with fair clinical outcomes. The all-inside PCL reconstruction is a new minimally invasive technique for PCL reconstruction. This study was done to evaluate the results of all-inside PCL reconstruction using quadrupled semitendinosus graft over 18 months follow up.

Patients and Methods
A prospective case series study that was held in EL Hadra University hospital between January 2018 to November 2018 over 35 patients. In all patients, All-Inside PCL reconstruction was done using quadrupled Semitendinosus tendon graft. All cases were assessed using Lysholm and IKDC scores. The minimum follow up was 18 months since index surgery

Results
The study included 35 patients who had isolated PCL injury. Twenty-nine patients (82.8%) were males and 6 patients were females (17.14%). The mean age of patients was 34 ± 3.2 years (range: 27-45). The mean duration from injury to the index procedure was 2.7 ± 0.9 months. The preoperative IKDC results were 20 patients with grade C (57.1%) and 15 patients with grade D (42.85%). The postoperative IKDC results were 21 with grade A (60%), 12 with grade B (34.2%) who had grade I posterior drawer at the end of the follow up, and 2 cases (5.7%) had IKDC grade C with posterior drawer grade II at the end of the follow up. The difference between both groups were statistically significant ($P<0.05$). Regarding complications, two cases (5.7%) had persistent posterior sag with posterior drawer grade II till the end of the follow up.

Conclusion
Surgical treatment of injuries of PCL with all-inside reconstruction for isolated PCL tears using autologous quadrupled semitendinosus graft provided good or excellent results after 18 months of follow-up with a low complication rate.

Introduction

The posterior cruciate ligament (PCL) provides restraining force against the posterior tibial translation, resisting between 85% and 100% of the forces directed posteriorly during knee flexion. The PCL can be functionally divided in two parts: a higher anterolateral (AL) bundle and another, smaller, bundle, posteromedial (PM). [1]

The mechanism of PCL injury typically involves a traumatic, posteriorly directed force to the tibia with the knee in a flexed position. This mechanism commonly occurs during a motor vehicle collision or when an athlete falls on their knee with the foot plantarflexed. Additional implicated mechanisms include hyperflexion, hyperextension, and extreme rotation. [2]

Isolated posterior cruciate ligament (PCL) injuries are uncommon and usually occur in the context of combined ligamentous knee injury. Isolated PCL tears account for approximately 3% of acute knee injuries. PCL deficiency can lead to a deterioration in knee function and premature development of medial and patellofemoral compartment osteoarthritis due to abnormally high contact forces.[3]

The successful results seen from nonoperative treatment in the previously mentioned studies are likely skewed because only grade 1 and 2 isolated PCL injuries were studied. Therefore, nonoperative management only recommend for these lower-grade injuries. In higher-grade PCL tears, surgical management are highly recommended. The main indications for operative treatment of PCL injuries are avulsion fracture of the PCL tibial insertion, acute or chronic isolated grade 3 PCL injury, PCL insufficiency in the setting of the multiple-ligament injured knee. [3]

The evolution of surgical arthroscopic techniques and instrumentation, combined with an improved understanding of PCL anatomy and biomechanics, has led to an increased impetus for posterior cruciate ligament reconstruction (PCLR). However, the optimal technique for PCLR has not yet been established, with almost every aspect of the surgical procedure and postoperative rehabilitation remaining controversial. [4]

Despite advances in techniques for PCL reconstruction, the results of surgical treatment of this ligament are not comparable to those of the reconstruction of the anterior cruciate ligament (ACL), probably due to several factors that affect the outcome and that are still a matter of controversy, including the number of bundles to be reconstructed, better positioning of the tunnels, the best method for graft fixation, inlay reconstruction versus transtibial tunnel, and the degree of graft tension during surgery. [5] Moreover, as the graft passes through the tibia, it is forced to make the “killer turn” around the posterior tibial margin.[2]

Operative challenges include visualization of the tibial footprint and drilling of the tibial tunnel without damaging posterior neurovascular structures. The choice, configuration, deployment, tensioning, and fixation of the graft are also contentious. [6]

Numerous surgical techniques like arthroscopic transtibial, open inlay, and arthroscopic inlay were described for PCL reconstruction. Many authors have observed that reconstruction with single bundle provides good stability and restores the biomechanics of the knee immediately after surgery, but in some cases, with time, again the patient presents with abnormal posterior translation, secondary to a possible stretching of the graft caused by unequal distribution of tension forces. Moreover, traditional PCL reconstruction may not be effective to correct the posterior and rotational laxity of the knee. [6]

In an attempt to address these limitations, many modifications to traditional PCL reconstructions were done. Some authors advocate the double bundle PCL reconstruction, others the all-inside PCL reconstruction and internal bracing concepts. [4, 7, 8]

The Novel all-inside PCLR technique utilizes suspensory fixation in both tibial and femoral sockets and allows for either allograft or autograft to be used. This reconstruction avoids the “killer turn” seen with the transtibial technique, which may decrease the chance of graft attrition while delivering decreased morbidity and excellent visualization using an all-arthroscopic approach. While early results using this technique are promising, long-term clinical and functional outcome studies are needed to validate this novel PCL reconstruction.[2]

This study was done to assess the clinical outcomes after All-inside single bundle PCL reconstruction using quadrupled Semitendinosus tendon graft.

Patients and Methods

This is a prospective clinical case series study that was held in EL Hadra University hospital, Alexandria University. Between January 2018 to November 2018, thirty-five patients with isolated PCL injury were submitted to the study. In all patients, All-Inside PCL reconstruction was done using quadrupled Semitendinosus tendon graft. All cases were done by single surgeon (First author). The study was approved by the ethics committee of the Alexandria University and the patients signed an informed consent form.

The inclusion criteria included all skeletally mature patients from 16 to 45 who had isolated intra-substantial PCL injury (grade 2 and 3) regardless of time of injury. Patients with combined ligamentous injuries, PCL avulsions, degenerative arthritis or other skeletal injures were excluded from the study. Patients with previous knee surgeries, BMI > 30 or injuries contralateral knee were also excluded from the study. Furthermore, those patients who were not willing to follow the protocol of postoperative rehabilitation were also excluded.

Patients were evaluated preoperatively with accurate history taking about the exact mechanism of injury, physical examination with the assessment of the alignment of the lower limbs, abnormalities during gait, and the range of motion of the affected knee, compared with the contralateral knee. The clinical test used to evaluate the PCL was the posterior drawer test with the knee at 90° in neutral position and the posterior sag sign.

The result was considered normal when there was no difference in posterior translation of the tibia compared with the contralateral side; grade 1,when the tibial anteromedial (AM) margin had a small posterior translation, but remained anterior to the medial femoral condyle; grade 2, when the tibial anterior margin was in line with the medial femoral condyle; and finally grade 3, when the tibial anterior margin was posterior to the medial femoral condyle.[9]

Magnetic resonance imaging (MRI) study was performed preoperatively in all patients to confirm the diagnosis of rupture of the PCL and associated meniscal injuries.

All patients were evaluated preoperatively and postoperatively at 6, 12, and 18 months by the International Knee Documentation Committee [IKDC] form[10] and the Lysholm scale.[11]

Surgical technique:

All cases were performed under general anesthesia. The patients were positioned supine on a radiolucent table with the operative knee flexed to 90 degrees, supported with a padded side support and footrest. A high thigh tourniquet was inflated throughout the operation at 350 mmHg.

A high anterolateral (AL) portal was first created adjacent to the patellar tendon. A low anteromedial (AM) portal, also adjacent to the patellar tendon, was then established under direct vision, in line with the ACL and just above the intermeniscal ligament, to facilitate access to the tibial PCL footprint. A standard posteromedial (PM) portal was created under direct vision inside PM compartment using 30 degrees scope. (Figure 1)

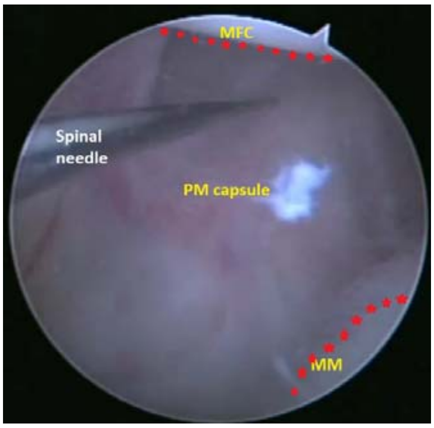

Figure 1: Creation of the posteromedial portal under direct visualization

The semitendinosus was harvested with a tendon stripper through a 2- to 3-cm oblique incision over the pes anserinus. This typically provided 27 to 32 cm of graft that was then quadrupled in the standard fashion to form a GraftLink construct (Figure 2).

Figure 2: preparation of the quadrupled Semitendinosus GraftLink construct.

The graft was typically 8-9 mm in diameter and 75-90 mm in length. The GraftLink was then secured with a loop of high-strength tape (FiberTape) as an internal brace.

Each end of the graft was marked at 15-20 mm. This acted as an arthroscopic visual aid during graft passage and helps ensure that the correct length of graft enters the retro-sockets. The advantage of all inside repair is to place only 15 to 20 mm of graft in the retro-sockets, which leaves 35 to 40 mm of intraarticular graft. This intra-articular distance was calculated similar to the length of the native PCL (32 to 38 mm).

The 30 degrees arthroscope was then inserted through the AL portal to facilitate visualization of the posterior tibia. A shaver blade and radiofrequency devices were inserted through PM portal to clear the tibial footprint. The tibial socket was chosen at approximately 7 mm lateral and distal to the posterior horn of the medial meniscus and 15-20 mm distal to tibial articular surface. (Figures 3-5)

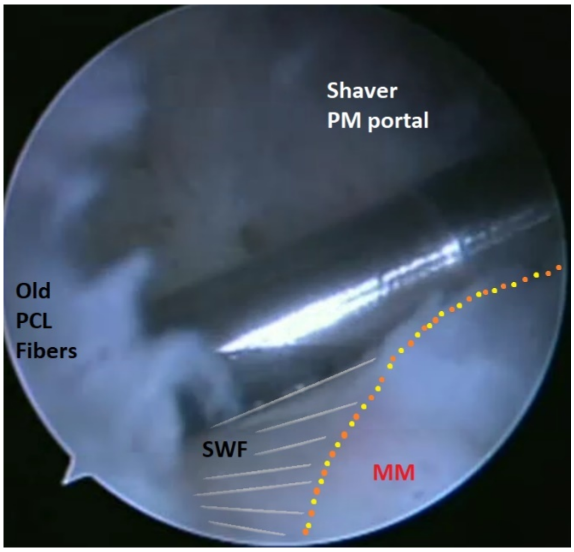

Figure 3: preparation of the tibial footprint using shaver from posteromedial portal

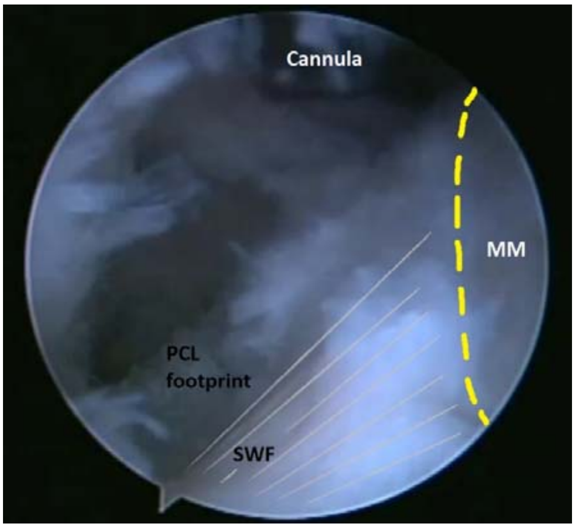

Figure 4: landmarks of tibial footprint just inferior and lateral to shiny white fibers (SWF) of the posterior horn of the medial meniscus.

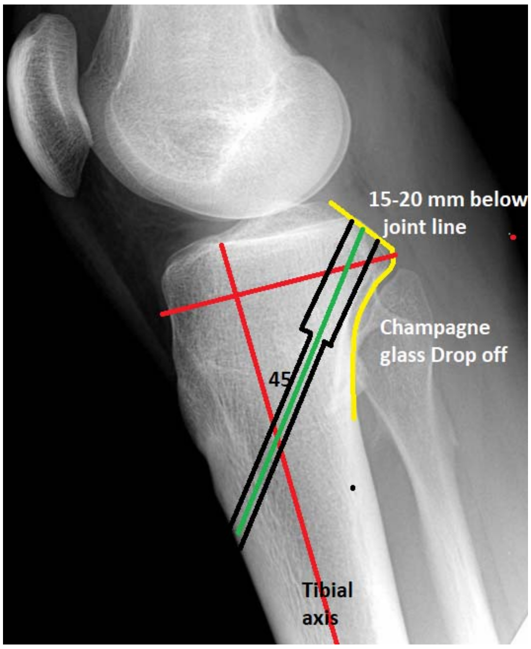

Figure 5: Planning of tibial tunnel and socket measurements.

The tibial aiming guide was then inserted through the AM portal and positioned over the marked area in the PCL footprint. The drill guide handle was typically set between 70-80 degrees to avoid placing the socket inferior to the "killer turn." Fluoroscopy was then used to confirm placement of tibial guide over the tibial foot print just above champagne glass drop off.

The retrograde drill was sized according to the graft diameter. The socket depth is measured during retrograde drilling from the calibrated shaft markings on the drill pin. Typically, a 30-mm socket was drilled to accept approximately 20 mm of graft. The additional 10 mm accommodates any graft laxity during final tensioning. (Figures 6-10)

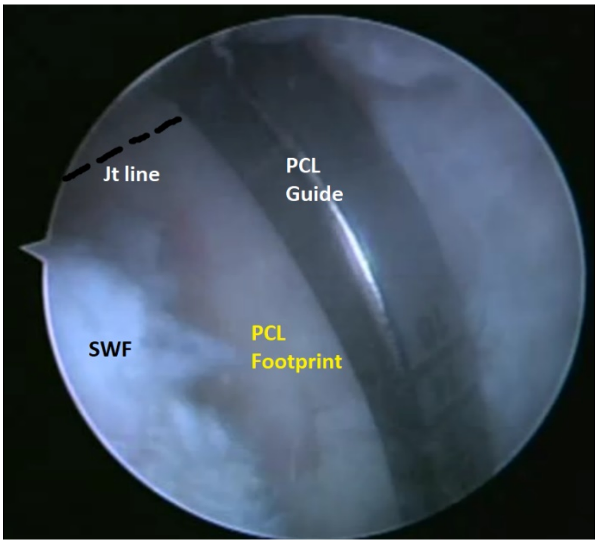

Figure 6: Use of curved PCL tibial guide to create tibial socket.

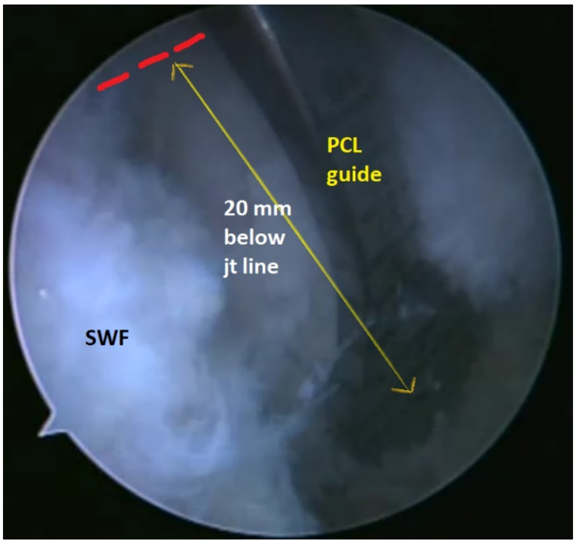

Figure 7: the tip of the tibial guide placed about 20mm distal to joint line.

Figure 8: creation of the tibial tunnel using Flipcutter retrodrill.

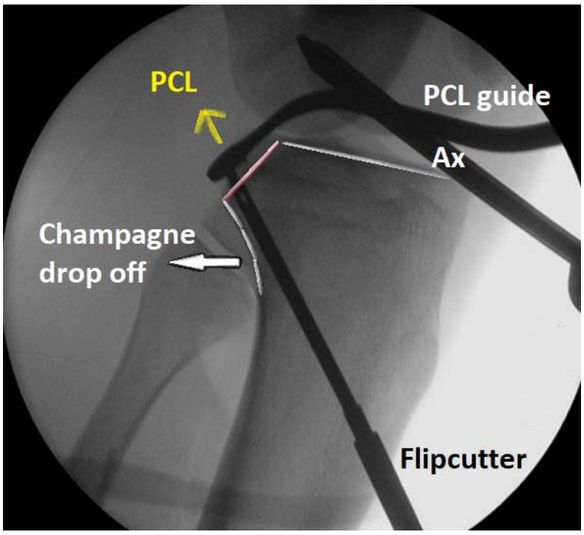

Figure 9: Fluoroscopy of the PCL tibial tunnel to ensure correct placement of the guide wire.

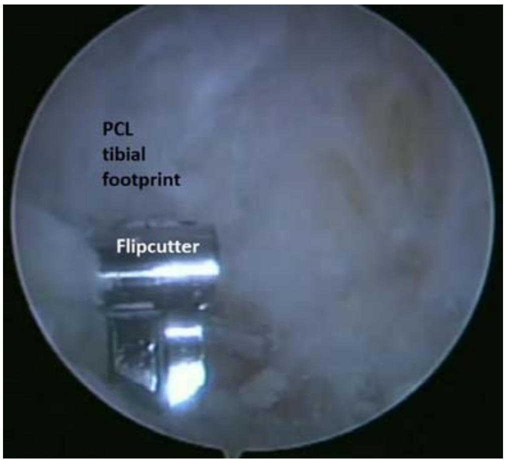

Figure 10: The tibial Flipcutter is deployed to ream the tibial socket

After reaming, a suture shuttle loop was passed through the drill sleeve and into the joint. The suture loop end was retrieved with a suture grasper and pulled through the AM portal for later graft passage. (Figure 11)

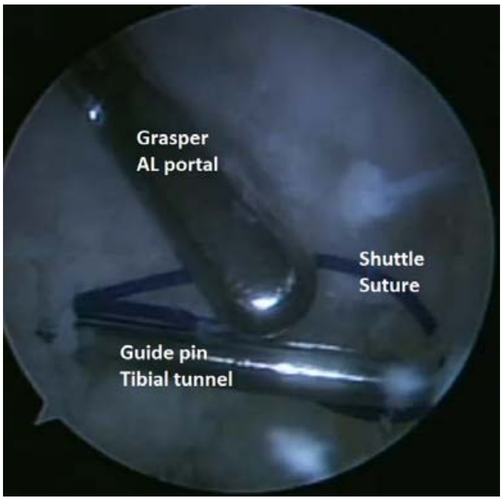

Figure 11: the shuttle suture was retrieved from tibial socket to AM portal using grasper.

For single bundle PCL reconstruction, the aim was mainly to reconstruct the AL bundle because of its favorable biomechanical properties. The AL portal was used as working portal and AM portal was used as main viewing portal of the lateral wall of the medial femoral condyle in the intercondylar notch. The wall was prepared by use of the shaver device. Arthroscopic bony landmarks, particularly the medial bifurcate prominence, roof of the notch, and cartilage margins, are identified. The RF device was used to mark the intended socket position.

The center of the AL bundle was identified at a point triangulated among 3 arthroscopic landmarks: proximal to the medial bifurcate prominence, 7 mm posterior to the cartilage margin at the apex of the notch, and approximately 8 mm proximal to the distal articular cartilage margin, in a line parallel to the long axis of the femur. A 20-mm socket was created in the prepared position using a retrodrill of the same size of the graft. After socket reaming, a suture shuttle loop was passed through the drill sleeve into the joint and retrieved through the AM portal for later graft passage. (Figures 12-15)

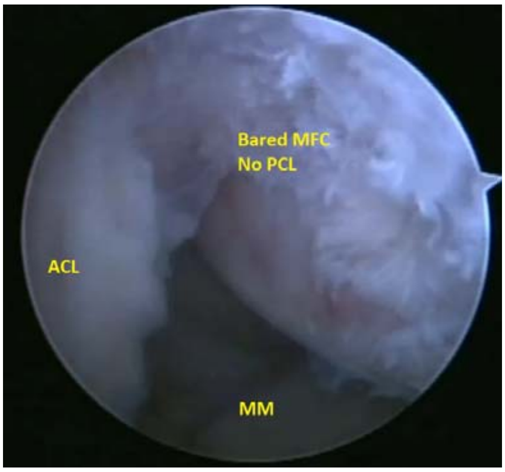

Figure 12: viewing of lateral wall of the medial femoral condyle from AL portal.

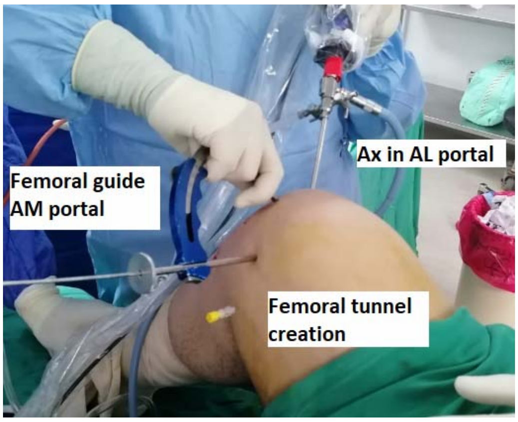

Figure 13: Creation of the femoral tunnel using femoral guide and Flipcutter.

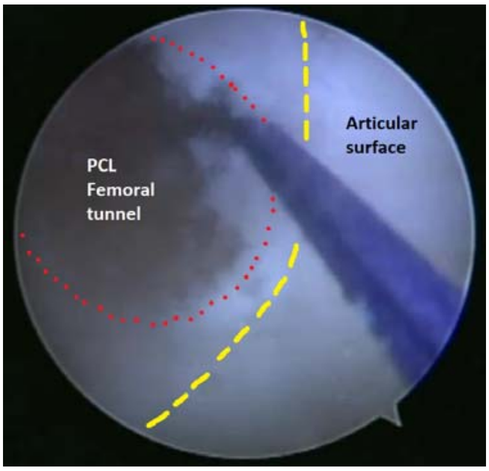

Figure 14: Creation of the femoral socket just behind the articular cartilage.

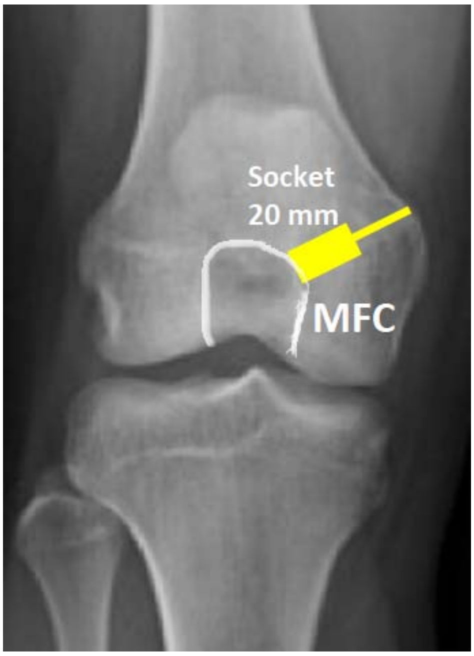

Figure 15: Planning of the femoral tunnel socket measurements.

The looped sutures from the tibial and femoral sockets were collectively retrieved with a suture grasper passed through the AM portal. A single end of each suture was withdrawn, ensuring that there is no soft-tissue entrapment. A snare at the retrieved end of each suture was individually linked to the Tightrope of the GraftLink and used as a lead suture to draw the graft into the sockets. (Figure 16)

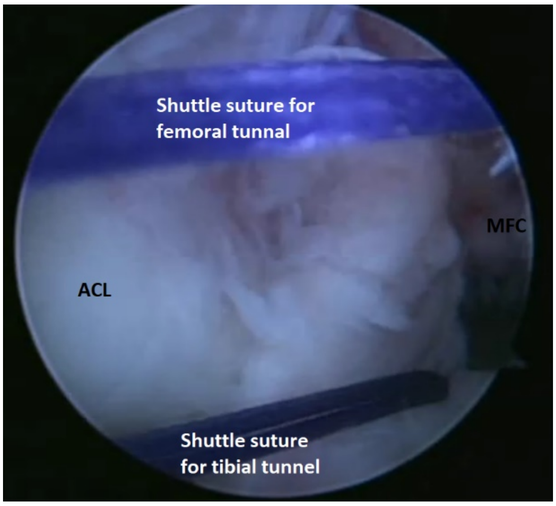

Figure 16: the shuttle sutures were retrieved through single portal to avoid formation of any soft tissue bridges.

Under arthroscopic visualization, 15 mm of the tibial end was pulled into the tibial retro-socket through the AM portal. The adjustable button for the Tightrope was applied to the tensioning sutures and seated onto the anterior tibial cortex for cortical fixation and, later, final tensioning. The femoral ends were then pulled into the joint and partially seated in the respective retro-socket. The button was flipped beyond the femoral cortex. Care was taken to ensure that there is no soft tissue interposition because this would reduce the quality of graft tensioning and fixation. (Figure17)

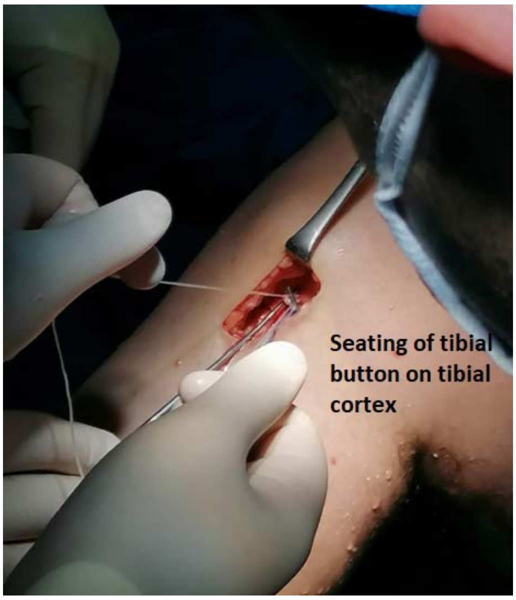

Figure 17: Seating of the tibial Tightrope button first on the anterior cortex of the tibia.

The GraftLink construct was tensioned with the knee in 90 degrees of flexion and concomitant anterior tibial translation by the assistant. With the button flipped and docked firmly against the medial femoral cortex, the free ends of the femoral tensioning suture of the Tightrope were pulled back and forth to tension the residual length of graft within the retrosocket. The same process was repeated on the tibial side. (Figure 18)

Figure 18: Tensioning of PCL GraftLink in 90 degrees of flexion and holding leg in anterior drawer position by the assistant.

It is vital to ensure that the retro-sockets have sufficient depth to accommodate any slack in the graft. Insufficient socket depth will cause the graft to "bottom out," leaving residual laxity, a difficult problem to correct at this stage of the procedure. Therefore, more tibial socket reaming of 30 mm depth is mandatory to avoid this problem. Conversely, pulling too much graft into the sockets by over-tensioning will reduce the intra-articular length of graft and overconstrain the knee.

The knee was cycled several times through full range of movement before the Tightrope button fixation was verified and readjusted at 90 degrees of flexion. Before the tensioning sutures were cut, the posterior drawer test and arthroscopic visualization were used to verify satisfactory fixation and restoration of normal anteroposterior laxity.

For reinforced GraftLink internal brace constructs, the free ends of the Fibertape loop were then anchored distally in the tibia at 90 degrees of flexion with the assistant holding leg in anterior drawer position. Before closure, the wounds and hamstring harvest tract were infiltrated with a large volume of dilute local anesthetic.

Postoperative Rehabilitation

After surgery, a hinged knee PCL brace is worn continuously for 12 weeks. For the first 6 weeks, patients are restricted to partial weight bearing with the brace locked in extension. The focus is on quadriceps activation, passive prone knee flexion from 0 to 90 degrees, and active extension exercises. From 6 to 12 weeks, the patients were allowed to fully bear weight with the brace in situ and range of movement is increased to 0 and 120 degrees of flexion. Patients were restricted from squatting or sudden deceleration for 6 months. Sports were allowed after 9-12 months postoperatively.

Statistical Analysis

The software used for the statistical analysis was SPSS (Statistical Package for Social Sciences) for Windows, version 25. For quantitative variables, the averages were calculated. For the qualitative variables, we calculated absolute and relative frequencies. The examination of the association between qualitative variables was performed using the chi-square or Fisher's exact test. Comparison of quantitative variables between the preoperative and postoperative periods was performed using the Wilcoxon test. The significance level was set at 5%.

Results

The study included 35 patients who had isolated PCL injury. Twenty-nine patients (82.8%) were males and 6 patients were females (17.14%). Fourteen patients were heavy manual workers (40%), fifteen were light workers with sedentary lifestyle (42.9%) and 6 were housewives (17.1%). Eighteen cases had road traffic accident in form of dashboard injury (51.4%) and 17 had direct injury by falling on their flexed knees (48.6%).

The mean age of patients was 34 ± 3.2 years (range: 27-45). The mean duration from injury to the index procedure was 2.7 ± 0.9 months. The right side was affected in 24 cases (68.6%) and the left side was affected in 11 patients (31.4%). Seventeen cases (48.5%) had medial meniscal tears. Eight patients (22.8%) had chondral ulcers of the medial femoral condyle (4 grade I, 2 grade II, 2 grade III)

The preoperative IKDC results were 20 patients with grade C (57.1%) and 15 patients with grade D (42.85%). The postoperative IKDC results were 21 with grade A (60%), 12 with grade B (34.2%) who had grade I posterior drawer at the end of the follow up, and 2 cases (5.7%) had IKDC grade C with posterior drawer grade II at the end of the follow up. The difference between both groups were statistically significant using Chi square test. (P<0.05) (Table I, Figure 19)

Table I: IKDC results pre and postoperatively

	Preoperative IKDC	Postoperative IKDC	X^2	P value
Grade A	0	21	31.1	0.000
Grade B	0	12		
Grade C	20	2		
Grade D	15	0		

X^2 = Chi Square test, P value significant <0.05

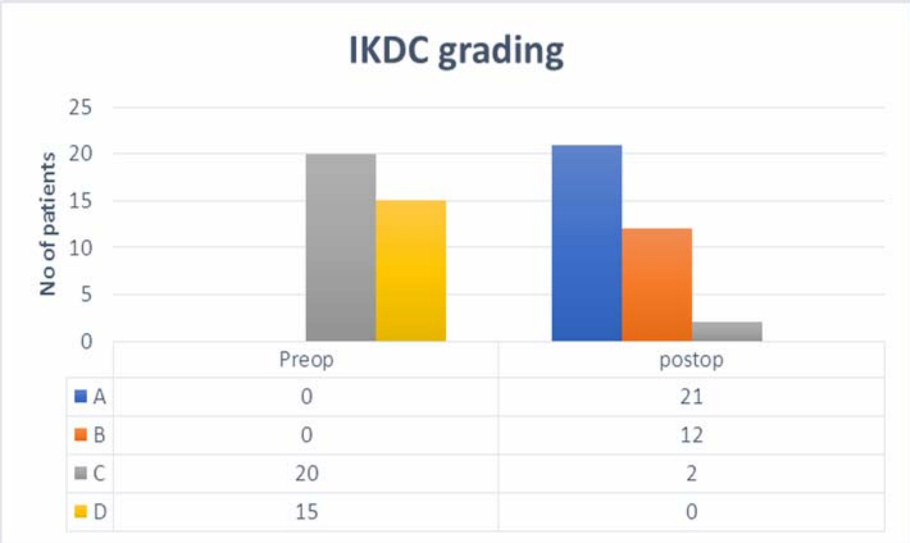

Figure 19: Chart showing difference between preoperative and postoperative IKDC grading

Regarding preoperative Lysholm score, 26 patients (74.28%) were fair (score from65-83) and 9 patients (25.7%) were poor (score < 65). Postoperatively, 16 patients (45.7%) had excellent outcome (score from 95-100) and 19 patients (54.2%) had good outcome (score 84-94). The difference was statistically significant (P <0.05). (Table II, Figure 20)

Table II: Lysholm score pre and postoperatively

	Preoperative Lysholm	Postoperative Lysholm	X^2	P value
Excellent (95-100)	0	16	10.3	0.001
Good (84-94)	0	19		
Fair (65-83)	26	0		
Poor (<65)	9	0		

X^2 = Chi Square test, P value significant <0.05

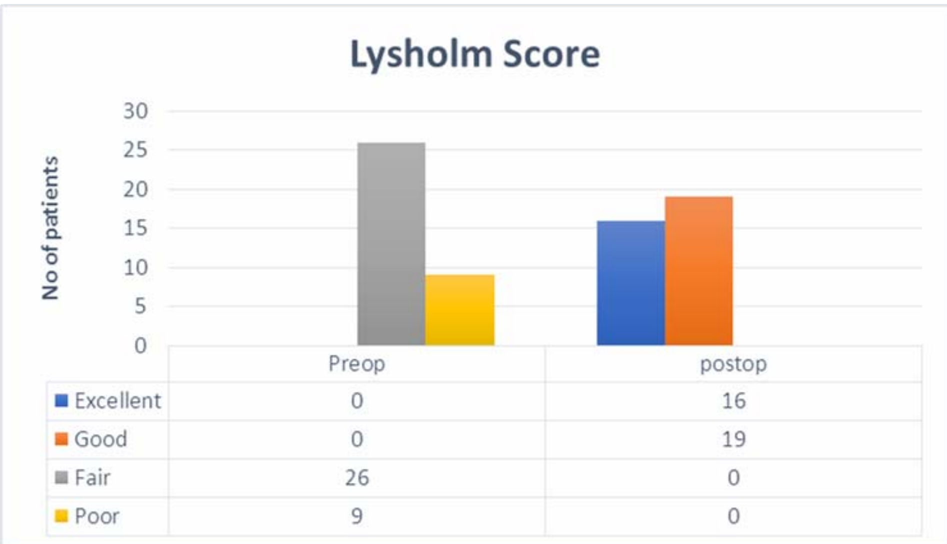

Figure 20: Chart showing difference between preoperative and postoperative Lysholm scoring

The subjective IKDC score improved from a preoperative mean of 42 ± 3.6 points to a mean postoperative value of 89.3 ± 2.1 points. The difference was statistically significant. (P <0.05) The mean Lysholm score improved from preoperative value of 58.2 ± 2.6 points to a mean postoperative value of 88.9 ± 4.1 points. The difference was statistically significant. (P <0.05) (Figure 21)

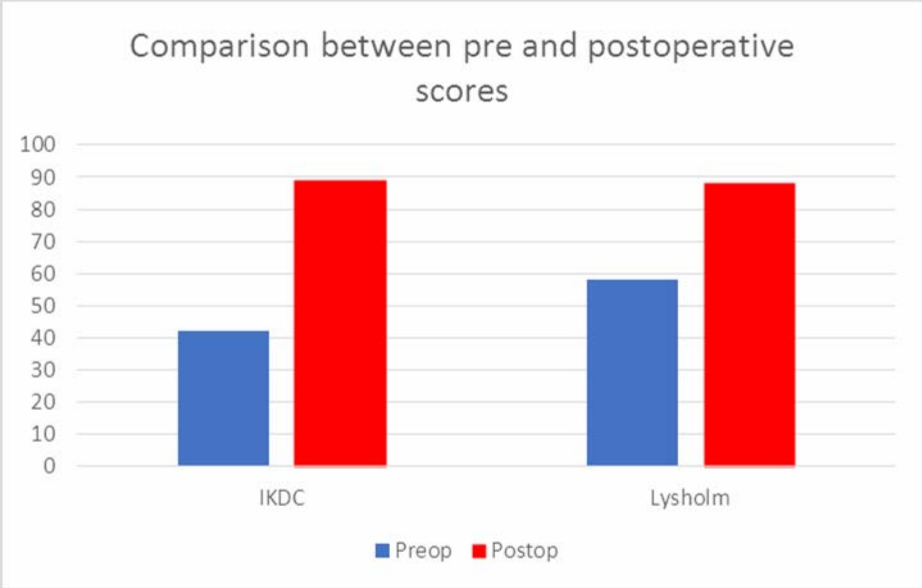

Figure 21: Chart comparing preoperative and postoperative scoring.

Regarding complications, two cases (5.7%) had persistent posterior sag with posterior drawer grade II till the end of the follow up. They were graded IKDC grade C at the end of the follow up. Twelve cases had grade B (34.2%) with grade I posterior drawer at the end of the follow up. However, none of them had poor clinical subjective results. No patients had lost ROM at the end of the follow up. Neither age nor gender nor KD grade nor meniscus or cartilage injury was associated with poor subjective outcomes.

Discussion

According to Hoher et al, [3] the ideal graft for PCLR would replicate an intact native PCL, with a large fan-shaped femoral footprint and comparatively smaller tibial insertion footprint. This would explain the less favorable results of PCL reconstructions in compare with ACLR. [3, 12, 13] Many authors therefore had adopted double bundle PCL reconstruction. [6, 7] However, Garofalo et al, showed abnormal results in 40% of their patients undergoing PCL reconstruction with double bundle. [14] Mygind-Klavsen et al reported residual side-to-side laxity at final follow-up was 2.7mm in the isolated PCLR patients.[15] Two recent prospective randomized studies have found that the clinical outcomes are similar for both single and double bundle PCLR techniques. [16, 17]

All-inside PCL reconstruction technique has many advantages. It has less morbidity drilling away from neurovascular structures. It has less bone removal (blind socket not tunnels). Moreover, it gives more exact socket placement and shape, easier concomitant surgery, less incision complications with less potential for infection. Furthermore, the use of a single semitendinosus autograft eliminates morbidity associated with bone-tendon autografts and the risks of allografts. In addition, by preserving the gracilis, the patient does not lose deep knee flexion and internal rotation strength. benefit of preserving the gracilis is that it can be used to reconstruct other ligaments in patients with multiligament injuries [4]

Another advantage in this technique is the possibility to fix the graft on tibial cortex. The traditional techniques used to fix the PCL has always had, especially at the tibia, a specific problem of reliability for the lower bone density tibia insertion, sometimes the interference screws "sinking" in the cancellous bone; the possibility to have a cortical fixation also at the tibia level guarantees greatly an advantage for the bone integration and tension of the graft. [18]

Additionally, adjustable-loop fixation on both sides of the graft has been reported to allow more optimal graft tensioning.[19-21] Noonan and colleagues reported that retensioning and knot tying of the adjustable-loop fixation reduced final cyclic elongation by 50% compared with a closed-loop device after reconstruction.[22]

The hamstring grafts are recommended over other grafts for PCL reconstruction for several reasons. First, the nonaggression to extensor mechanism, which enhances rehabilitation and reduces postoperative morbidity. Second, the greater ease in passing the graft through the bone tunnels. Third, the ability to fix the graft with dual suspensory fixation. [6]

Prince et al described the all inside PCL reconstruction using the GraftLink technique using a quadrupled tibialis anterior or peroneus longus allograft. [20] They reported the following advantages: anatomic contoured guide, avoidance of killer turn, no fluoroscopy needed, neurovascular shield, bone preservation, dual tensioning construct and the sockets may decrease risk of tunnel widening with suspensory fixation. [20]

Slullitel et al [23] described the all inside double bundle PCL reconstruction that was modified by Hoogeslag et al [24] using two separate tendons. This technique combine the advantages of double bundle concept and all inside concept for PCL reconstructions. However, no clinical data were published for this technique. Nancoo et al described the transMedial all-inside PCLR using a reinforced tibial inlay graft. [4]

Vasdev et al [21] used all inside GraftLink construct for PCL reconstruction. However, they passed the construct through the PM portal. This is in contrast to the previously described techniques in which the GraftLink construct was passed through the AM portal. They believed this abolish the effect of the killer turn on the PCL graft as the graft is passed from the PM portal directly into the tibial and femoral sockets, breaking the killer turn into 2, because difficulty is often encountered while negotiating the graft over the tibia. This technique also prevents overcrowding of the joint space and entwining of the shuttles when performed through the AM portal.[21]

Although multiple techniques and modifications were reported for the all-inside PCL reconstruction, there is a paucity of clinical data on this technique.

Freychet et al, [25] had a total of 32 patients (23 men and 9 women) with a mean age of 27 and mean follow-up of 24 months. The median duration from injury to reconstruction was 169 days. All cases were submitted to ***all inside PCL reconstruction***. The mean side-to-side difference on kneeling stress radiographs was 11.1 mm. The posterior drawer test was positive in 7 patients (grade I) and the posterior sag sign was positive in 5 patients after 24 months postoperatively. The mean final IKDC score was 85, Lysholm score 87.4 and Tegner score 6.6 points.[25]

Our results were ***comparable to*** Freychet et al. [25] The final subjective IKDC score was 89.3 ± 2.1 points and mean final Lysholm score was 88.9 ± 4.1 points. At the end of follow up, 12 with grade B (34.2%) who had grade I posterior drawer and 2 cases (5.7%) had IKDC grade C with posterior drawer grade II.

In this study, there was no association between meniscal or cartilage injury and postoperative knee scores. ***Similarly***, a recent study with minimum 10 years of follow-up, Moatshe and colleagues [26] reported meniscal and cartilage injuries at time of surgery were not associated with the development of osteoarthritis. ***Systematic review***s evaluating PCLR concluded that normal knee stability was not fully restored but found a significant reduction in posterior knee laxity and improved mean Lysholm knee score.[27-30]

Limitations

This study has several limitations, including limited sample size, lack of a control group, case series design. Also, the lack of kneeling stress radiographs, instrumented posterior drawer testing using KT 1000 were also a drawbacks to the study. Moreover, the short term follow up (18 months) was not enough to assess radiological signs for arthritis after PCL reconstruction.

Conclusion

Surgical treatment of injuries of PCL with all-inside reconstruction for isolated PCL tears using autologous quadrupled semitendinosus graft provided good or excellent results after 1.5 years of follow-up with a low complication rate.

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