RESEARCH ARTICLE

Outcomes of Repair and Reconstruction of the Acute Posterolateral Corner Injuries of the Knee Combined with Cruciate Ligaments Injuries

Mohammadreza Minator Sajjadi, MD[1]; Sohrab Keyhani, MD[1]; Morteza Kazemi, MD[2]; Mohamad Movahedinia, MD-MPH[2]; Seyyed-Mohsen Hosseininejad, MD[2,3]; Reza Noktehsanj, MD[2, 4]

Research performed at Academic Hospitals of Shahid Beheshti University of Medical Sciences, Tehran, Iran

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Abstract

Background: This study aimed to report objective and subjective knee stability scores for patients who underwent acute repair of avulsed posterolateral corner (PLC) structures or acute reconstruction of midsubstance tears combined with delayed reconstruction of cruciate ligaments.

Methods: A total of 48 sport and vehicle accident traumatic patients were enrolled in a three-year follow-up study. The patients were investigated by clinical exams, subjective and objective International Knee Documentation Committee (IKDC) score, Tegner score, Lysholm score, and stress imaging. All scores were compared between the reconstruction and repair groups.

Results: Subjective IKDC scores were obtained at 83.3±9.6 and 88.3±4.39 for the reconstruction and repair groups, respectively. Only two patients in the reconstruction group had abnormal objective IKDC scores. Based on the Tegner score, 15 out of 18 patients in the repair group and 20 out of 24 patients in the reconstruction group regained their pre-injury functional level. Mean Lysholm scores for the reconstruction and repair groups were estimated at 83.4±8.2 and 88.2±4.1, respectively. Mean lateral joint opening differences between two knees in the reconstruction and repair groups were -0.2±0.1mm and 0.5±0.1mm, respectively. There were no statistically significant differences between groups outcomes. We had no failure of treatment at the final follow-up.

Conclusion: Acute intervention within 3 weeks after PLC injuries combined with delayed cruciate ligaments reconstructions showed favorable outcomes. Both repair and reconstruction are effective when deciding based on the type of injury (i.e., avulsion and midsubstance tear).

Level of evidence: IV

Keywords: Cruciate ligaments, Lateral collateral, Ligament, Popliteofibular ligament, Posterolateral corner, Reconstruction, Repair

Introduction

Posterolateral corner (PLC) injuries of the knee are infrequent, however, important due to the potential functional disability of the knee (1). Posterolateral corner injuries are often seen in sports injuries, vehicle accidents, and falls (2). The anatomically important structures of the PLC of the knee are the lateral collateral ligament (LCL), popliteus tendon (PT), and popliteofibular ligament (PFL) (3). These structures protect the cruciate ligaments from varus stress of the knee, external rotation, and abnormal posterior translation of the tibia. The PLC

Corresponding Author: Reza Noktehsanj, Bone Joint and Related Tissues Research Center, Akhtar Orthopedic Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran
Email: rezanoktehsanj@gmail.com

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isolated injuries rarely occur; nevertheless, they are often associated with concurrent injury of the anterior and/or posterior cruciate ligament (4, 5).

The diagnosis and treatment of acute PLC injuries are important, especially in multiligament knee injuries. Untreated PLC injuries are associated with the failure of the reconstructed cruciate ligament (6, 7). The management of the PLC injury is challenging due to the confounding multiligamentous anatomy of the PLC structures. There are controversial reports regarding the optimal timing of surgery and decision-making between repair or reconstruction as a successful surgical treatment with low rates of failure.

This three-year follow-up study aimed to report clinical and radiological outcomes of repair and reconstruction for acute PLC injuries, treated within 3 weeks of injury, combined with delayed ACL and/or PCL reconstruction.

Materials and Methods

Setting and population

The current study prospectively investigated 48 patients with knee functional instability or pain due to acute PLC injury within April 2014-September 2019, who underwent PLC repair or reconstruction. The study was approved by the local ethics board of Shahid Beheshti Universityof Medical Sciences, and written informed consent was obtained from all participants. The acute injury was defined as the injury cured within 3 weeks of trauma. Patients who refused to participate in follow-ups and those who had any contraindication for surgery, such as infection or comorbidities, were excluded from the study. Moreover, the patients who underwent concomitant repair and reconstruction were excluded to make a better comparison.

Diagnosis of PLC and combined cruciate ligament injuries were preoperatively determined according to the physical examination and imaging modalities, including stress radiographs, and confirmed by magnetic resonance imaging (MRI). The knee stability was examined by the dial test, external rotation recurvatum test, and posterolateral drawer test. To quantitate and rate the knee instability, stress radiography at 20 degrees was obtained preoperatively for varus gapping at the final follow-up visit. Plain anteroposterior and lateral X-rays were also taken to exclude other fractures around the knee. Finally, T2-weighted MRI was obtained to discriminate acute from chronic PLC injuries. The functional outcomes were assessed using the International Knee Documentation Committee (IKDC), Lysholm, and Tegner scores. All patients completed the Tegner preinjury score questionnaire at the baseline and postoperatively at the final follow-up visit. Other scores were only completed postoperatively.

Surgical treatment

Decision making

The final surgical plan (repair versus reconstruction) was made based on the MRI findings and the soft tissue evaluation on direct view in the operation room where we examined the affected knee under anesthesia. Posterolateral corner peel-off or bony avulsion injuries affecting the insertion of PLC structures, including FCL, PT, and/or PFL, was selected for repair (22 patients), while midsubstance tears were candidates for reconstruction (26 patients). Arthroscopic reconstruction of ACL and/or PCL were performed 2-3 months after the open surgical repair or reconstruction for PLC injuries when pain and swelling were relieved and patients had a full passive range of motion of the knee.

Posterolateral corner repair

The direct lateral incision from the fibular head to the lateral epicondyle was extended 3-5 cm distally and 1 cm proximally. Peroneal nerve was explored from the posterior of the biceps femoris tendon proximally to the fibular neck distally. With the knee in flexion, we longitudinally split the iliotibial band, and then, exposed LCL. Popliteus tendon attachment in the popliteus sulcus was exposed in the lateral condyle area. Lateral collateral ligament avulsion from lateral epicondyle and avulsion from the fibular head, which is named arcuate sign, could be a candidate for PLC repair. In such cases, the fracture site was precisely irrigated, incarcerated soft tissues were debrided, and subsequently, LCL was fixed to the lateral epicondyle by anchor suture and distally to the fibular head by screw or anchor suture with a 20-degree flexion and a slight valgus of the knee. In popliteus peeled-off cases, anterior to the LCL insertion, and deep to the anterior one-fifth of the popliteus sulcus, we fixed the popliteus tendon by anchor suture with the knee kept in 60 degrees flexion and adequate tension. If needed, posterolateral capsule and lateral meniscus peripheral tears were sutured before LCL and popliteus repair [Figure 1].

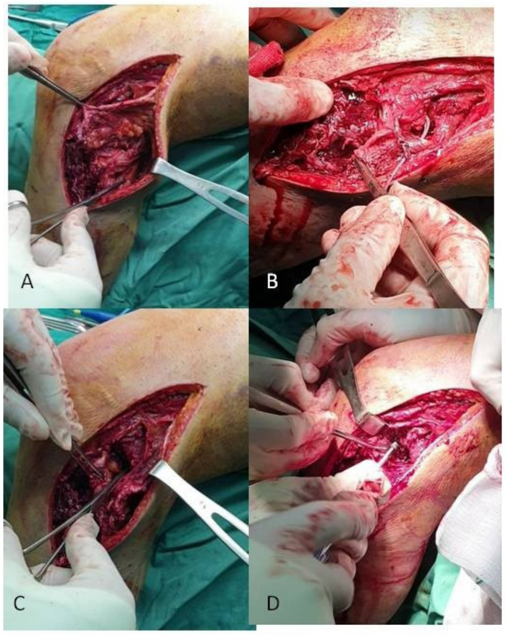

Figure 1. A) Longitudinal lateral approach and the exploration of the peroneal nerve; B) Gerdy tubercle avulsion; C) Detachment of popliteus tendon and its retraction within the popliteus sulcus; D) Application of anchor suture in the anterior of popliteus sulcus to fix the femoral insertion of the popliteus tendon.

Posterolateral corner reconstruction

We made two small incisions, including a 3-5 cm incision on lateral epicondyle to provide access to the LCL insertion and popliteus tendon attachment and a second 3-5 cm vertical incision that was made on the fibular head extending distally to make exposure for fibular head and explore the peroneal nerve with precise care to avoid hurting the lateral meniscus or its attachments. Popliteus tendon midsubstance injury could be found in the popliteus sulcus through the incision on the lateral epicondyle.

The next step was the creation of sockets or tunnels in the femur and fibula as the graft fixation points. These tunnels were situated based on palpable bony landmarks and were confirmed by fluoroscopy. The first tunnel was made at the native popliteus tendon insertion site, at the anterior one-fifth of the popliteal sulcus on the lateral side of the lateral femoral condyle. The tunnel exited from the medial aspect of the distal femur proximally and anteriorly to the adductor tubercle.

Afterward, we made the second tunnel at the LCL proximal insertion site. This location was approximately 3.1 mm posterior and 1.4 mm proximal to the femoral lateral epicondyle and approximately 18.5 mm from the center of the popliteus tendon insertion site. A Beath pin was drilled into the femur at this location in a direction parallel to the previously drilled popliteal socket. The location of the Beath pin was checked under fluoroscopy and, as importantly, was assessed clinically for isometry. Two grafts of 25-30 mm length were put into the femoral LCL and femoral popliteus sockets and fixed by two interference screws.

The third bone tunnel was formed in the fibula. A pin was drilled from the anterolateral part of the fibular head, which was the insertion site of the LCL, directing proximally and medially, toward a tubercle located posteromedial to the fibular head. The placement was confirmed with fluoroscopy, and then, a 7-mm tunnel was reamed over the K-wire with the protection of the peroneal nerve at all stages.

The last bone tunnel was made in an anteroposterior direction within a flat spot between Gerdy's tubercle and fibular head. As the end of the tunnel was 1-cm under the posterior tibia plateau just medial to the proximal tibiofibular joint, fingertip touching of pin tip helped us to protect essential structures of this area. Both LCL and popliteus grafts were passed under the iliotibial band; LCL graft superficial to the popliteus graft passing through the fibular tunnel was fixed anteroposteriorly to the fibular head tunnel by another interference screw in the knee with 20 degrees flexion and mild valgus force. The ends of both LCL and popliteus grafts were passed posteroanteriorly through the proximal tibia tunnel, fixed by an interference screw to the anterior entry of the tunnel with the knee in 60 degrees flexion and adequate tension [Figure 2].

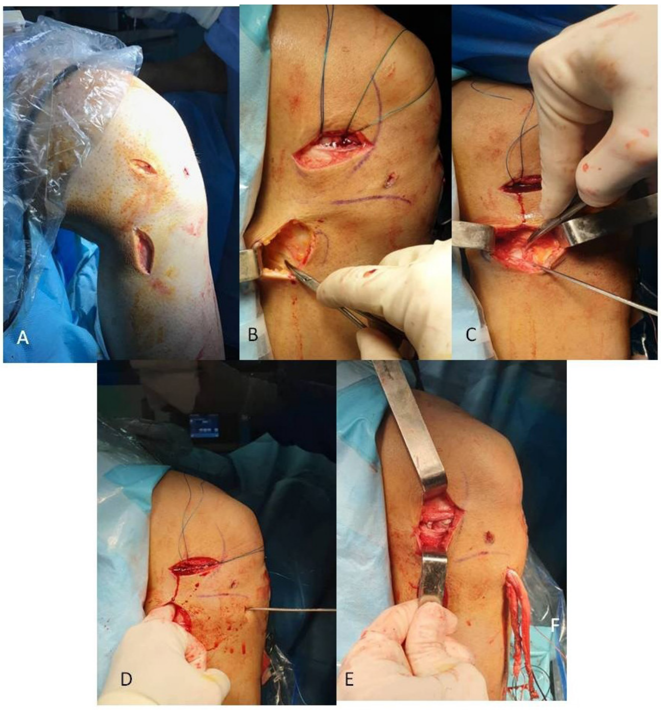

Figure 2. A) Two 3-cm incisions on fibula head (longitudinal) and femur lateral epicondyle (horizontal); B) Exploring peroneal nerve by a longitudinal distal incision and showing tunnels for LCL graft (posterior) and popliteus graft (anterior) in a horizontal incision; C) Using a guide to locate the route of the tunnels in fibula for LCL graft; D) Inserting the guide to locate the final tunnel in the anteroposterior direction and putting the fingertip back to the posterior os of the tunnel to protect the posterior components; E) Final stage of reconstruction by popliteus and popliteofibular graft passage from posterior to the anterior within the transverse tunnel in the proximal tibia and interference screw fixation in the anterior end of the tunnel.

Rehabilitation protocol

The patients were ordered a 6-week non-weight bearing period without knee immobilization. Rehabilitation began immediately postoperatively with a focus on the restoration of quadriceps strength and function, tibiofemoral and patellofemoral range of motion, and improvement of edema and pain. Passive range of motion to 90 degrees was asked for the first 2 weeks, followed by the complete range of motion as tolerated. At week 6, patients were allowed to start spiraling on an immobile bicycle and to get off their crutches. As full-weight bearing began, the patients started closed chain strength exercises. Partially-isolated hamstring strengthening was permitted at least 4 months postoperatively, and running workouts were permitted approximately 6 months postoperatively. Return to sports activities was allowed when the normal strength, stability, and range of motion of the knee had been gained, typically between 6 and 9 months, according to the concomitant cruciate injuries.

Statistical analysis

All statistical analyses were performed in SPSS software version 16 and presented in the form of mean, standard deviation, and median. Mann-Whitney U test was used to analyze quantitative variables (i.e., age, subjective IKDC score, lateral joint opening difference, and Lysholm score). Additionally, Chi-square and Fisher's Exact tests were performed for assessing differences in categorical variables between the two groups. A *P-value* of less than 0.05 was considered significant.

Results

A total of 48 acute PLC injuries due to sports trauma (n=21 cases) and vehicle accidents (n=27 cases) were enrolled for PLC repair/reconstruction within April 2014-September 2019. Among the patients, four and two cases respectively in the repair and reconstruction groups refused to be visited post-operatively, and therefore, were excluded. All patients who refused to complete the study were injured in vehicle accidents. The final distribution of patients among the two groups was 18 cases of repair and 24 cases of reconstruction for PLC injuries. More than half of the patients were male, and the mean age of the patients was obtained at 31.4 years, ranging from 18 to 56 years. Totally, 10 right and 12 left knees underwent reconstruction surgery, while 9 right and 7 left knees were repaired. Other patients underwent bilateral surgery. The mean interval between the injury and surgery was 16 days (at the range of 12-22 days). The mean final follow-up visit was 3 years after surgery ranging from 23 to 50 months. All patients had concomitant cruciate ligaments injury, including 12 ACL tears, 11 PCL tears, and 19 both ACL and PCL tears. Regarding these baseline characteristics, there was no significant difference between the two groups, as shown in [Table 1].

All subjective and objective scores improved significantly in both the repair and reconstruction groups at the time of the final follow-up (*P<0.001*). Like subjective IKDC, the Lysholm score improvement was higher in the repair group; nevertheless, it was not significantly different from that in the reconstruction group. On the other hand, the lateral joint opening improved more in the reconstruction

Table 1. Baseline characteristics of the patients in the reconstruction and repair groups

	Reconstruction (n=24) Mean±SD or n (%)	Repair (n=18) Mean±SD or n (%)	*P-value*
Gender			
Male	14 (58.3%)	11 (61.1%)	0.82
Female	10 (41.7%)	7 (38.9%)	
Age (years)	68.7±4.3	69.1±5.4	0.74
Side of injury			
Right	10 (41.7%)	9 (50%)	
Left	12 (50%)	7 (38.9%)	0.78
Bilateral	2 (8.3%)	2 (11.1%)	
Mechanism of trauma			
Sports injuries	11 (45.8%)	10 (55.5%)	0.68
Vehicle accidents	13 (54.2%)	8 (44.4%)	
Concomitant cruciate ligaments injury			
ACL	7 (29.1%)	5 (27.8)	
PCL	6 (29.1%)	5 (22.2)	0.84
ACL+PCL	11 (41.8%)	8 (50%)	
Interval between injury and PLC surgery (days)	15±3	16±4	0.42

ACL: Anterior cruciate ligament; PCL: Posterior cruciate ligament; PLC: Posterolateral corner

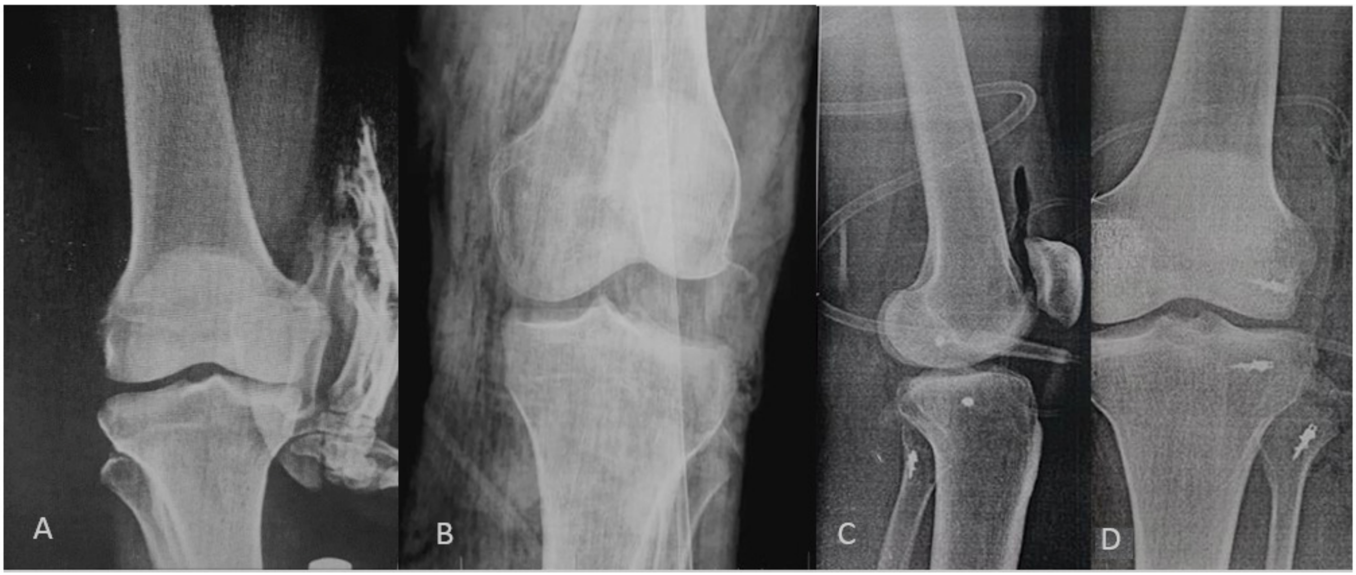

Figure 3. A and B) Varus stress radiography at 20 degrees in the right and left knees with left LCL avulsion (arcuate sign), Gerdy tubercle, and popliteus tendon avulsion; C and D) One-year radiography after Gerdy tubercle, LCL, and popliteus tendon repair.

group than in the repair group postoperatively, though not significantly [figures 3; 4]. Preoperative varus stress radiographs showed a significant difference in lateral joint opening of 5.4 mm between injured and intact knee (at the range of 5-7.5 mm), which improved significantly to 0.15 mm (ranging from -0.2 to 0.5 mm) at the final follow-up (*P<0.001*). [Table 2] tabulates the functional scores in detail. The IKDC objective score revealed no significant difference between the two groups, as shown in [Table 3].

Despite the absence of postoperative complications in all patients, two patients in the reconstruction group had abnormal objective IKDC scores. We had two cases with a peroneal nerve injury in the reconstruction group pre-operatively. Both cases had normal continuity of the peroneal nerve during surgery and recovered until the last follow-up with acceptable scores postoperatively.

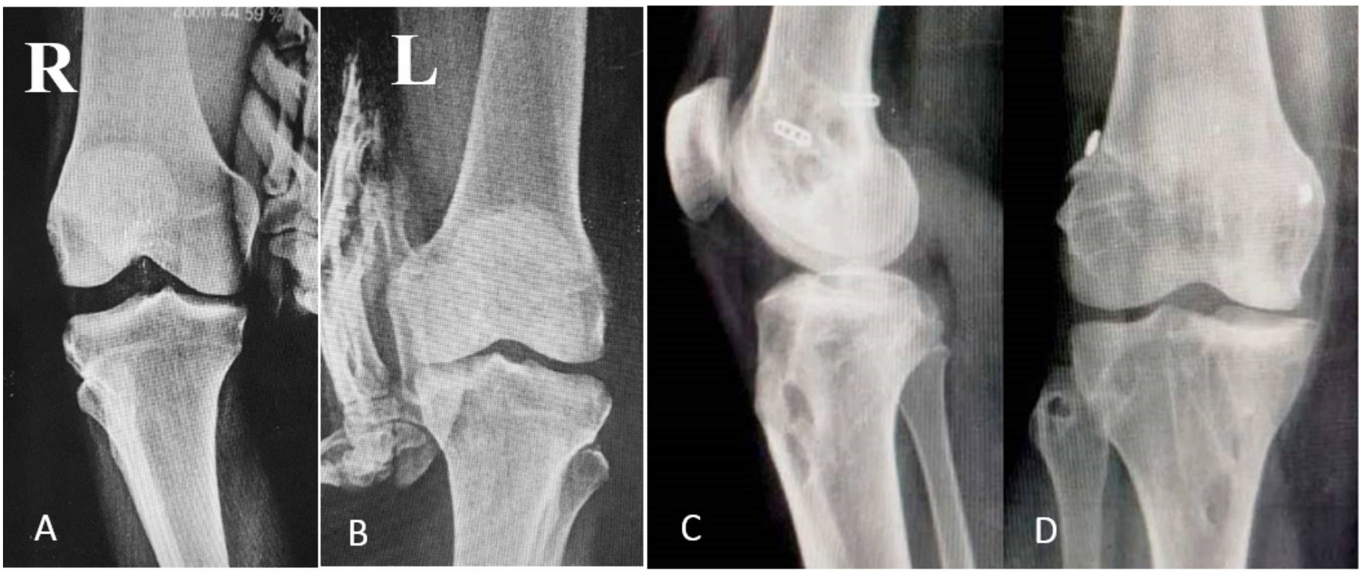

Figure 4. A and B) Varus stress radiography at 20 degrees in the right and left knees with right PLC, ACL, and PCL injury; C and D) One-year radiography after PCL, ACL, and PLC reconstruction.

Table 2. Subjective knee stability scores and lateral joint opening difference

	Reconstruction Mean±SD	Repair Mean±SD	*P-value*
IKDC score (Subjective)			
Preoperative	65.6±7.4	66.4±6.5	0.65*
Postoperative	83.3±9.6	87.3±4.4	
Lysholm score			
Preoperative	59.8±5.5	60.5±4.7	0.70*
Postoperative	84.4±8.2	88.2±4.1	
Lateral joint opening difference (mm)			
Preoperative	4.6±0.1	5±0.1	0.02*
Postoperative	-0.2±0.1	0.5±0.1	
Tegner score			
Preinjury	4.7±0.9	6±2.2	0.25*
Postoperative	4.2±0.9	5.6±2.5	

IKDC: International Knee Documentation Committee

Table 3. Objective IKDC score pre- and post-operation

		Reconstruction (n=24) n (%)	Repair (n=18) n (%)	*P-value*
Final IKDC score (Objective)	Normal	14 (58.3%)	11 (61.1%)	0.55
	Near normal	8 (33.3%)	7 (38.9%)	
	Abnormal	2 (8.4%)	0 (0%)	
	Sever abnormal	0 (0%)	0 (0%)	

IKDC: International Knee Documentation Committee

Discussion

We found a significant improvement of subjective and objective knee scores after the acute repair of the PLC avulsion injuries and acute reconstruction for midsubstance tears in the mid-term follow-up. Surgical treatment for PLC injuries was scheduled within 3 weeks of injury. As all patients had concomitant cruciate ligaments injury, delayed ACL and/or PCL reconstruction was conducted 2-3 months later when pain and swelling were relieved and patients had full passive knee range of motion. The findings of our study demonstrated that acute intervention within 3 weeks of PLC injuries, even repair in accurately-selected cases with the delayed reconstruction of cruciate ligaments, resulted in favorable outcomes.

Although the complex anatomy of PLC has now been well defined (3, 8, 9), PLC injuries have been challenging for orthopedic surgeons in terms of evaluation and treatment. There is no consensus about the optimal time and plan of intervention-repair versus reconstruction. Previous reports support that acute treatment within 3 weeks of injury has led to enhanced results, though similar results have been observed for the treatment of chronic cases after 3 weeks (10-12). The findings of some studies agree with the hypothesis that early intervention in PLC injuries, whether repair or reconstruction, within the acute phase, can result in less knee stiffness, and patients would be able to return earlier to their preinjury activity level, whereas some others are in favor of the delayed intervention (13-15).

Previous studies regarding PLC injury mostly recommend reconstruction, as repaired cases had higher failure rates. The results of studies comparing the repair and reconstruction of PLC injuries indicate a failure rate of 37-40% for PLC repair versus 6-9% for reconstruction (11, 14, 16). In early reports, the reconstruction of most concomitant cruciate ligament injuries was performed at the same time as PLC reconstruction, however, in a staged fashion when decided to repair the PLC injuries. Nonetheless, it is hypothesized that delayed ACL and/or PCL reconstruction accounts for higher rates of failure in PLC repair groups. Later evidence has revealed that despite previous poor outcomes for repairs, suitable case selection can help to achieve good and even better results than reconstructive interventions. In our study, 15 out of 18 patients in the repair group and 20 out of 24 patients in the reconstruction group, based on Tegner score, returned to their preinjury functional level. According to this hypothesis, PLC peeling off or bony avulsion injuries affecting the insertion of the PLC structures were scheduled for repair, while midsubstance tears were candidates for performing reconstruction surgery.

Different reconstructive techniques, including Larsen and La Prade, have been introduced for acute and chronic cases of posterolateral instability. La Prade et al. evaluated the outcomes of 30 cases of isolated and combined PLC injuries, repaired avulsion injuries, and reconstructed mid-substance ruptures. They also conducted simultaneous cruciate ligaments reconstructions in relevant cases (17). We conducted La Prade's reconstruction method with some modifications. In this regard, all three anatomical parts of PLC were reconstructed to have a more stabilized knee. In our technique, rather than a routine large longitudinal incision in the lateral side of the knees, we made two minimal incisions that resulted in fewer scar tissues, adhesions, and damage to the soft tissues. Geeslin et al. reported an average of a 6.2-mm difference in varus stress opening preoperatively, reduced to 0.1 mm at the final follow-up. In addition, they found no failure among their nine repaired PLC cases. However, the lateral compartment opening difference in the mentioned study was not as well as our final follow-up, and there was no statistically significant difference between the repair and reconstruction groups (18).

One of our study limitations was the lack of isolated PLC injury, which made us report the outcomes of PLC repair/reconstruction with concomitant ACL/PCL reconstruction. Moreover, since there was no evidence of failure in each group at the time of final follow-up, we were limited in comparing the failure rate between repair and reconstruction of PLC injuries. This limitation can be attributed to the small sample size in the current study. We had one surgical algorithm, according to which we reconstructed cruciate ligaments after 2-3 months of the primary PLC repair/reconstruction. Because of this constant approach, the findings of the study cannot be employed to compare the results of concurrently-reconstructed cruciate ligaments with staged ones.

The outcomes of the acute intervention, whether repair or reconstruction, would be in close relation with the appropriate case selection for each method. In combined injuries, acute repair/reconstruction for PLC and staged cruciate ligament reconstruction would have favorable outcomes.

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Conflicts of interest: The authors declare that there is no conflict of interest.

Ethical considerations: The study protocol was reviewed and approved by the Ethics Committee of Shahid Beheshti University of Medical Ssciences. Additionally, written informed consent was obtained from all patients at the baseline.

Mohammadreza Minator Sajjadi MD[1]
Sohrab Keyhani MD[1]
Morteza Kazemi MD[2]
Mohamad Movahedinia MD-MPH[2]
Seyyed-Mohsen Hosseininejad MD[2,3]
Reza Noktehsanj MD[2, 4]
1 Clinical Research Development Unit of Taleghani Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran
2 Bone Joint and Related Tissues Research Center, Akhtar Orthopedic Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran
3 Joint, Bone, Connective Tissue Rheumatology Research Center (JBCRC), Golestan University of Medical Sciences, Gorgan, Iran
4 Department of Surgery and Orthopedics, Ardabil University of Medical Sciences, Ardabil, Iran

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