# Modified anatomical posterolateral corner reconstruction of the knee using combined fibula-and tibia-based anatomic reconstruction with tibial posterior cortical fixation using a titanium staple

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**Received:** 20 November 2022
**Revised:** 10 January 2023
**Accepted:** 28 January 2023
**Published:** 27 June 2023

**The Egyptian Orthopaedic Journal** 2023, 58:8–14

**Purpose**
The purpose of this study is to evaluate the results of the anatomical reconstruction of a posterolateral corner (PLC) using a technique of combined fibula-and tibia-based anatomic reconstruction using a single semitendinosus autograft with posterior tibial cortical surface fixation using a titanium staple.

**Patients and methods**
Between August 2016 and July 2018, 13 male patients with chronic PLC injury underwent a PLC reconstruction of the knee by a modified anatomical PLC reconstruction using a technique of combined fibula-and tibia-based anatomic reconstruction using a single semitendinosus autograft with posterior tibial cortical fixation using a titanium staple. Instability was the main complaint, the mean age was 27.54 ± 4.63 with motorcycle accident being the most common cause of injury in five (38.5%) patients, contact sport was the second common cause of injury in four (30.8%) patients, twisting injury represented 15.4%, and motor vehicle injury in 15.4%. The mean time from injury to surgery was 3.54 ± 1.51 months, all cases had associated injuries; seven cases presented as combined PLC and anterior cruciate ligament injuries with one case having chondral lesion and another case having medial meniscal injury; the other five cases had combined PLC and posterior cruciate ligament injury with one case having a medial meniscal injury. The mean follow-up period was 11.31 ± 2.78 months. Before surgery as well as at the final follow-up, all study patients completed the subjective Lysholm and International Knee Documentation Committee (IKDC) questionnaires. The side-to-side difference (SSD) of the lateral joint opening in stress varus radiographs and external rotation angle (dial test) were measured.

**Results**
The final results at the end of the follow-up period showed marked improvement in IKDC and Lysholm score presented as a significant improvement of IKDC score from the preoperative mean score 25.92 ± 7.02–71.08 ± 4.39 ($P$<0.001) and Lysholm score improvement from 33.4 ± 5.7 to 87.7 ± 8.5 ($P$<0.001). Improvement of SSD of lateral joint opening in stress radiographs from 6.1 ± 0.6 to 3.4 ± 0.3 mm ($P$<0.001) and SSD of the external rotation angle (dial test) improved from 26.5 ± 3.8° preoperatively to 7.7 ± 3.3° postoperatively ($P$<0.001).

**Conclusion**
Anatomical PLC reconstruction using the fibular tunnel technique using a single semitendinosus graft with posterior cortical fixation at the tibial side using a titanium staple is a simple technique that gives excellent short-term follow-up results that need long-term follow-up to determine the graft function, especially in cases of multiple-ligament injured knee.

**Keywords:**
knee ligament, posterolateral corner, titanium staple

Egypt Orthop J 2023, 58:8–14

1110-1148

## Introduction

Reconstruction of the posterolateral corner (PLC) is a challenging technique; success to address all components of the PLC is important to gain stability and prevent postoperative laxity [1].

Injury of the PLC is always associated with injury of one or both cruciate or it may be a part of multiple-ligament injured knee [2].

The three main functional structures of PLC are fibular collateral ligament (FCL), popliteus, and popliteofibular ligament (PFL); these structures are responsible mainly for controlling varus and external rotation of the tibia [3–5].



 DOI: 10.4103/eoj.eoj_66_22

Failure to diagnose and treat PLC injury in combined knee ligament injuries will result in failure of the other reconstructed ligament, which will result in postoperative laxity and disability [6].

Techniques for posterolateral reconstruction include both anatomic and nonanatomic technique;, these include biceps tenodesis and fibular-based techniques using single or double femoral tunnels [7,8]. The first anatomical reconstruction technique of PLC was described by LaPrade in 2004; all the components of PLC are reconstructed using a split tendoachilis allograft. This technique controls both rotatory and varus laxity. [9–12]. Many modifications of the LaPrade technique were done using an autograft [13,14].

In our technique, we described a technique for anatomical reconstruction of the PLC with the use of a single semitendinosus tendon, fibular tunnel combined with fixation of the posterior limb of the graft to the back of the tibia at the level of the musculotendinous junction of the popliteus using a titanium staple to reconstruct all components of PLC.

## Patients and methods

This case series study was prospectively designed with consecutive patient recruitment; the study was approved by the ethics committee of the Faculty of Medicine, Tanta University, Egypt, and conducted according to the Declaration of Helsinki. All subjects gave their written informed consent to participate in this investigation.

Between August 2019 and July 2021, 13 patients underwent a PLC reconstruction of the knee by a modified anatomical PLC reconstruction using combined fibula-and tibia-based anatomic reconstruction with posterior tibial cortical fixation using a titanium staple.

The inclusion criteria were the following: isolated or combined grade III PLC injury presented as posttraumatic varus instability more than 5 mm on clinical examination tested at 20° of flexion confirmed by varus stress radiograph with a gapping of more than 4 mm done in 20° flexion compared with the healthy side; external tibial rotation in 30° knee flexion more than 10° compared with the uninjured knee to diagnose the posterolateral rotatory instability. Exclusion criteria: grade IV osteoarthritis, chronic varus alignment with varus thrust which is an indication for osteotomy, associated common peroneal nerve injury, and revision surgeries.

The examination was done including a clinical test for the cruciate; a dial test (at 30° and 90° flexion) and a varus stress test at (0° and 30° flexion) were performed, which were compared with the healthy side; the instability was graded from 0 to 3+.

The patient had preoperative standing long leg film, and all patients had preoperative MRI.

Before surgery as well as at the final follow-up; all study patients completed the subjective Lysholm and International Knee Documentation Committee (IKDC) questionnaires.

The side-to-side difference (SSD) of the lateral joint opening was calculated as the closest perpendicular distance between the lateral femoral condyle and the corresponding tibial plateau in millimeters. The patients had clinically applied varus stress radiographs taken at a 20° flexion angle.

This measurement is carried out both preoperatively and postoperatively at least 1 year after surgery (Fig. 1).

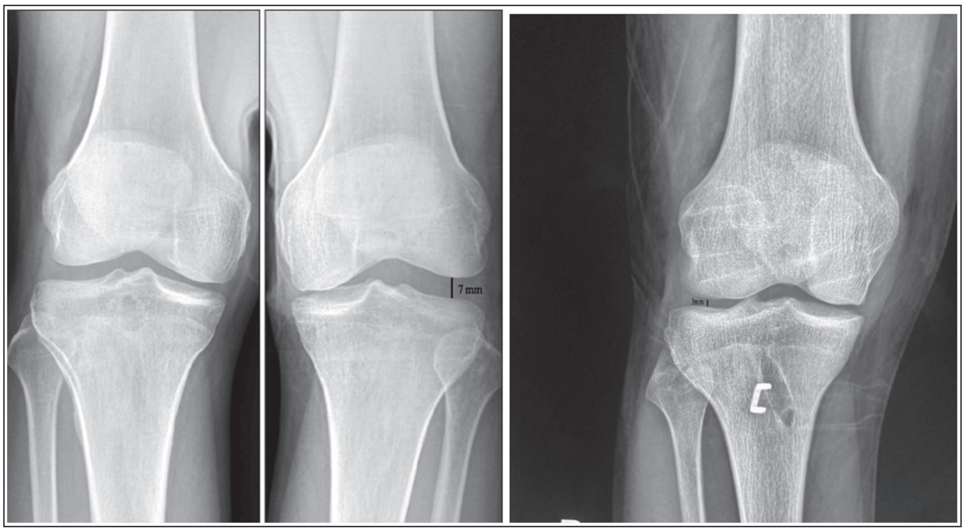
Surgical technique: under general or local anesthesia the patient is positioned in a supine position with the knee positioned at 30° flexion. We did not use a lateral post, but the knee is allowed to hang from the table to gain 90° flexion, and a pneumatic tourniquet is applied to the upper thigh. Examination under anesthesia includes external rotation recurvate test, stress varus to detect varus opening at 30° of flexion and in extension, dial test at 30 and 90°, and examination of both cruciate ligaments for concomitant injury (Fig. 2).

The semitendinosus muscle is harvested through a 1.5–2 cm longitudinal incision thumb breadth distal and 2 cm medial to the tibial tuberosity, followed by an incision of Sartorius fascia proximal to the superior border of the gracilis tendon; the accessory band run between the gracilis and the semitendinosus is released and then the tendon of the semitendinosus is harvested and the end is whipstitched with no. 2 Vicryl.

Lateral curved incision is centered over the head of the fibula and extended proximally to the lateral epicondyle, dissection of the subcutaneous tissue with full-thickness subcutaneous skin flaps raised the anterior and posterior regions.

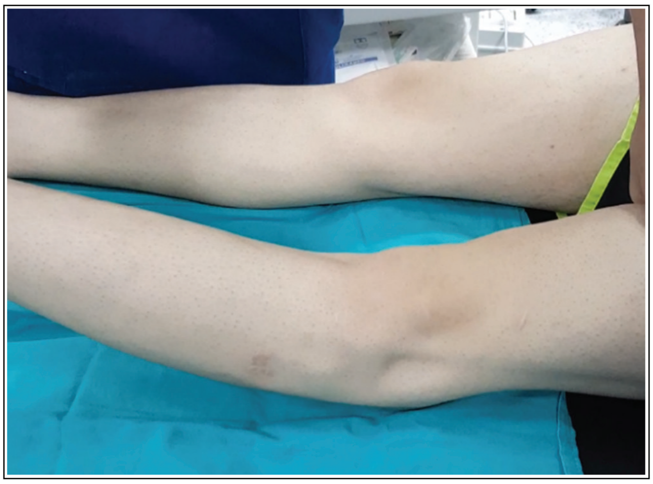
Identification and neurolysis of the common peroneal nerve.
Dissection and exposure of the head of the fibula followed by drilling of the fibular tunnel using a 2.7 mm drill-tipped passing pin in an oblique direction

**Figure 1**



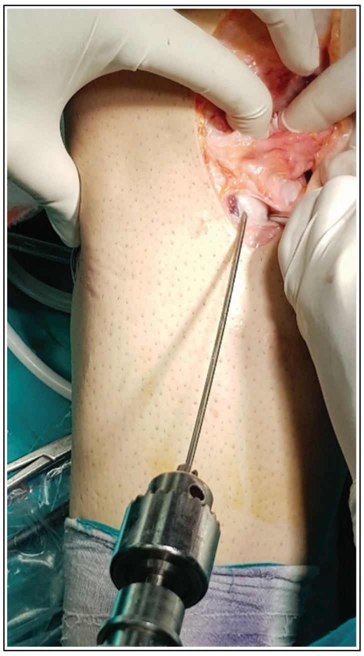

(a) Preoperative lateral joint opening measurement in stress varus radiographs. (b) Postoperative lateral joint opening measurement in stress varus radiographs.

**Figure 2**



Examination shows evident recurvatum external rotation test.

**Figure 3**



Drilling of the fibular tunnel.

from the anterolateral to the posteromedial direction started at the distal attachment of the FCL, which is 8 mm posterior to the anterior margin of the fibular head and 28 mm distal to the tip of the fibular styloid to the attachment site of the posterior division of the PFL on the posteromedial aspect of the fibular styloid and then over drilling to 6 mm followed by placing of passing sutures (Fig. 3).

Passage of the graft through the fibular tunnel.
Dissection of the interval between the lateral head of the gastrocnemius and biceps with the use of the periosteal elevator popliteus is dissected and elevated from the back of the tibia at the level of its musculotendinous junction with roughing of the bone surface with a curate to increase the chance for the tendon to bone healing.

The posterior limb of the graft is anchored to the back of the tibia at the level of the musculotendinous junction of the popliteus muscle using a staple to reconstruct the PFL with the tibia in neutral rotation and this will redirect the direction of the popliteus limb to support the PLC and correct the recurvate (Fig. 4).

**Figure 4**

Fixation of the posterior limb of the graft to the back of the tibia through the interval between the medial head of gastrocnemius and biceps tendon using a staple at the level of musculotendinous junction of the popliteus to reconstruct the popliteofibular ligament.

**Figure 5**

FCL fixation of the graft in the femoral tunnel using 7×25-mm bioabsorbable interference screw with the knee in valgus neutral rotation in 30 flexions. Popliteus femoral insertion tensioned and fixed in 70 degreds flexion. Diagram showing the technique: FCL, fibular collateral ligament; PFL, popliteofibular ligament; PL, popliteus.

Split of the iliotibial band capsulotomy is done to the popliteus and the FCL femoral footprint is identified. The FCL is located proximal and posterior to the attachment of the popliteus separated from it by about 1.8 mm. A 2.7 mm drill-tipped pin is drilled which is over-reamed to 6 mm up to the medial cortex and the passing suture placed in both tunnels.

Passing of the graft under the iliotibial band is done followed by tension applied to both ends in the FCL fixation of the graft in the femoral tunnel using a 7×25-mm bioabsorbable interference screw with the knee in valgus neutral rotation in 30° flexion. Popliteus femoral insertion tensioned and fixed in 70° flexion (Figs. 5 and 6).

**Figure 6**

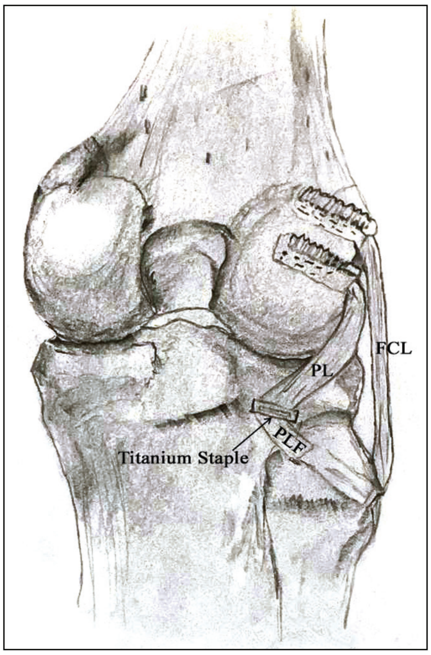



Diagram showing the technique: FCL, reconstructed fibular collateral ligament; PFL, reconstructed popliteofibular ligament; PL, reconstructed popliteus tendon.

Associated injuries are addressed by arthroscopy before reconstruction of the PLC for anterior cruciate ligament (ACL) injury reconstruction using the ipsilateral quadriceps graft posterior cruciate ligament (PCL) injury reconstruction using ipsilateral peroneus longus graft, repair or partial meniscectomy for associated meniscal injuries, and for chondral lesion, microfracture was done.

Range of motion and stability is checked; the wound is irrigated and closed, and postoperative knee brace fixed in extension is applied.

### Rehabilitation

All patients went through a similar rehabilitation program. Controlling postoperative pain, and swelling, increasing patellar mobility, stimulating muscles, and preventing tension on the graft to prevent postoperative laxity are the main goals of rehab programs for the first 3 weeks following surgery. The patient was immobilized in a hinged knee brace that was locked at 0°; however, by the third week, the brace was freed to allow for a range of motion of 0–110°. At this stage, patients are allowed to do partial weight bearing as tolerated while using crutches for 6 weeks; patients are also allowed to bear full weight.

The brace is removed 3 months after surgery, and at all stages of the rehabilitation program, patients are advised to limit excessive foot and tibial rotation.

Patients can resume their everyday activities 4 months after surgery; running is permitted at 5 months; and contact sports are permitted at 7 months.

### Follow-up evaluation

All patients were evaluated at 1-year; postoperative knee function was evaluated according to the Lysholm knee scoring scale and IKDC subjective knee evaluation forms.

Dial test is done preoperatively and postoperatively at the end of the follow-up period in 30° flexion in the prone position, and foot thigh angle is measured with a goniometer and SSD is documented. Stress varus radiographs done in 20° flexion in both knees and lateral joint gapping is measured as the shortest distance between the subchondral bone surface of the central part of the lateral femoral condyle and lateral tibial plateau done preoperatively and postoperatively and SSD is documented.

**Table 1 Distribution of the studied cases according to different parameters (*N*=13)**

| | *n* (%) |
|---|---|
| Age (years) | |
| Mean±SD | 27.54 ± 4.63 |
| Median (minimum–maximum) | 29.0 (18–34) |
| Follow-up period | |
| Mean±SD | 11.31 ± 2.78 |
| Median (minimum–maximum) | 12.0 (6–18) |
| Time from injury to surgery | |
| Mean±SD | 3.54 ± 1.51 |
| Median (minimum–maximum) | 3.0 (2–6) |
| Injury pattern | |
| Twisting | 2(15.4) |
| Motor cycle | 5 (38.5) |
| Motor vehicle | 2 (15.4) |
| Contact sport injury | 4 (30.8) |
| Associated injury | |
| PLC+ACL | 5 (38.5) |
| PLC+PCL | 4 (30.8) |
| PLC+ACL+chondral lesion | 1 (7.7) |
| PLC+ACL+medial meniscal injury | 1 (7.7) |
| PLC+PCL+medial meniscal injury | 2 (15.4) |

ACL, anterior cruciate ligament; PCL, posterior cruciate ligament; PLC, posterolateral corner.

### Statistical analysis of data

Data were fed to the computer and analyzed using IBM SPSS software package, version 20.0. (IBM Corp., Armonk, New York, USA). Categorical data were represented as numbers and percentages. For continuous data, they were tested for normality by the Shapiro–Wilk test. Quantitative data were expressed as a range (minimum and maximum), mean, SD, and median. Paired *t* test was used to compare two periods for normally distributed quantitative variables. The significance of the obtained results was judged at the 5% level.

## Results

Thirteen male patients had PLC chronic injury; instability was the mean complaint and the mean age was 27.54 ± 4.63. Motorcycle accident was the most common cause of injury in five (38.5%) patients, contact sport was the second most common cause of injury in four (30.8%) patients; twisting injury represented 15.4% and motor vehicle injury 15.4%.

The mean time from injury to surgery was 3.54 ± 1.51 months; all cases had associated injuries; seven cases presented as combined PLC and ACL injury with one case having a chondral lesion and another case had a medial meniscal injury; the other five cases had combined PLC and PCL injury with one case had a medial meniscal injury, the mean follow-up period was 11.31 ± 2.78 months.

**Table 2 Comparison between the two studied periods according to different parameters (*N*=13)**

| | Preoperative | Postoperative | *t* | *P* |
|---|---|---|---|---|
| IKDC | | | | |
| Mean±SD | 25.92 ± 7.02 | 71.08 ± 4.39 | 19.124* | <0.001* |
| Median (minimum–maximum) | 25 (18–41) | 71 (63–77) | | |
| Lysholm | | | | |
| Mean±SD | 33.4 ± 5.7 | 87.7 ± 8.5 | 18.552* | <0.001* |
| Median (minimum–maximum) | 34 (22–42) | 91.0 (71–95) | | |
| SSD OS lateral joint opening | | | | |
| Mean±SD | 6.1 ± 0.6 | 3.4 ± 0.3 | 12.763* | <0.001* |
| Median (minimum–maximum) | 6 (5–7) | 3.5 (3–4) | | |
| SSD of ER angle | | | | |
| Mean±SD | 26.5 ± 3.8 | 7.7 ± 3.3 | 14.663* | <0.001* |
| Median (minimum–maximum) | 25 (20–30) | 5 (5–15) | | |

IKDC, International Knee Documentation Committee; SSD, side-to-side difference; *t*, paired *t* test.
*P*: *P* value for comparing between preoperative and postoperative
*Statistically significant at *P* value less than or equal to 0.05.

The final results at the end of the follow-up period showed a marked improvement in IKDC and Lysholm score presented as a significant improvement of IKDC score from preoperative mean score 25.92 ± 7.02–71.08 ± 4.39 ($P$<0.001) and Lysholm score improvement from 33.4 ± 5.7 to 87.7 ± 8.5 ($P$<0.001).

The mean preoperative and postoperative lateral joint opening SSD measured in millimeters as the distance between the subchondral bone of the lateral tibial plateau and lateral condyle of the femur in stress varus radiographs done at 20° flexion showed significant improvement from 6.1 ± 0.6 to 3.4 ± 0.3 mm ($P$<0.001).

The SSD of external rotation angle (dial test) improved from 26.5 ± 3.8° preoperatively to 7.7 ± 3.3° postoperatively ($P$<0.001).

### Complications

Superficial wound infection occurred in only one patient; another patient had postoperative DVT that was treated by low molecular weight heparin therapy, and no cases presented with postoperative common peroneal nerve affection (Tables 1 and 2).

## Discussion

Injury of PLC is disabling as it results in marked and handicapping instability. It may occur as an isolated injury which is less common than combined injuries, so it may occur as a part of multiple-ligament injured knee; a lot of nonanatomical techniques for the reconstruction of PLC was described, but these techniques did not address all the components of PLC. Anatomical reconstruction of PLC was first described by LaPrade aimed to reconstruct all the anatomical components of PLC (LCL, PFL, popliteus), which theoretically will restore the native biomechanics [15–17].

In this study, anatomical reconstruction of the three components of PLC was done using a single semitendinosus autograft passed through the fibular tunnel with cortical fixation of the posterior limb of the graft to the back of the tibia at the site of the posterior orifice of the tibial tunnel done in LaPrade technique using a titanium staple with postoperative significant improvement of IKDC and Lysholm scores from 25 to 71 and 33 to 87, respectively. These results were comparable to the results of other anatomical techniques described for PLC reconstruction. LaPrade investigated a group of 54 patients who underwent anatomic PLC repair. At the time of the final follow-up, the average IKDC score was 62. A study by Franciozi *et al*. [18] evaluated the outcomes of a modified anatomical PLC reconstruction resulting in mean postoperative IKDC and Lysholm scores of 70 and 81, respectively.

In this study, inferior results were observed in cases with associated PCL and meniscal injury. These findings are comparable to those by Feucht *et al*. who found that ACL injuries resulted in better patient-reported outcomes and a faster return to work than PCL injuries [19-21].

In our study, varus stability was not completely restored and residual lateral laxity could be seen subjectively and radiologically, despite a significant improvement in SSD of the lateral joint opening measured on stress varus radiographs from an average of 6.1 mm preoperatively to 3.4 mm postoperatively. The amount of residual varus was related to the degree of preoperative lateral joint opening and chronicity of injury. In certain clinical investigations, persistent varus laxity following anatomical PLC reconstruction was noted. Some studies observe improvement in varus stress using Larson fibular sling reconstruction compared with the LaPrade anatomical technique [8,18,22,23], and other studies show no difference between the two techniques [7,24-26].

External rotation angles in every patient in this study significantly improved postoperatively to levels that were comparable to the unaffected side on the opposite side. Even though several clinical research undervalued the benefits of popliteal tendon reconstruction [8,25], based on earlier biomechanical investigations we think that reconstructing all components of PLC to manage excessive tibial external rotation and varus instability and limiting hyperextension [16,27,28].

All cases included in the study had associated cruciate injury either anterior or posterior cruciate as isolated injury of the lateral knee structures is rare. The majority of patients did not resume their preinjury level of participation in sports; this finding is consistent with that from Van der Wal *et al.* [23], who suggested warning the patients not to go back to their preinjury lifestyles. In addition, we discovered that the remaining varus laxity affects the athletic level.

Our technique is simple as it does not require a tibial tunnel for tibial side fixation so there is less postoperative pain that allows early postoperative rehabilitation and less postoperative edema Also, it needs only one semitendinosus graft to reconstruct all components of PLC. This allows the availability of grafts in cases of multiple-ligament injured knee;

most previous techniques used two separate allografts, but an allograft is not available in some countries and also there are hazards of disease transmission. Some techniques used two hamstring autografts [24,29], as a PLC injury is a part of multiple-ligament injuries. Some techniques described the use of a single peroneus longus [30] and semitendinosus graft [6,15,17,31].

The main drawback of our technique and study is the short period of follow-up as the long-term follow-up result may be different with the long-term follow-up. The cortical surface fixation of the tibial side may be a weak fixation that gives less tendon-to-bone healing in comparison with the tibial tunnel technique and the third drawback of our study is the small number of cases.

In conclusion, anatomical PLC reconstruction using the fibular tunnel technique using a single semitendinosus graft with posterior cortical fixation at the tibial side is a simple technique that gives excellent short-term follow-up results that need long-term follow-up to determine the graft function in cases of multiple-ligament injured knee.

**Financial support and sponsorship**
Nil.

**Conflicts of interest**
Authors declared that there is no conflict of interest in this study.

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