

Femoral-Sided Bony Avulsion of the Posterior Cruciate Ligament in an Adolescent Athlete: A Case Report

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Abstract

Femoral-sided bony avulsion fractures of the posterior cruciate ligament (PCL) are uncommon injuries, particularly in skeletally immature patients. These injuries may occur following hyperextension trauma and can result in posterior knee instability. Displaced femoral-sided avulsion fractures are generally considered for operative treatment to restore the anatomical PCL attachment and knee stability. Arthroscopic primary repair may provide an opportunity to preserve the native ligament and avoid conventional ligament reconstruction, particularly when the avulsed fragment remains suitable for fixation. A 16-year-old male presented to the Sports Medicine Clinic approximately one month after sustaining a hyperextension injury to his left knee while playing recreational football. Clinical examination revealed posterior sag, a Grade II positive posterior drawer test, and a positive quadriceps active test, while the collateral ligaments and rotational stability were preserved. Radiographs, computed tomography (CT), and magnetic resonance imaging (MRI) demonstrated a 1 × 1 cm posteriorly displaced femoral-sided bony avulsion of the PCL, with open distal femoral and proximal tibial physes. The native PCL remained attached to the avulsed fragment, while the medial and lateral menisci, articular cartilage, the anterior cruciate ligament, and collateral ligaments were intact. The patient underwent arthroscopic primary repair using two double-luggage-tag sutures and a 4.5-mm self-punching PEEK-Ti knotless anchor placed at the anatomical femoral footprint. Postoperatively, the knee was protected in a hinged brace with posterior tibial support for eight weeks, followed by a structured rehabilitation program. The patient was followed regularly after surgery with a structured rehabilitation program. At the three-month follow-up, he demonstrated full range of motion; the posterior drawer, posterior sagging, and active quadriceps test were all negative, and pain was about 2 out of 10. This case highlights that, in selected skeletally immature patients, arthroscopic primary repair of a displaced femoral-sided PCL bony avulsion may be a viable option when the native ligament and avulsed fragment remain suitable for anatomical fixation. Careful clinical assessment, appropriate CT and MRI evaluation, anatomical reduction, and protection of the repair during rehabilitation are important to achieve favorable outcomes.

Categories: Sports Medicine, Orthopedics, Anatomy

Keywords: adolescent, arthroscopic repair, bony avulsion, femoral-sided pcl avulsion, knee instability, open physis, posterior cruciate ligament

Introduction

The posterior cruciate ligament (PCL) is the primary restraint to posterior translation of the tibia and an important contributor to rotational stability and normal knee kinematics. PCL injuries are less common than anterior cruciate ligament (ACL) injuries and may occur as isolated lesions or as part of multiligamentous knee trauma. They encompass several distinct patterns, including midsubstance tears, tibial-sided avulsions, and proximal injuries at the femoral attachment. The clinical behavior and treatment considerations differ according to the site and structural characteristics of the injury, making accurate identification of the specific PCL injury pattern essential [1].

Femoral-sided bony avulsion represents an uncommon form of proximal PCL injury in which the ligament remains attached to an avulsed osseous fragment at its femoral origin. It should be distinguished from a midsubstance tear and from a femoral soft-tissue “peel-off” lesion, in which the ligament separates from its femoral attachment without a substantial bony fragment. This distinction has practical implications because preservation of an adequate bony fragment and viable native ligament may permit direct anatomic fixation and restoration of the original ligament-bone attachment rather than reconstruction. Arthroscopic repair of femoral-sided PCL injuries has been described using suture-anchor constructs placed at the native femoral footprint [2].

How to cite this article

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Clinical recognition of these injuries may be difficult, particularly when the initial radiographs do not clearly demonstrate the avulsed fragment. Posterior sag, increased posterior translation on the posterior drawer test, and a positive quadriceps active test may indicate PCL insufficiency, but imaging is essential to define the exact injury pattern. Magnetic resonance imaging (MRI) is useful for assessing PCL continuity and associated intra-articular injuries, whereas computed tomography (CT) provides detailed characterization of the osseous fragment, including its size, displacement, and morphology, which can be particularly important for operative planning [3].

PCL injuries are particularly uncommon in children and adolescents, and femoral-sided avulsion injuries in this population have been described mainly in isolated reports. A 2023 report described two pediatric patients with femoral-sided PCL avulsion fractures, including an acute displaced injury and a chronic nonunion, both treated arthroscopically. These reports highlight the importance of recognizing femoral-sided PCL avulsion as a distinct injury pattern in children and demonstrate that preservation and fixation of the native ligament can be feasible in appropriately selected patients [4].

The presence of an open physis adds another consideration when treating these injuries. In skeletally immature patients, surgical treatment must restore knee stability while minimizing the risk of iatrogenic physeal injury. Pediatric PCL literature has therefore emphasized techniques that preserve the native ligament and respect the physis when repair is possible. Arthroscopic repair of proximal PCL injuries has been specifically proposed in pediatric patients because it can preserve the native ligament, avoid graft harvesting, and provide a physeal-respecting alternative to reconstruction in selected acute proximal avulsion injuries [5].

The choice between nonoperative treatment, primary repair, and reconstruction depends on the degree of displacement, fragment size and quality, ligament integrity, associated injuries, skeletal maturity, and residual instability. Minimally displaced injuries may be treated conservatively in selected patients, whereas displaced avulsions with persistent instability generally require operative management. When the avulsed fragment and attached ligament remain suitable for fixation, primary repair offers the potential to restore the native ligament and its anatomical femoral attachment while avoiding graft reconstruction. In a patient with an open physis, this approach may also avoid the need for reconstructive tunnels that could place the physis at risk [6].

More recent arthroscopic techniques have further expanded the options for femoral-sided PCL fixation. Contemporary approaches include direct suture-anchor and transfemoral fixation strategies designed to preserve the native femoral insertion and restore appropriate ligament tension. Despite these technical developments, the literature remains limited, particularly for displaced femoral-sided bony avulsions in adolescent athletes with open physes [7].

In this report, we present an adolescent athlete with an open distal femoral physis who sustained a displaced femoral-sided bony avulsion of the PCL following a sports-related hyperextension injury. The injury was treated with arthroscopic primary repair using two double-luggage-tag sutures and a knotless suture anchor placed at the anatomical femoral footprint. This case highlights the diagnostic and technical considerations involved in treating this uncommon injury and illustrates the potential role of anatomic primary repair in preserving the native PCL while avoiding reconstructive tunnels in a skeletally immature patient.

Case Presentation

A 16-year-old male adolescent was referred to the Sports Medicine Clinic at Queen Alia Hospital approximately one month after sustaining an injury to his left knee. He presented with persistent symptoms and clinical features of posterior knee instability. At the time of presentation, he was approximately four weeks from the initial injury and was referred to our facility for further evaluation and definitive management.

The injury occurred while the patient was playing recreational football, when he sustained a hyperextension injury of the left knee. He was initially evaluated at an outside hospital, where plain radiographs and CT of the knee were obtained. He was managed initially with a posterior back slab for pain control and immobilization. Because of persistent clinical suspicion of a PCL injury, MRI was subsequently performed. The patient was then referred to our institution for specialized assessment and definitive management approximately one month after the initial injury.

On examination, the patient demonstrated posterior sag, a Grade II positive posterior drawer test, and a positive quadriceps active test. Varus and valgus stress testing revealed stable medial and lateral collateral ligaments, and the pivot-shift test was negative, with no clinical evidence of associated rotational instability.

Imaging

Initial plain radiographs of the left knee obtained at the outside hospital were reviewed at our institution. The radiographs demonstrated an osseous fragment at the femoral origin of the PCL, raising suspicion for a

femoral-sided bony avulsion. The injury was subsequently further characterized with CT and MRI (Figure 1).

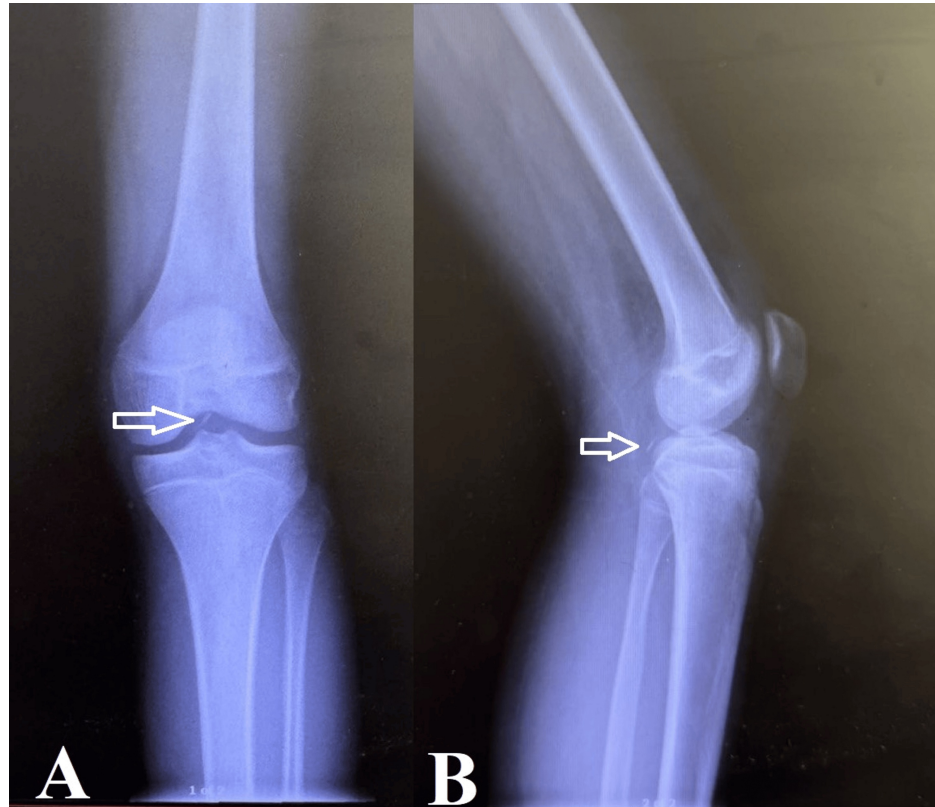


FIGURE 1: Initial radiographs.

Initial anteroposterior (A) and lateral (B) knee radiographs demonstrating normal alignment with no obvious osseous abnormality except for a small intra-articular chip avulsion fracture (arrow).

CT of the left knee demonstrated a displaced bony fragment arising from the femoral attachment of the PCL. The fragment measured approximately 1×1 cm and was displaced posteriorly from its native femoral footprint. The distal femoral and proximal tibial physes were both open, confirming skeletal immaturity. The CT findings established the size, location, and displacement of the avulsed fragment and assisted in operative planning (Figure 2).

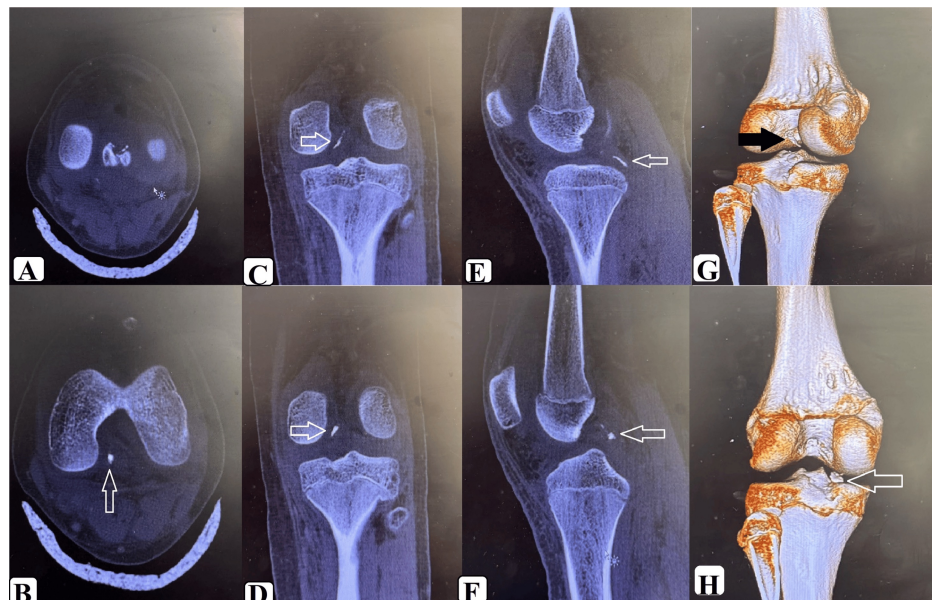


FIGURE 2: CT scan findings.

Initial computed tomography (CT) scan of the left knee showing a displaced bony avulsion fragment arising from the femoral attachment of the posterior cruciate ligament (PCL). Axial (A, B), coronal (C, D), sagittal (E, F), and three-dimensional reconstruction (G,H) images demonstrate the approximately 1 × 1 cm avulsed fragment with posterior displacement from its native femoral footprint (arrows). The distal femoral and proximal tibial physes are open, consistent with skeletal immaturity.

MRI of the left knee confirmed an avulsion injury of the PCL from its femoral attachment, with the ligament remaining attached to the displaced osseous fragment. The distal femoral and proximal tibial physes were open. Importantly, the medial and lateral menisci, articular cartilage, ACL, and medial and lateral collateral ligaments were intact, with no associated intra-articular or collateral ligament injury identified. These findings supported the diagnosis of an isolated femoral-sided bony PCL avulsion and demonstrated that the native ligament and avulsed fragment were suitable for consideration of primary repair (Figure 3).

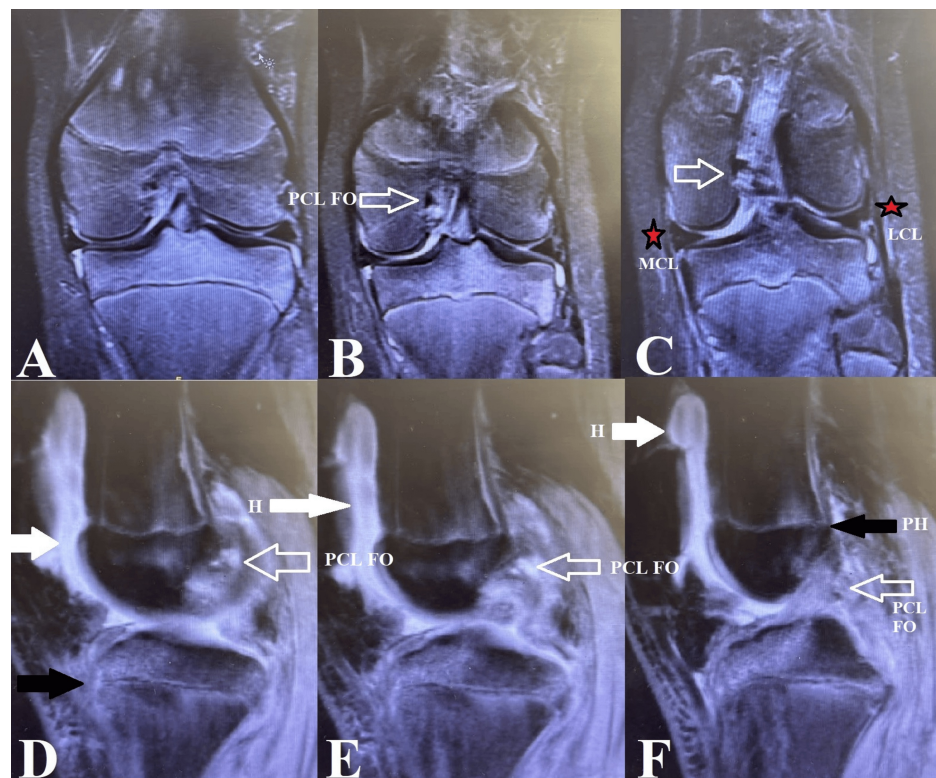


FIGURE 3: MRI findings.

Initial magnetic resonance imaging (MRI) of the knee. Coronal T2-weighted images (A–C) demonstrate bone marrow edema at the femoral origin of the posterior cruciate ligament (PCL) (arrows), with intact medial and lateral collateral ligaments (red stars, MCL, LCL) and preserved medial and lateral menisci. Sagittal T2-weighted images (D–F) demonstrate disruption of the PCL at its femoral attachment, with the ligament remaining attached to the avulsed osseous fragment (open arrows, PCL femoral origin (PCL FO)), significant hemarthrosis (white arrows, hemarthrosis (H)), and open distal femoral and proximal tibial physes (black arrows, open physis (PH)).

Treatment decision

Given the displacement of the bony fragment and the clinically significant posterior instability, operative treatment was recommended. The patient and his family were counseled regarding the diagnosis, available treatment options, and the potential risks and benefits of primary repair and ligament reconstruction. Considering the preserved integrity of the avulsed PCL and its attached bony fragment, the 1 × 1 cm fragment, and the patient's open distal femoral physis, the decision was made to attempt arthroscopic primary repair with anatomic restoration of the native PCL femoral attachment. Reconstruction was planned as a backup option if the fragment or ligament was found to be unsuitable for fixation intraoperatively. The patient and his family provided informed consent for the procedure.

Operative findings and surgical technique

The patient underwent arthroscopic surgery two days after presentation to our institution. Diagnostic arthroscopy confirmed a displaced femoral-sided bony PCL avulsion, with the ligament remaining attached to the avulsed osseous fragment. We assessed the fragment and attached ligament arthroscopically and considered them suitable for primary repair. The arthroscopic appearance of the injury is shown.

Initial Diagnostic Arthroscopy

Through an anterolateral viewing portal and anteromedial working portal, knee arthroscopy showed the anteromedial compartment demonstrating acute hemarthrosis, capsular distension, and synovial reaction following traumatic injury (Figure 4).

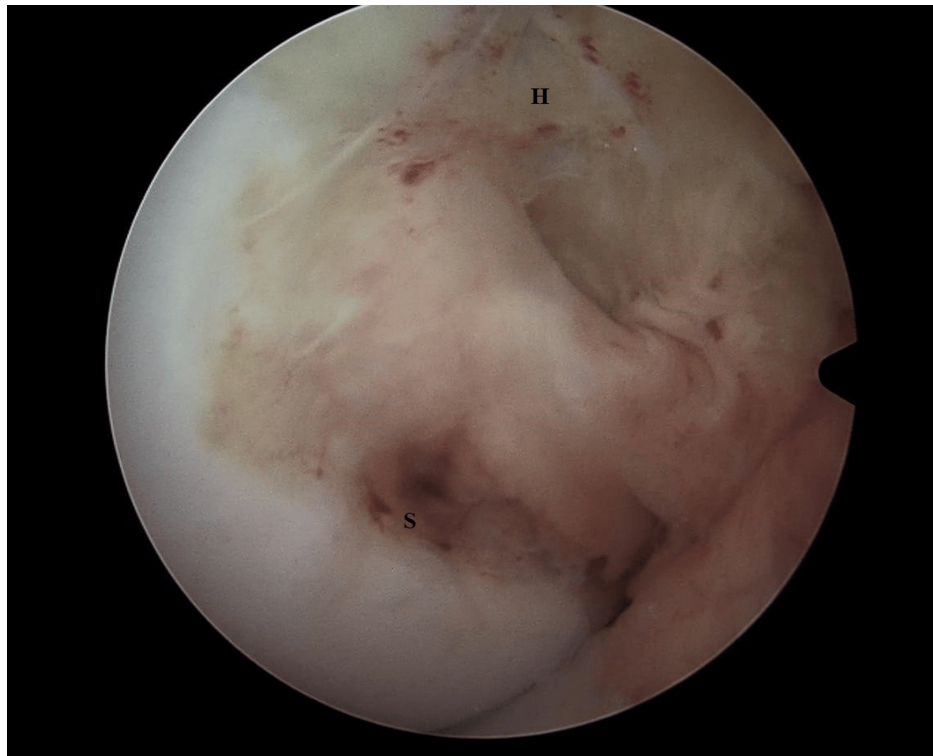


FIGURE 4: Diagnostic arthroscopy.

Arthroscopic anteromedial view of the knee showing acute hemarthrosis (H) and synovial reaction (S) upon joint entry.

Fragment Identification and Probing

Identification and arthroscopic probing of the displaced 1 × 1 cm femoral-sided PCL bony avulsion fragment attached to native ligament tissue is shown in Figure 5.

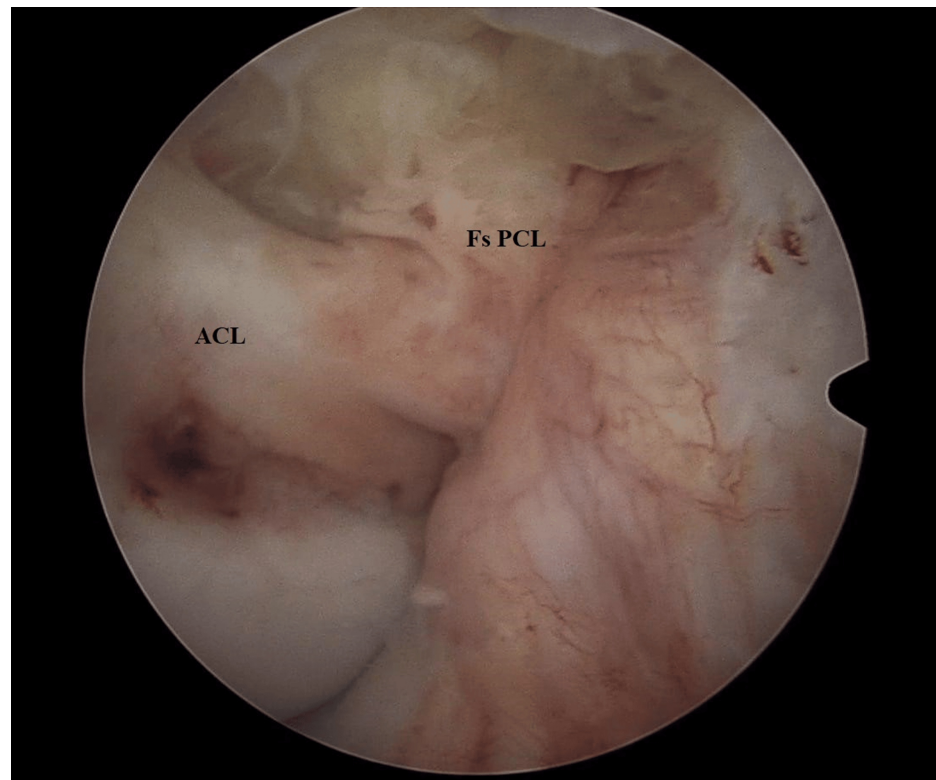


FIGURE 5: Identification and probing of PCL avulsion.

Arthroscopic view identifying and probing the displaced 1 × 1 cm femoral-sided posterior cruciate ligament (PCL) (PCL fs) avulsion fragment with intact anterior cruciate ligament (ACL).

Ligament and Fragment Mobilization

Arthroscopic elevation and probing of the avulsed PCL tissue and bone fragment were performed, mobilizing it from surrounding capsular adhesions (Figure 6).

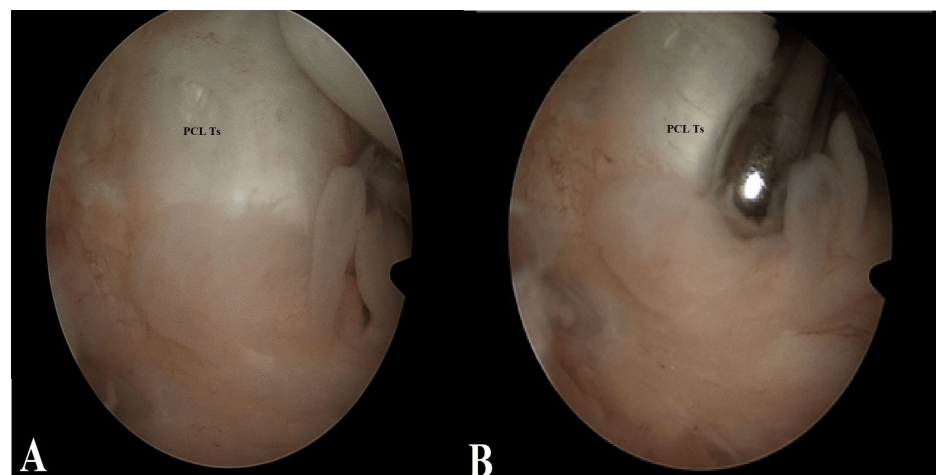


FIGURE 6: Posteromedial portal PCL tibial attachment (PCL Ts) view.

Arthroscopic intraoperative views (A, B) through the posteromedial viewing portal demonstrating the intact tibial footprint and attachment of the posterior cruciate ligament (PCL).

Femoral Footprint Preparation

Mechanical debridement and decortication of the native anterolateral femoral PCL origin were performed

using an arthroscopic shaver and burr down to a bleeding bony bed.

First Suture Passage

Passage of the initial high-strength braided suture construct was performed in a double-luggage-tag configuration through the proximal PCL substance near the avulsed junction.

Second Suture Placement

Placement of the second double-luggage-tag suture construct was performed, establishing dual-point circumferential graft capture for balanced load distribution (Figure 7).

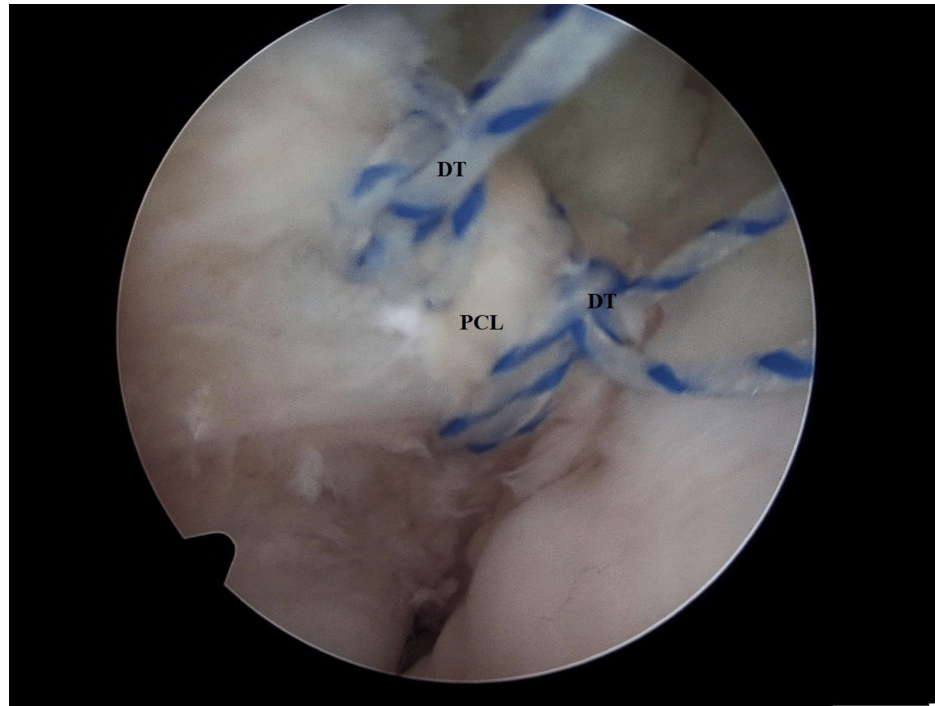


FIGURE 7: Second double-luggage-tag suture placement.

Placement of the two double-luggage-tag sutures (DT) for dual-point circumferential graft control of the posterior cruciate ligament (PCL).

Suture Management and Driver Loading

Retrieval of all suture limbs was performed through the anteromedial working portal and threading them into the eyelet of the knotless anchor driver (Figure 8).

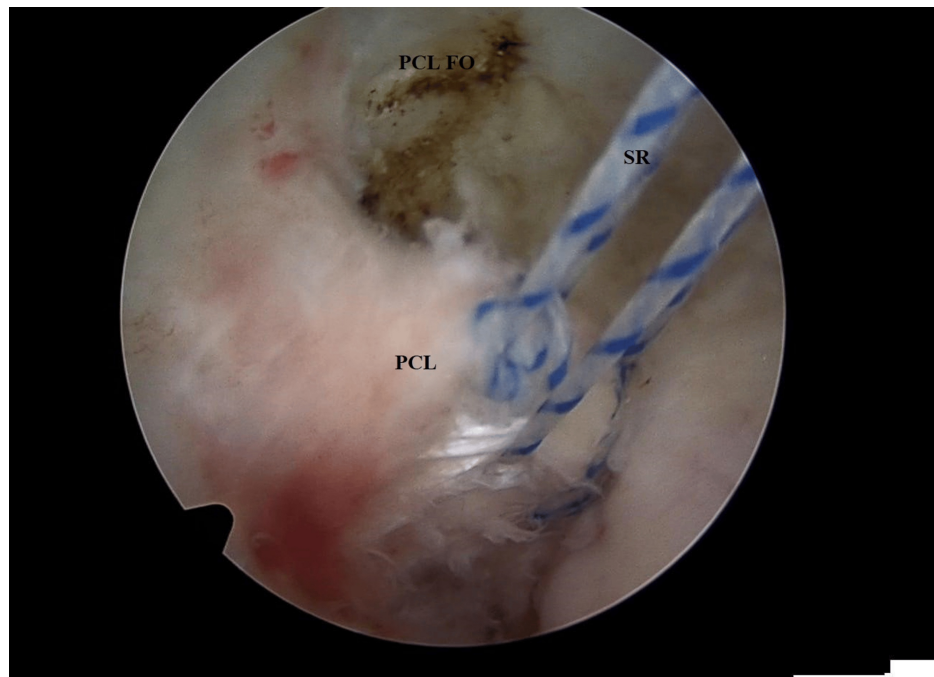


FIGURE 8: Suture retrieval and driver loading.

Retrieving all suture (SR) limbs through the anteromedial portal and threading them into the eyelet of the 4.5-mm knotless anchor driver, posterior cruciate ligament (PCL), PCL femoral origin (PCL FO).

Knotless Anchor Insertion

Insertion and seating of the 4.5-mm PEEK-Ti self-punching knotless suture anchor into the decorticated femoral origin were performed under direct visualization (Figure 9).

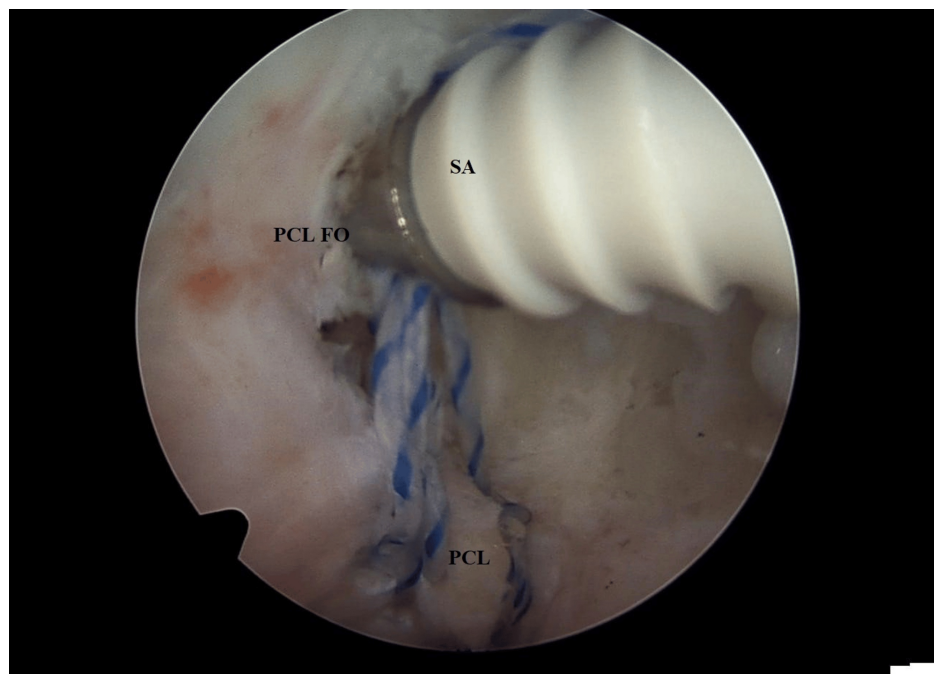


FIGURE 9: Knotless suture anchor placement.

Driving the 4.5-mm PEEK-Ti self-punching knotless suture anchor (SA) into the decorticated femoral origin (posterior cruciate ligament (PCL) FO) under direct vision.

Anatomic Reduction and Suture Tensioning

Complete anatomic reduction of the avulsed PCL tissue and bone fragment flush against the decorticated femoral footprint was performed under uniform suture tension (Figure 10).

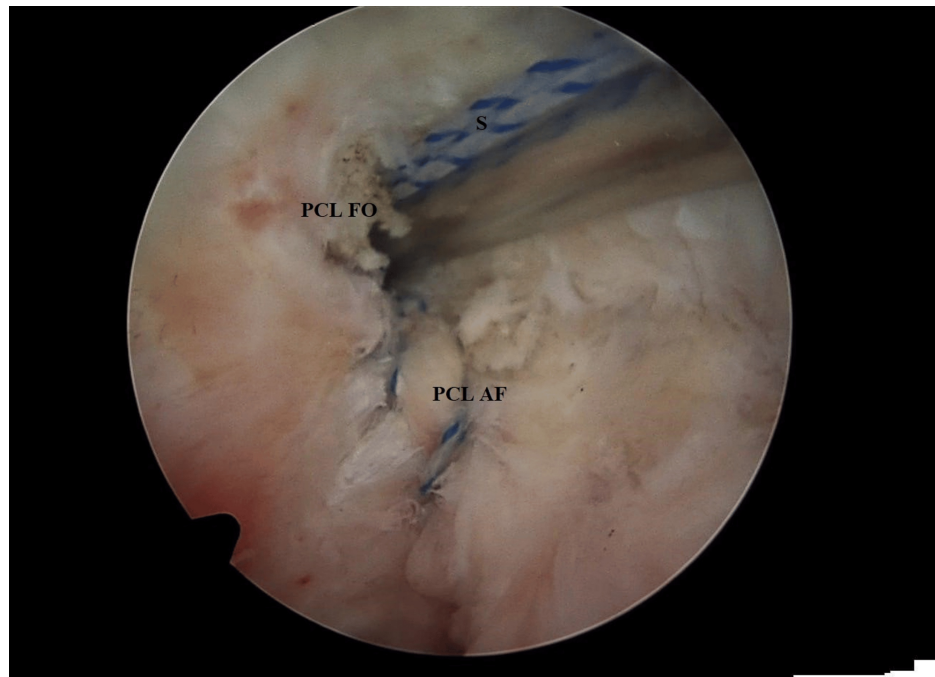


FIGURE 10: Anatomic reduction and suture tensioning.

Tensioning suture (S) limbs to pull the avulsed posterior cruciate ligament (PCL AF) tissue and bone fragment flush against the decorticated femoral bed (PCL FO).

Final Arthroscopic Verification

Final probing confirmed firm anatomic reduction, restoration of native PCL tension, and joint stability throughout passive knee motion (Figure 11).



FIGURE 11: Final arthroscopic verification of stability.

Final arthroscopic probing confirmed firm anatomic reduction (posterior cruciate ligament (PCL) femoral origin (PCL FO)), proper ligament tensioning, and joint stability.

Following fixation, arthroscopic examination demonstrated restoration of the PCL to its native femoral footprint. The previously observed posterior sag was resolved, and the knee demonstrated improved posterior stability on intraoperative examination. The final arthroscopic appearance following repair is shown in Figure 11.

Postoperative course and rehabilitation

Following the procedure, the patient was admitted for postoperative observation and management. The knee was protected in a hinged knee brace with posterior tibial support to minimize posterior tibial translation and protect the repair during the early healing phase. The brace was maintained for six weeks, and the postoperative rehabilitation protocol was initiated with protection of the repaired PCL followed by gradual progression of knee motion and weight-bearing according to the planned rehabilitation program. The patient was kept in a non-weight-bearing status for six weeks. Gradual flexion started after six weeks.

Follow-up

The patient was followed prospectively in the outpatient clinic at predefined intervals. Clinical assessment included evaluating range of motion, stability, and pain. At three months after surgery, the patient demonstrated full range of motion; a stable knee, showing negative posterior drawer, posterior sag, and active quadriceps tests; and pain of about 2 out of 10. The range of motion was 0° to 120°, with a negative posterior drawer grade and a negative quadriceps active test. The patient had not yet returned to his sport at the three-month assessment.

Discussion

This case illustrates an uncommon femoral-sided bony avulsion of the PCL in a skeletally immature adolescent and demonstrates the feasibility of arthroscopic primary repair when the avulsed fragment and attached native ligament remain suitable for fixation. The patient was 16 years old, had open distal femoral and proximal tibial physes, and presented approximately one month after a hyperextension injury sustained during recreational football. Imaging demonstrated a 1 × 1 cm posteriorly displaced femoral fragment with the native PCL remaining attached. Arthroscopic fixation restored the ligament to its anatomical femoral footprint and improved posterior stability. Although a single case cannot establish the superiority of repair over reconstruction or other fixation methods, it provides an example of a tissue-preserving approach to this unusual injury pattern [4-7].

Femoral-sided PCL avulsion differs from the more commonly recognized tibial-sided avulsion and may occur either as a soft-tissue “peel-off” injury or as a true bony avulsion in which the ligament remains attached to

an osseous fragment. This distinction is important because a viable fragment and intact native ligament may permit anatomical fixation rather than reconstruction [1,2,6]. Pediatric PCL injuries themselves are uncommon. In a systematic review of surgically treated pediatric PCL injuries, femoral avulsions accounted for 21% of cases, while tibial avulsions and midsubstance injuries were more frequently reported [8]. A subsequent systematic review identified only 26 studies of pediatric PCL avulsion fractures, emphasizing the limited evidence base [9]. Femoral-sided injuries have been described only in a small number of pediatric reports, including the two cases reported by Chipman et al. [4]. The current case therefore adds to the limited literature on this specific injury pattern.

The mechanism in our patient was a hyperextension injury during recreational football, without a reported direct posterior force to the tibia. Hyperextension has been described as a mechanism of PCL injury and may be particularly relevant to femoral-sided avulsion in younger patients [1,4,8]. The absence of associated ACL, collateral ligament, meniscal, or chondral injury suggests that the force predominantly affected the PCL. Clinically, the patient demonstrated posterior sag, a positive posterior drawer, and a positive quadriceps active test, while the collateral ligaments and rotational stability were preserved. These findings were consistent with significant isolated PCL insufficiency. The delayed presentation of approximately one month is noteworthy because PCL injuries may initially be overlooked when symptoms are nonspecific, or the acute examination is limited by pain and swelling [10,11].

Imaging was essential for defining the injury and determining its reparability. Initial radiographs raised suspicion for an osseous fragment at the femoral PCL attachment. CT subsequently demonstrated the 1 × 1 cm posteriorly displaced fragment and confirmed open distal femoral and proximal tibial physes. CT is particularly useful for defining the size, displacement, and morphology of an avulsed bony fragment, whereas MRI provides assessment of the ligament and associated intra-articular structures [11,12]. In this patient, MRI confirmed that the PCL remained attached to the fragment and demonstrated intact menisci, articular cartilage, ACL, and collateral ligaments. These findings provided the anatomical basis for considering preservation of the native PCL rather than reconstruction.

Skeletal maturity was an additional consideration in treatment selection. Reconstruction of the PCL in a skeletally immature patient may require femoral and tibial tunnels, although physal-sparing techniques have been described [8]. Arthroscopic repair of proximal PCL injuries has therefore been proposed as an option when the native ligament remains suitable for fixation, with potential advantages including preservation of native tissue and avoidance of graft harvesting [5]. In the present case, however, the open physes alone did not determine the treatment. The decision to repair was based on the combination of preserved PCL attachment, a discrete 1 × 1 cm fragment, adequate fragment quality, anatomical femoral location, and clinically significant instability. This distinction is important because repair should be considered according to the characteristics of the injury rather than skeletal immaturity alone.

Treatment should be individualized according to fragment displacement, ligament integrity, tissue quality, skeletal maturity, and the degree of knee instability. Conservative management may be appropriate for selected minimally displaced injuries without significant instability, whereas primary repair may be considered when the native ligament and avulsed fragment remain suitable for fixation. Reconstruction may be necessary when primary repair is not feasible, including cases with irreparable tissue or chronic injuries in which anatomical repair cannot be achieved.

Arthroscopic techniques have expanded the options for fixation of proximal PCL injuries. Suture-anchor and transosseous methods have both been described, allowing restoration of the native ligament to its femoral attachment [2,3,6,7]. In our patient, two double-luggage-tag sutures and a 4.5-mm self-punching PEEK-Ti knotless anchor were used to secure the fragment and attach the PCL to the anatomical femoral footprint. This provided direct fixation without a conventional femoral reconstruction tunnel, which was particularly relevant in the presence of an open distal femoral physis. Nevertheless, the present case cannot determine whether this construct offers advantages over other fixation techniques.

The available evidence supports repair in carefully selected PCL injuries but remains limited, particularly in children. A systematic review of PCL repair involving 226 patients reported a 5.6% overall failure rate, but most included studies were low-level evidence, and the authors emphasized the need for higher-quality comparative studies [13]. Pediatric evidence is similarly limited. In the systematic review by Jayne et al., most reported pediatric avulsion injuries improved following treatment, including 11 of 12 arthroscopically treated patients, but the small sample and heterogeneity of techniques prevented meaningful comparison between approaches [9]. Thus, the current case should be viewed as an example of a repairable injury pattern, rather than evidence that repair is preferable to reconstruction in general.

The one-month delay before definitive treatment is another relevant feature. Delayed presentation can potentially compromise primary repair because of displacement, scar formation, loss of fragment mobility, or nonunion. Nevertheless, the fragment in this patient remained suitable for reduction and fixation, and the PCL remained attached to it. The chronic femoral-sided avulsion with nonunion reported by Chipman et al. further illustrates that chronicity does not automatically exclude consideration of repair, although tissue quality and reducibility must be assessed individually [4]. In our patient, anatomical restoration remained

achievable despite the delay.

Postoperatively, the knee was protected in a hinged brace with posterior tibial support for eight weeks, followed by progressive rehabilitation. Because there is no standardized rehabilitation protocol specifically for this uncommon injury and fixation construct, progression should be individualized according to fixation stability, tissue quality, skeletal maturity, and clinical findings. Longer follow-up will be necessary to assess sustained posterior stability, return to sport, and any growth-related complications.

The principal limitations of this report are its single-case design and relatively short follow-up. These limitations prevent conclusions regarding the superiority or long-term durability of arthroscopic repair and do not allow comparison with reconstruction or other fixation techniques. Nevertheless, the case highlights the importance of recognizing femoral-sided PCL avulsion in adolescents with posterior instability following a hyperextension injury. When imaging demonstrates a viable displaced fragment with preservation of the native PCL, arthroscopic anatomical repair may provide an opportunity to restore the native ligament while avoiding conventional reconstruction. Further cases with longer follow-up are needed to determine the durability and broader applicability of this approach.

Conclusions

Femoral-sided bony avulsion of the PCL is an uncommon injury in skeletally immature patients and may be difficult to recognize following sports-related trauma. In adolescents presenting with posterior knee instability after hyperextension injury, careful clinical examination combined with radiographs, CT, and MRI is important for defining the injury pattern and assessing the integrity of the native PCL and avulsed fragment. When the native ligament remains attached to a viable displaced bony fragment and anatomical reduction is achievable, arthroscopic primary repair may provide a means of restoring the native PCL while avoiding conventional ligament reconstruction. In the present case, arthroscopic repair using a suture-anchor construct provided restoration of the femoral PCL attachment and improved posterior stability despite delayed presentation. Although longer follow-up and additional cases are required to determine the durability and broader applicability of this approach, this case highlights primary anatomical repair as a potential treatment option for selected femoral-sided PCL avulsion injuries in skeletally immature patients.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Supervision: Laith Hseinat

Disclosures

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