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Unifragmentary and Isolated Tibial Bony Avulsion Fracture of the Posterior Cruciate Ligament: A Case Report

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Luis David Rosales Lemus [1], Nineth Eugenia Quixtan Castillo [2], Marcos David Castillo Cabrera [1]

1. Medicine and Surgery, Universidad de San Carlos de Guatemala, Guatemala, GTM 2. Traumatology and Orthopedics, Guatemalan Social Security Institute, Accident Hospital, Guatemala, GTM

Corresponding author: Luis David Rosales Lemus, dr.luisrosalesdl@gmail.com

Abstract

A unifragmentary and isolated tibial bony avulsion fracture of the posterior cruciate ligament is an infrequent entity caused by high-energy trauma. Recognition of the injury mechanism and evaluation of the degree of displacement and size of the bone fragment are decisive for guiding therapeutic management.

We present the case of a 29-year-old male patient who sustained a motorcycle accident with direct pretibial impact to the right knee. Physical examination revealed pain, edema, and a positive grade III posterior drawer test. Plain radiographs showed a posterior bony detachment, which was confirmed by 3D tomography, with a displaced bone fragment measuring 1.81 cm × 1.20 cm at the tibial insertion of the posterior cruciate ligament. Given the severe instability and the large size of the fragment, conservative management was ruled out, and open reduction and internal fixation (ORIF) was performed three days after the injury using an inverted-J posteromedial approach with a 4.0-mm cannulated screw. The patient showed restoration of joint stability, a negative posterior drawer test, and adequate functional recovery during follow-up.

This case demonstrates how clinical suspicion based on the trauma mechanism and the quantitative precision of 3D tomography are essential for guiding timely treatment. Open reduction and internal fixation via a posteromedial approach offers effective, rigid, and anatomical fixation for large fragments, potentially preventing chronic sequelae such as nonunion or residual joint instability.

Categories: Sports Medicine, Physical Medicine & Rehabilitation, Orthopedics
Keywords: avulsion fracture, posterior cruciate ligament, posterior drawer test, posterior translation, tibial avulsion

Introduction

The posterior cruciate ligament (PCL) is one of the main intra-articular ligamentous structures of the knee joint. It originates in the posterior intercondylar area of the tibia and extends to the anterior part of the intercondylar surface of the medial femoral condyle [1-3]. It is composed of two bundles, the anterolateral bundle (ALB) and the posteromedial bundle (PMB). The PMB is smaller than the ALB and extends toward the posterior aspect of the tibia [1-3]. The PCL restricts posterior tibial translation relative to the femur and limits hyperextension, external rotation, and varus-valgus movement. The ALB becomes tense with knee flexion, and the PMB becomes tense with extension [1-3].

PCL injuries are rare, accounting for 3% to 20% of all knee ligament injuries [2,4]. Isolated PCL injuries are unusual, as they are frequently associated with meniscal injuries (16.8%) or other ligamentous injuries (19%) [5]. Among isolated PCL injuries, isolated PCL avulsion fractures are even less frequent, with an annual incidence of approximately 2 cases per 100,000 individuals [6]. These PCL avulsion fractures can occur due to a fall on a flexed knee with the foot in plantar flexion. This foot position allows the knee to contact the ground at the tibial tuberosity, displacing the tibia posteriorly, which does not happen with the foot in dorsiflexion, as the patella contacts the ground. Additionally, associated injury mechanisms include hyperflexion, pretibial trauma, and hyperextension [2,4-7].

For the recognition and evaluation of suspected PCL avulsion fractures, it is important during history taking to ascertain whether the patient has sustained any direct trauma to the knee. Some symptoms that may be reported include intense acute knee pain, immediate inability to bear weight, and a sensation of instability [1,6,8]. During physical examination, distal pulses (dorsalis pedis and posterior tibial), capillary refill, and the function of the common peroneal and tibial nerves should be assessed, given the risk of popliteal compromise in high-energy posterior trauma [1]. The posterior drawer test should be performed at 90 degrees of joint flexion. According to the injury to ligamentous components and laxity in the posterior drawer test, the PCL injury is classified as grade I when there is a posterior displacement of less than 5 mm; grade II with posterior displacement between 5 mm and 10 mm; grade III with posterior displacement greater than 10 mm; and grade IV when the displacement is greater than 10 mm and associated injuries are

present [1,2]. Imaging evaluation consists of anteroposterior and lateral radiographs, which are used to assess tibial or femoral bony avulsion. Stress radiographs are used to diagnose PCL injuries; an increase of 8 mm or more in posterior translation is indicative of PCL avulsion or complete rupture. 3D tomography is considered the ideal diagnostic imaging method for determining fragment size, degree of displacement, and preoperative surgical assessment [2,5].

The treatment algorithm is divided into nonsurgical (conservative) and surgical management. Nonsurgical treatment is reserved for acute isolated injuries with posterior drawer grade I or II, rotational laxity less than five degrees, and absence of varus-valgus instability. This consists of joint immobilization for three to four weeks and rehabilitation focused on quadriceps strengthening [2,4,6]. In contrast, surgical treatment is performed for acute injuries with posterior translation >10 mm (grade III), multiligamentous involvement, or fractures with large displaced avulsed fragments, as well as rotational laxity greater than five degrees or the presence of varus-valgus instability. The surgical approach is usually delayed one to two weeks after the injury and can be performed openly or arthroscopically. The open approach is performed through a posteromedial or posterior incision, which allows direct exposure of the avulsion site, facilitating anatomical reduction of the fragment and fixation with screws or anchors [9]. Ligamentous reconstruction may also be performed in cases with comminuted or small fragments [4,5]. Surgical omission in ligament avulsion fractures inevitably leads to chronic joint instability, nonunion, and progressive functional deterioration [6,8]. When stable anatomical fixation is achieved via an open surgical approach, studies report a consolidation rate exceeding 90% [10]. Radiological follow-up at three months confirms bone consolidation in most patients, and no significant differences in repair between the two techniques have been reported.

Although motorcycle collisions are typically associated with multiligamentous injury, few reports document a unifragmentary and isolated tibial PCL avulsion fracture resulting from a direct pretibial impact, with 3D CT quantification of the fragment and fixation with a single cannulated screw through a posteromedial approach. This report aims to contribute to this evidence and to support the use of 3D CT in therapeutic decision-making.

Case Presentation

We present the case of a 29-year-old male patient with no relevant medical history who was involved in a motorcycle accident, presenting with multiple abrasions, pain, and swelling in the right knee, rendering him unable to bear weight or walk. On physical examination, he experienced pain during active and passive extension of the affected knee. The knee remained stable under varus and valgus stress. The anterior drawer test was negative, and there were no signs of distal neurovascular compromise. Posterior tibial sag and a positive grade III posterior drawer test were evident. We performed imaging studies, including right knee X-rays (Figure *1*), which showed an irregular tibial bone fragment separated by avulsion of the posterior cruciate ligament. A computed tomography scan of the knee with 3D reconstruction (Figure *2*) was performed, which confirmed the bone fragment, measuring 1.81 × 1.20 cm, displaced by the avulsion fracture at the PCL insertion.

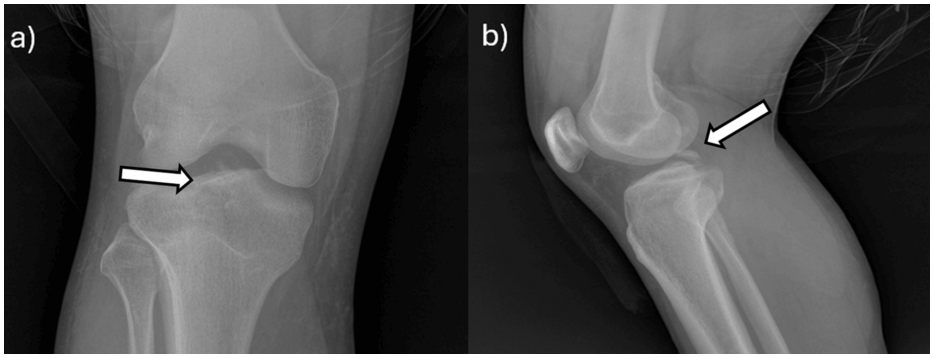


FIGURE 1: Initial plain radiographs of the right knee

(a) Anteroposterior view: subtle cortical discontinuity is observed in the posterior tibial intercondylar region corresponding to the posterior cruciate ligament avulsion site (white arrow). (b) Lateral view: evidence of posterosuperior detachment and displacement of the bone fragment at the tibial insertion site of the posterior cruciate ligament (white arrow).

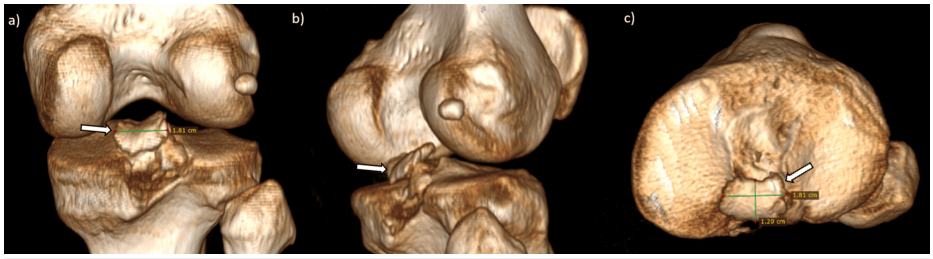


FIGURE 2: Computed tomography scan with three-dimensional reconstruction (3D CT) of the right knee

(a) Posterior coronal view: the avulsed bone fragment in the posterior intercondylar fossa with a transverse diameter of 1.81 cm (white arrow). (b) Sagittal/posteromedial oblique view: the separation and cephalic displacement of the bone fragment relative to the tibia (white arrow). (c) Superior axial view of the tibial plateau: precisely delineates the size of the unifragmentary bone fragment measuring 1.81 × 1.20 cm at the PCL tibial insertion (white arrow).

Based on the severe instability clinically evidenced by the grade III posterior drawer test, the fragment displacement observed on the initial radiographs (Figure *1* b), and the three-dimensional tomographic confirmation of a large bone fragment measuring 1.81 cm × 1.20 cm at the tibial insertion site (Figure *2* a-c), the indication for open reduction and internal fixation (ORIF) was established. This surgical decision was based on established literature criteria, which contraindicate conservative management for avulsions with grade III instability or large displaced bone fragments due to the high risk of nonunion and chronic residual joint instability.

Surgery was performed three days after the injury. ORIF was carried out with the patient in the prone position, using an inverted-J posteromedial approach. Following skin and fascial incision, the internervous and intermuscular plane was developed between the medial belly of the gastrocnemius muscle (retracted laterally to protect the popliteal neurovascular bundle) and the semimembranosus tendon, followed by a vertical capsular arthrotomy to directly expose the avulsion site in the posterior intercondylar fossa. Anatomical reduction of the fragment was performed under direct vision, and the fragment was stabilized with a 4.0-mm cannulated screw oriented perpendicular to the fracture line. Immediate postoperative control radiographs in anteroposterior and lateral views (Figure *3* a,b) confirmed adequate fixation, and the patient was discharged on postoperative day 1. At the two-week follow-up, the suture material was removed, and examination showed adequate wound healing, a negative posterior drawer test, and complete restoration of joint stability, allowing for controlled initiation of the functional rehabilitation protocol. The patient's complete clinical timeline is summarized in Table *1*.

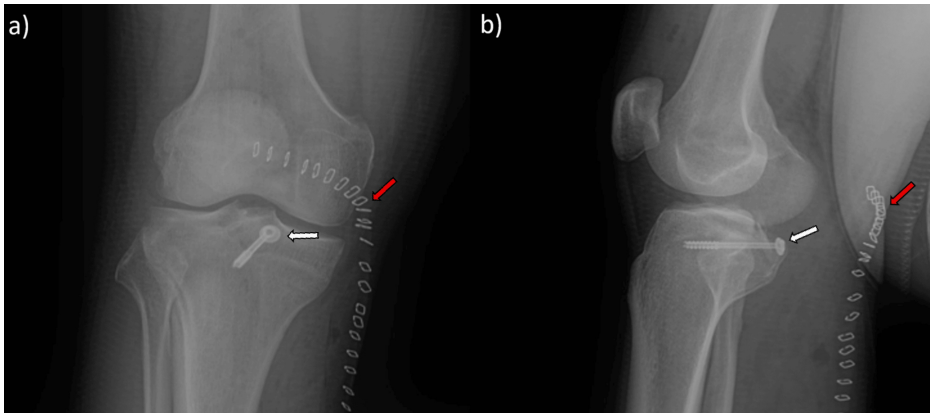


FIGURE 3: Postoperative radiographic control

(a) Anteroposterior view: rigid internal fixation with a 4.0 mm cannulated screw (white arrow). The semicircular arrangement of the surgical skin staples (red arrow) corroborates the extent and proximal curvature of the inverted "J" posteromedial approach. (b) Lateral view: complete anatomical reduction of the bone fragment to the posterior cortex and the perpendicular direction of the cannulated screw towards the anterior cortex (white arrow), as well as the arrangement of the staples delineating the posteromedial surgical path (red arrow).

Time point	Findings/Intervention
Day 0	Motorcycle collision with direct pretibial impact to the right knee; pain, swelling, and inability to bear weight
Presentation	Grade III posterior drawer test; varus-valgus stability preserved; negative anterior drawer test; no distal neurovascular compromise
Imaging	Radiographs: posterior bony detachment; 3D CT: displaced fragment measuring 1.81 × 1.20 cm at the tibial PCL insertion
Day 3	ORIF via inverted-J posteromedial approach with a 4.0 mm cannulated screw; postoperative radiographs confirmed adequate reduction and fixation
Day 4 (postoperative day 1)	Hospital discharge
Two-week follow-up	Suture removal, adequate wound healing, negative posterior drawer test, and restored joint stability

TABLE 1: Clinical timeline of the patient

PCL: posterior cruciate ligament.

Discussion

The PCL is the primary stabilizer against posterior tibial translation, also limiting hyperextension, external rotation, and varus-valgus deformities through its two components: the ALB and the PMB [1-3]. PCL injuries are infrequent, accounting for 3% to 20% of knee ligament injuries [2,4], and rarely present in isolation, commonly being associated with meniscal (16.8%) or other ligamentous (19%) injuries [5]. Within this group, bony avulsion fractures of the PCL represent an even rarer entity, with an estimated annual incidence of 2 cases per 100,000 inhabitants [6].

The classic injury mechanism involves direct impact on the tibial tuberosity with the knee flexed and the foot in plantar flexion, generating a posterior shear force on the tibia. Other mechanisms include hyperflexion, pretibial trauma, and hyperextension [2,4-7]. Although motorcycle accidents are typically associated with high-energy trauma involving complex injury patterns and multiligamentous injuries [2,4,5], the observed direct injury mechanism in this patient reproduced the forces described in the literature as generating maximum shear and tension on the tibial insertion [2,4-7]. Unlike the multiligamentous pattern characteristic of high-energy road traffic trauma [2,4,5], the injury mechanism caused an isolated unifragmentary avulsion without peripheral damage.

The debate between conservative and surgical management is well established in the trauma literature [2,4-6,9]. Conservative management is strictly indicated for grade I or II injuries with posterior translation less than 10 mm and preserved rotational stability [2,4,6]. In contrast, in the presence of displaced avulsions with grade III instability (>10 mm), conservative management carries a high risk of treatment failure, manifested by subjective and objective chronic joint instability, development of nonunion of the avulsed bone fragment, and early joint degeneration [6,8]. In patients with large and viable bone fragments, ORIF is superior to ligamentous reconstruction and closed orthopedic management [4,5], ensuring stable biomechanical fixation [9,10].

The diagnostic and therapeutic approach for this patient was based on the finding of posterior translation greater than 10 mm on the posterior drawer test, which classified the injury as grade III and ruled out conservative management [1,2]. This severity contraindicates conservative management, which is exclusively reserved for grades I or II without significant rotational or varus-valgus laxity [2]. While plain radiographs raised suspicion of bony avulsion, computed tomography with 3D reconstruction proved to be an indispensable diagnostic tool for confirming the dimensions of the fragment (1.81 cm × 1.20 cm) and ruling out joint comminution [2,5].

Clinical guidelines establish that large bony avulsions should be treated with ORIF, unlike intrasubstance tears or small fragments with severe instability that require ligamentous reconstruction [4,5]. Opting for conservative management in these types of injuries would have carried a high risk of nonunion, chronic joint instability, and progressive functional deterioration [6,8]. The choice of a posteromedial approach with an inverted-J incision and a 4.0-mm cannulated screw allowed for safe and direct exposure of the posteromedial angle, reducing the risk of neurovascular injury and facilitating correct fixation [9]. The literature reports anatomical bone consolidation rates exceeding 90% with open fixation techniques [10].

Preoperatively, the patient was unable to bear weight or ambulate and had a grade III posterior drawer test.

At the two-week follow-up, the posterior drawer test was negative, joint stability was restored, wound healing was adequate, and there was no neurovascular compromise, which allowed the functional rehabilitation protocol to begin. These early findings support the benefit of early rigid and anatomical fixation in large grade III PCL avulsion fractures [9,10].

This report has several limitations. First, it describes a single patient, and the findings therefore cannot be generalized. Second, the available follow-up is short (two weeks), so data on long-term bone union, objectively measured range of motion, and validated functional outcome scores are not available. Accordingly, this report focuses on the diagnostic approach and short-term surgical management of this uncommon injury. Future reports and case series should incorporate longer follow-up and validated functional outcome measures.

Conclusions

Unifragmentary and isolated tibial bony avulsion fractures of the posterior cruciate ligament constitute an infrequent clinical entity whose timely identification depends on rigorous clinical suspicion based on recognition of the injury mechanism and detection of instability through the posterior drawer test. Understanding the kinematics of this trauma is crucial for guiding the precise indication for advanced imaging studies, where computed tomography with three-dimensional reconstruction stands out as a fundamental tool for quantifying fragment displacement and size, overcoming the limitations of plain radiography and guiding decisions regarding conservative management in unstable injuries. For large fragments with grade III instability, open reduction and internal fixation via a posteromedial approach with a cannulated screw represents a surgical technique that provides anatomical and biomechanically stable fixation, restores joint congruity, and may prevent disabling sequelae such as nonunion and chronic joint instability, allowing early functional rehabilitation with satisfactory clinical outcomes. Because these observations derive from a single patient with limited follow-up, the recommendations presented here cannot be generalized and require confirmation in larger case series or comparative studies.

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.

Concept and design: Luis David Rosales Lemus, Nineth Eugenia Quixtan Castillo

Acquisition, analysis, or interpretation of data: Luis David Rosales Lemus, Marcos David Castillo Cabrera, Nineth Eugenia Quixtan Castillo

Drafting of the manuscript: Luis David Rosales Lemus, Marcos David Castillo Cabrera, Nineth Eugenia Quixtan Castillo

Critical review of the manuscript for important intellectual content: Luis David Rosales Lemus, Marcos David Castillo Cabrera, Nineth Eugenia Quixtan Castillo

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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