Posterior Cruciate Ligament Tibial Avulsion Fracture Following Low-Energy Trauma: A Case Report and Imaging Review

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AUTHOR CONTRIBUTIONS
Mulia Rahmansyah contributed to the conception and design of the study, radiological interpretation, case analysis, and critical revision of the manuscript.
Muhammad Iqbal Zarkashi was involved in data acquisition, clinical data collection, and drafting of the initial manuscript.
Pramesti Indri Miranti contributed to imaging analysis, interpretation of CT and MRI findings, and manuscript revision.
Karina Shasri Anastasy contributed to literature review, data organization, and editing of the manuscript.
Deasyka Yastani contributed to the conceptual framework, scientific writing, critical appraisal of the discussion, and final approval of the manuscript.
All authors read and approved the final manuscript.

CONSENT AND ETHICAL STATEMENT
Written informed consent was obtained from the patient. This study complied with ethical standards and the Helsinki Declaration.

CONFLICT OF INTEREST / DISCLOSURE
No conflict of interest

ABSTRACT

PCL avulsion fracture is a specific form of PCL injury. This fracture directly causes instability of the knee joint backwards, which will lead to increased pressure on the articular cartilage and eventually degenerative changes in the joint. Mr. D, 38 years old, came to the emergency room with complaints of falling and slipping. The patient fell in a semi-sitting position with the right knee bent inwards. After falling, the patient was unable to stand up and felt pain in the back of the knee. On physical examination were found edema, tenderness, posterior tibial sag, and posterior drawer test (+), with limited range of motion extension of the dextra genu joint. On radiological examination of the AP lateral genu dextra and CT scan of the right knee, an avulsion fracture was found in the intercondyloid posterior aspect of the tibia dextra. On MRI of the genu dextra, there was an avulsion fracture in the intercondyloid posterior aspect of the tibia dextra with PCL retraction. Based on the history and examination, the patient was diagnosed with Avulsion Fracture with Posterior Cruciate Ligament Injury. CT Scan and MRI are efficient examinations that can help establish the diagnosis of PCL.

CASE REPORT

BACKGROUND

Posterior cruciate ligament (PCL) tibial avulsion fracture is an uncommon injury, particularly in adults, and is most frequently associated with high-energy trauma such as motor vehicle accidents [1-3]. Low-energy mechanisms leading to PCL avulsion fractures are rarely reported and may pose a diagnostic challenge due to subtle clinical and radiographic findings [2,3]. Delayed or missed diagnosis can result in chronic posterior knee instability, accelerated articular cartilage degeneration, and long-term functional impairment [4,5].

This case highlights a rare presentation of PCL tibial avulsion fracture following low-energy trauma and emphasizes the crucial role of multi-modality imaging in establishing an accurate diagnosis [2]. The combined use of plain radiography, computed tomography, and magnetic resonance imaging

allowed precise characterization of the fracture morphology, associated ligamentous injury, and concomitant intra-articular findings. By documenting this atypical mechanism of injury and its imaging features, this report contributes to the existing literature by expanding the clinical spectrum of PCL avulsion fractures and reinforcing the importance of advanced imaging in patients with persistent posterior knee pain despite low-energy trauma.

Introduction

Fracture is a discontinuity of the bone, articular cartilage, or epiphyseal cartilage, either complete or incomplete [1]. Avulsion fracture disrupts the function and movement of the affected joint [2]. Avulsion fractures in adolescents are most often associated with sport injuries, while in adults, avulsion fractures are more commonly associated with traumatic injuries. The exact prevalence is difficult to determine because most of the literature on avulsion fracture consists of case reports [3].

The Posterior Cruciate Ligament (PCL) is one of the four main ligaments of the knee joint. It is the strongest ligament in the knee and serves a primary role in maintaining the joint stability [4,5]. The most common mechanism of PCL injury is a posteriorly directed force applied to the anterior aspect of the proximal tibia, or knee hyperflexion with the foot in plantar flexion [6,7]. The reported incidence of PCL injuries ranges from 3% to 38% of knee injuries, with recent reports showing an increase in incidence over the years. Several studies have reported that this injury is more common in countries such as India and China, where motorcycle accidents are more frequent, with a prevalence of 35% [8].

PCL avulsion fracture is a specific form of PCL injury. It directly causes posterior knee joint instability, increases articular cartilage stress, and eventually results in degenerative changes in the joint [9]. MRI is an efficient, non-invasive, and reliable modality for diagnosing PCL avulsion fractures and assessing knee morphology [10].

CASE PRESENTATION

A 38-year-old male was brought to the Emergency Department of Hermina Daan Mogot Hospital with complaints of inability to stand and pain in the posterior aspect of the right knee after sustaining a slip-and-fall incident approximately 30 minutes prior to admission. The patient fell in a semi-seated position with the right knee flexed inward. No wounds, lacerations, or bleeding were observed around the knee. On physical examination, edema and tenderness of the right knee were noted, with limited range of motion (ROM) in extension. Both the posterior tibial sag and posterior drawer tests were positive on the right knee. Radiological examinations of the right knee, including anteroposterior (AP) and lateral X-rays, as well as a computed tomography (CT) scan, revealed an avulsion fracture involving the posteromedial articular surface of the right tibia. Magnetic resonance imaging (MRI) of the right knee demonstrated an avulsion fracture of the posteromedial articular surface of the tibia with bone marrow edema. Retraction and tearing of the PCL, medial meniscus (MM) injury, and joint effusion were also observed. Based on the history and physical examination, the patient was diagnosed with PCL avulsion fracture.

DISCUSSION

Avulsion fractures often occur following a history of trauma caused by sudden movements of the extremities [2]. In this case, the patient fell in a semi-sitting position with hyperflexion of the right knee joint. Following the fall, he experienced pain in the posterior aspect of the knee and was unable to stand [11].

On physical examination, no wounds, lacerations, or bleeding were observed on the knee, indicating the absence of open fracture in the knee area. Edema and tenderness were noted on the right knee, with limited range of motion in extension. Both posterior tibial sag and posterior drawer tests were positive. These findings indicated the need for radiographic imaging to confirm the diagnosis. Radiological examination of the right knee, including AP and lateral radiographs as well as CT scan, revealed an avulsion fracture of the posteromedial articular surface of the proximal right tibia [2,12].

The general radiographic features of acute avulsion fracture often involve small bone fragments with irregular, non-sclerotic edges that are neither thickened nor sharp, with fragments located near the sites of soft tissue attachment [13]. Radiographic findings such as soft tissue swelling, loss of tissue planes, joint asymmetry, widening of the joint space, or effusion may increase suspicion for injury or avulsion fractures [14].

PCL is one of the four main ligaments of the knee joint and is the strongest ligament in the knee, and serves a primary role in stabilizing the knee joint [15]. The most common mechanisms of PCL injuries are hyperflexion or hyperextension of the knee joint, or rotational injury combined with varus or valgus stress [14]. According to Wang et al., PCL injuries often occur in conjunction with multi-ligament injuries and are frequently accompanied by avulsion fractures of the surrounding bony structures [16]. According to Grazziano et al., PCL injuries are not always accompanied by pain, however, patients often complain of discomfort following trauma caused by either hyperflexion or hyperextension movements. This is because PCL injuries may also involve damage to surrounding tissues. Therefore, in addition to patient history and physical examination at the injury site, radiological evaluation plays a significant role in diagnosing PCL that may involve other tissue damage [16].

PCL tears are uncommon injuries, and avulsion fractures of the PCL represent a very rare variant [8,9,19]. The incidence of PCL injuries varies from 3% to 38% of acute knee injuries [18,20]. According to Schulz et al., the two most common

causes of PCL injury are motor vehicle accidents (45%) and athletic injuries (40%) [21]. Among these, motorcycle accidents (28%) and football-related injuries (25%) are the leading specific causes[8,22]. The most frequent injury mechanism is the dashboard injury (35%), which occurs when a posteriorly directed force is applied to the proximal tibia while the knee is flexed. This mechanism is frequently reported in China, India, and many countries with widespread motor vehicle use [8,21,23].

Avulsion fractures of PCL are a type of knee avulsion fracture representing the most common PCL lesion[8]. This fracture causes posterior instability of the knee joint, leading to increased pressure on the articular cartilage and resulting in degenerative changes in the joint [9]. Fan et al., in their study, defined PCL rupture as an injury occurring within the ligament, whereas avulsion fractures occur in the bony tissue, which is the ligament's insertion on the tibia. The posterior tibial slope plays a crucial role in the occurrence of both conditions. When retrograde force is applied to the proximal tibia, PCL rupture is more likely to occur with a smaller posterior tibial slope. On the other hand, PCL avulsion fractures are more prone to occur when the posterior tibial slope is bigger [10]. There are several types of PCL avulsion fractures: Type I: non-displaced; Type II: upward displacement of the posterior aspect of the avulsed tibial bone fragment; Type III: totally displaced avulsed bone fragment [17].

PCL avulsion fractures appear radiographically as a focal discontinuity of the posterior aspect of the tibia. CT with 3D reconstruction can provide additional information regarding the size and comminution of the fracture fragments [8]. According to Mui et al., in a comparison of CT and MRI findings, CT demonstrated ligament tears with a sensitivity of 80% and specificity of 98% [9]. To date, MRI remains an efficient and reliable non-invasive modality for diagnosing PCL avulsion fractures and assessing knee morphology [10].

CONCLUSION

Avulsion fractures as a PCL injury cause posterior instability of the knee joint, leading to increased pressure on the articular cartilage and eventually resulting in degenerative changes within the joint. Patient history, physical examination, and radiographic assessment are required for the diagnosis. PCL avulsion fractures appear radiographically as a focal discontinuity on the posterior aspect of the tibia. MRI is the gold standard for evaluating PCL, with reported accuracy ranging from 96% to 100%. Acute PCL injury can be identified on sagittal T1- and T2-weighted MRI images by increased signal within the ligament or disruption of its fiber continuity. MRI represents an efficient and reliable non-invasive modality for diagnosing PCL avulsion fractures and assessing overall knee morphology.

TEACHING POINT

Posterior cruciate ligament (PCL) tibial avulsion fracture can occur even after low-energy trauma and may be overlooked on initial radiographs. Multimodality imaging—particularly CT for fracture characterization and MRI for ligamentous and associated soft-tissue injuries—is essential for accurate diagnosis and prevention of chronic posterior knee instability.

QUESTIONS

Question 1: What imaging modality is most sensitive for detecting associated soft-tissue injuries in PCL avulsion fractures?

Answer: Magnetic resonance imaging (MRI), due to its superior soft-tissue contrast and ability to evaluate ligamentous, meniscal, and intra-articular structures.

Question 2: What is the typical radiographic appearance of a PCL tibial avulsion fracture?

Answer: A focal osseous fragment or cortical discontinuity at the posterior aspect of the proximal tibia at the PCL tibial insertion.

Question 3: Why is early diagnosis of a PCL avulsion fracture important?

Answer: To prevent chronic posterior knee instability, increased articular cartilage loading, and subsequent early degenerative joint changes.

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FIGURES

Figure 1: AP and lateral plain radiographs of the right knee show an avulsion fracture of the posteromedial articular surface of the proximal right tibia.

Figure 2: CT scan of the right knee showing an avulsion fracture on the posteromedial articular surface of the proximal right tibia

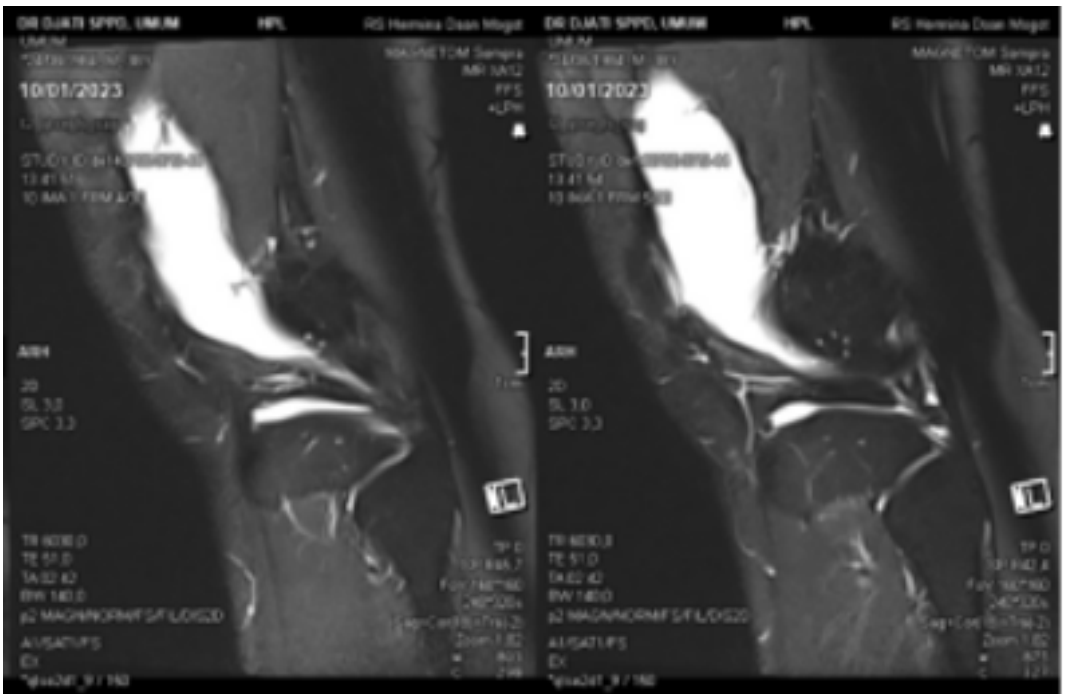

Figure 3: Sagittal MRI of the right knee showing a moderate fluid collection with hyperintense signal intensity at the posterior quadriceps tendon.

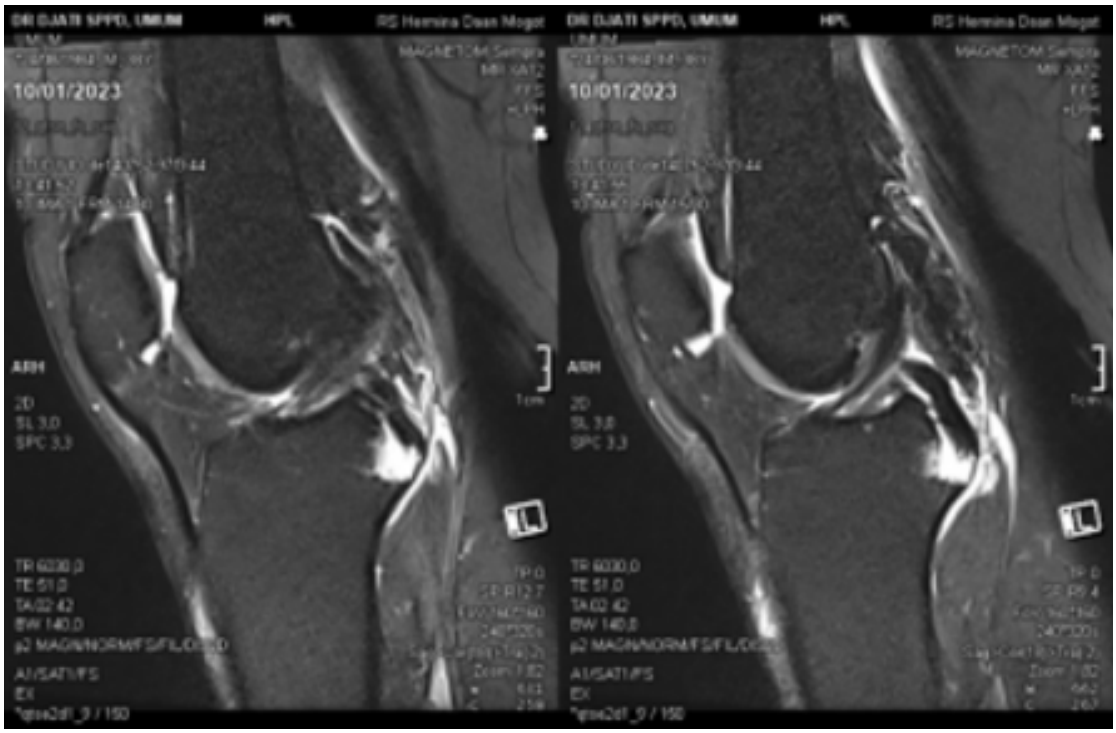

Figure 4: Sagittal MRI of the right knee showing bone marrow edema with tear and retraction of the PCL.

KEYWORDS

Magnetic Resonance Imaging (MRI), Medial Meniscus Injury, Joint Effusion, Posterior Cruciate Ligament Avulsion Fracture

ABBREVIATIONS

PCL = Posterior Cruciate Ligament
AP = Antero Posterior
CT = Computed Tomography
MRI = Magnetic Resonance Imaging
MM = Medial Meniscus
ROM = Range Of Motion