Marginal fractures of the medial tibial plateau have been reported in the literature as a secondary type of Segond fracture. Some reports described this entity in the setting of combined injuries such as root avulsions of the medial meniscus, complete disruption of the posterior cruciate ligament (PCL), partial tear of the anterior cruciate ligament (ACL), and tears of the medial meniscus and medial collateral ligament. It has been postulated that medial marginal fractures are secondary to compression of the medial aspect of the femoral condyle and tibial plateau with a corresponding posterolateral corner injury. However, this mechanism of injury may not always be as straightforward.

This article presents a case of an alternate injury pattern in a skeletally immature patient. A 16-year-old boy sustained a varus force and twisting injury to his knee, resulting in radiographic evidence of multiple avulsion fractures of the knee, including a fibular epiphysial avulsion fracture and medial and lateral Segond fractures. Usually, the avulsion fractures serve as markers for significant ligamentous injuries in adult patients, but our patient had minimal injury to the PCL, ACL, and posterolateral corner. Further physical examination and imaging studies revealed an anterior horn root avulsion, meniscocapsular separation, and anterior cortical rim fracture. A combination of imaging modalities helped us further characterize the injury pattern to devise the optimal surgical plan, especially the fixation of the anterior cortical fracture of the tibia.
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**CASE REPORT**

A 16-year-old boy sustained a right knee injury during a soccer game. He described a mechanism of injury consistent with a varus force and twisting injury to his knee. The patient reported immediate swelling of his knee with difficulty ambulating. On examination, he demonstrated a large effusion with significant guarding and hamstring spasm, making examination maneuvers challenging. Plain radiographs demonstrated a marginal fracture of the anteromedial tibial plateau within the epiphysis and an avulsion fracture of the fibular epiphysis at the knee (Figure 1). Computed tomography (CT) scan demonstrated a Segond fracture as well as the aforementioned injury pattern (Figure 2). Magnetic resonance imaging (MRI) demonstrated anterior displacement of the anterior horn of the medial meniscus, a lateral collateral ligament tear at the fibular insertion, a tear of the lateral capsular insertion from the tibial plateau (Segond component), and a contusion of the medial femoral condyle (Figure 3).

Due to the size of the anteromedial fracture and the presence of intra-articular pathology, the patient was taken to the operating room for diagnostic arthroscopy, fracture fixation, and examination under anesthesia, which demonstrated stable Lachman, posterior drawer, and external rotation dial tests. There was slight varus laxity at 30° (grade II). Arthroscopy revealed a fracture gap within the tibial plateau of the medial compartment that was beneath a displaced anterior meniscal horn, which demonstrated avulsion at the root and meniscocapsular junction (Figure 4). Based on a previously published anatomic study, the insertion pattern represented a type I anteromedial meniscus insertion (insertion into the condylar region of the plateau); however, it was not as clear due to the meniscal fraying and the underlying fracture. Under fluoroscopic guidance to maintain physis integrity, a 4.5-mm cannulated screw was placed percutaneously to transfix the fracture after anatomic reduction was achieved under arthroscopic and radiographic C-arm evaluation. The screw was placed in an all-epiphyseal fashion. Following the screw fixation of fracture, the anterior medial meniscus insertion was repaired using a knotless anchor (PushLock; Arthrex, Inc, Naples, Florida) with an all-inside technique. Two strands of Ethibond polyester suture (Ethicon, Somerville, New Jersey) were used to grasp the meniscus, and the strands were engaged into the PushLock anchor. The lateral compartment demonstrated a hemorrhagic posterior capsule with mild stretch injury; however, the popliteus was probed and found to be stable. Due to the stability of the posterolateral corner and grade II lateral ligament assessment, this injury was treated conservatively. Once the meniscus was reduced and the fracture fixed, the patient was placed in a hinged knee brace and monitored postoperatively for fracture healing.

Once fracture healing was achieved, the patient was taken through a meniscal repair postoperative rehabilitation protocol. At final 2-year follow-up, the patient returned to full sports activity with no instability and reported normal activities of daily living (Figure 5).

**Figure 1:** Lateral radiograph showing a marginal fracture of the anterior aspect of the proximal tibia and a small avulsion fracture at the fibular epiphysis (the Arcuate sign). **Figure 2:** Axial CT scan demonstrating a marginal fracture of the proximal anterior and lateral aspect (the Segond fracture) of the tibia (A). Sagittal CT scan revealing an anterior lip fracture of the epiphysis of the proximal tibia (B). 3-D CT scan demonstrating the same lesions (C).
Several types of medial knee avulsion fractures have been reported in the literature, and they are usually associated with root avulsions of the medial meniscus, complete disruption of the PCL, partial tears of the ACL, and tears of the medial meniscus and MCL.\(^2,9\) The mechanism of these injuries typically starts with a severe varus force to a flexed knee, resulting in forced external rotation of the tibia on the femur. Patients demonstrate the medial fracture pattern with a contrecoup disruption of the posterolateral ligament complex. In our patient, the posterolateral complex was minimally compromised, resulting in a more isolated injury to the fibular physis and lateral collateral ligament insertion alone.

Few reports exist regarding small avulsion fractures about the knee joint. These include the Segond fracture, cortical avulsion fractures of the medial tibial plateau by the deep capsular ligament (medial Segond fracture or reverse Segond fracture), and fractures of the posterior margin of the lateral tibial plateau or medial tibial plateau.\(^2,4,7,8\) Cohen et al\(^2\) previously described an impingement fracture of the anteromedial margin alone combined with PCL and posterolateral ligamentous injuries. The current case is unique in that multiple avulsion fractures were demonstrated about the knee within the same injury (Segond fracture, medial Segond fracture, and fibular epiphyseal avulsion fracture). The case was further confounded by the presence of an anterior horn root avulsion and meniscocapsular separation, which implies a slightly different mechanism of injury. While varus and external rotation forces were absorbed by the joint, the knee may have also been hyperextended, resulting in an anterior cortical rim fracture and an associated meniscocapsular separation. Magnetic resonance imaging and arthroscopic evaluation were critical in helping to further define the injury pattern and need for surgical intervention. In most cases, bony avulsion fractures such as the Segond fracture do not need to be addressed because they are markers of other more significant soft tissue injury, such as ACL rupture. However, in the current case, the anteromedial rim fracture was compromising anteromedial knee stability and meniscal function, so reduction and fixation were felt to be necessary.

While medial Segond fractures and classic Segond fractures typically represent severe ligamentous injury in the adult, these fracture patterns in our patient resulted in relative preservation of the PCL, ACL, and posterolateral corner structures (absent the lateral collateral ligament).\(^2,12\) We postulated that our patient was able to absorb greater injury due to the open physes present and that some component of physeal injury may have occurred. Few reports regarding avulsion fractures of the knee have been described, and even less have been found in the adolescent and pediatric population. This case represents an unusual injury pattern in that multiple avulsion fractures were visible in a patient with no significant ligamentous injury. Although CT scan may not be necessary in the majority of cases, CT with 3-D reconstruction is helpful for preoperative planning for the patient described in this report, where adequate understanding of fracture anatomy was essential. In the acute setting, where significant knee swelling keeps examiners from obtaining a quality knee examination, MRI is essential to evaluate for intra-articular injuries and ligamentous pathology.

![Figure 3: Coronal T2-weighted fast spin-echo image indicating a tear at the fibular insertion of the lateral collateral ligament and biceps femoris tendon with an associated tear of the lateral capsular ligament and contusion of the medial tibial condyle.](image)

![Figure 4: Lateral arthroscopic view of the right knee looking into the medial compartment showing the anterior aspect of the proximal tibia and displaced anterior horn of the medial meniscus.](image)

![Figure 5: Lateral radiograph of the right knee at 2-year follow-up.](image)