The Arcuate Sign: A Marker of Potential Knee Dislocation? A Report of Two Cases

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The arcuate sign is a well described finding of fibular head avulsion at the insertion site of the arcuate complex. It has been associated with posterolateral corner knee injury and resulting instability. The authors report two patients presenting with the arcuate sign following knee dislocation, which has not been previously described. As unrecognized spontaneously reduced knee dislocation often results in significant morbidity, the authors propose that the arcuate sign should raise clinical suspicion of this injury mechanism.

Introduction

We describe two patients who incurred severe knee trauma with well documented dislocation. Each presented to an outside hospital where the knee was relocated prior to transfer to our institution. Upon arrival, conventional anteroposterior (AP) and lateral knee radiographs were obtained. Both patients also had magnetic resonance (MR) imaging of the knee, one at 1.5 Tesla field strength and the other at 3 Tesla. MR was performed within two days of the initial traumatic event.

Case 1

A 20-year-old man had a posterior right knee dislocation following trauma incurred while riding a motorcycle. At presentation, he had non-palpable popliteal, dorsalis pedis, and posterior tibial artery pulses in the right leg, as well as corresponding absent arterial Doppler signals. He was also insensate below the knee with minimal intrinsic motor function in the foot. Given suspected popliteal artery injury and need for emergent revascularization, a right above knee popliteal artery to below knee popliteal artery bypass was performed with a left greater saphenous vein graft. A four compartment decompressive fasciotomy was also done.

Right knee radiographs obtained at the time of transfer showed a minimally displaced avulsion fracture of the fibular head (Figure 1). MR imaging was performed two days later, re-demonstrating the fibular head avulsion fracture with edema in the fibular head at the insertion site of the arcuate ligament complex (Figure 2). The biceps femoris tendon, fibular collateral ligament, and iliobibial band were intact. In addition, tears of the popliteus tendon, anterior cruciate ligament,
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Case 1

A 20-year-old man with posterior right knee dislocation following trauma incurred while riding a motorcycle. Post-reduction AP radiograph of the right knee shows a minimally displaced avulsion fracture of the fibular head. Other osseous findings included a large contusion in the anterior proximal tibia with a non-displaced tibial spine fracture. Contusions were also present in the medial and lateral femoral condyles. The patient was discharged home 12 days after admission. No subsequent surgical knee repair has been reported at our institution.

Case 2

A 28-year-old man suffered an anterior left knee dislocation after twisting his knee while chasing his dog down a flight of stairs. At presentation, he complained of tingling and numbness in the left lower extremity with difficulty dorsiflexing the foot, although he had strong palpable pulses. Radiographs demonstrated an avulsion fracture of the fibular head, with proximal retraction of the fracture fragment (Figure 3). Additional osseous fragments were noted in the intercondylar region. MR imaging performed the next day again showed the fibular head avulsion fracture with retraction of the biceps femoris tendon and fibular collateral ligament (Figure 4). Popliteus musculotendinous strain was also present, as were tears of the anterior and posterior cruciate ligaments. Other osseous injuries included an impact fracture of the anterior medial femoral condyle and contusions in the medial tibial plateau. The patient was later discharged, with no subsequent surgical knee repair reported at our institution.

Discussion

Avulsion fracture of the fibular head, referred to as the arcuate sign, indicates an injury to at least one of the posterolateral corner structures of the knee [1,2,3]. These ligamentous and tendinous structures have been variably termed the arcuate complex. Inserting from medial to lateral on the fibular head, they include the popliteofibular ligament (also known as the fibular insertion of the popliteus muscle), the arcuate ligament, and the conjoined tendon formed by the biceps femoris muscle tendon and fibular collateral ligament. The variably present fabellofibular ligament, posterolateral joint capsule, lateral gastrocnemius muscle, and popliteus muscle are also considered part of the complex [2,4].

The popliteofibular ligament and arcuate ligament attach directly to the posterior aspect of the styloid process of the fibula, while the conjoined tendon insertion on the lateral aspect of the fibular head is more lateral, anterior, and inferior [2]. The appearance of the arcuate sign can differ with respect to the specific site of injury. Lee, et al. reported that in patients with suspected injury to the popliteofibular ligament and arcuate ligament, the fracture fragment was small, ranging from 1 to 8 mm, and was displaced just medial and superior to the styloid process (see patient 1). On the other hand, in patients with injury to the fibular collateral ligament and biceps femoris muscle tendon, the fracture fragment was larger (1.5-2.5 cm), arose from the lateral aspect of the fibular head, and was more often displaced centrally for a greater distance (2-4 cm) from the fibular head (see patient 2) [2].

The mechanism of injury is often the result of either direct varus force with the tibia in external rotation.
or sudden hyperextension of the knee with the tibia internally rotated [2]. Usually, posterolateral corner injuries are associated with other structural abnormalities including cruciate ligament tears. Juhng, et al. reported a series of 18 cases in which 89% had a cruciate ligament injury, with 50% injuring both cruciate ligaments, 22% injuring only the anterior cruciate ligament, and 17% injuring only the posterior cruciate ligament [5]. In contrast, Huang et al. reported 13 patients, all of whom had posterior cruciate ligament tears with intact anterior cruciate ligaments [6]. Other findings include tears of the medial collateral ligament, medial or lateral meniscus, and iliotibial band, as well as osseous contusions and fractures [5,6]. Isolated injuries to the posterolateral corner are uncommon, frequently associated with a history of minor trauma, chronic posterolateral knee pain, and occasionally a sensation of knee instability in extension. Physical examination findings may also be minor and inconclusive, with posterolateral corner injury going unrecognized [2]. Chronic instability results and reconstructive surgery may be difficult [3,7]. Early recognition of this injury is therefore essential.

Figure 2. MR imaging of the right knee in Case 1, obtained 2 days following the traumatic event. A, Coronal fast spin-echo T2-weighted image and B, sagittal fast spin-echo T2-weighted image, demonstrate the minimally displaced fibular head avulsion fracture (arrows) with associated edema at the insertion site of the arcuate ligament complex. C, Coronal fast spin-echo T2-weighted image shows edema at the site of the popliteus tendon tear (asterisk), as well as an intact fibular collateral ligament (arrowheads). D, Sagittal fast spin-echo T2-weighted image shows a tear of the anterior cruciate ligament at its tibial attachment (open arrowhead). A torn posterior cruciate ligament is also partially seen (open arrow).
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While the arcuate sign is well described in the literature, it has not been reported in association with knee dislocation to our knowledge. In fact, Juhng et al. wrote that none of their patients with an arcuate sign sustained a complete knee dislocation [5] and the study of Lee et al. did not include patients with a history of knee dislocation and associated injury to the posterolateral corner [2]. Given the two cases reported here, we propose that the arcuate sign be considered not only as a marker of internal knee derangement, but also of potential knee dislocation.

Knee dislocation usually results from high energy trauma, such as automobile and motorcycle collisions, industrial and sports related injuries, and falls from heights [8-11]. Knee dislocations are described according to the position of the tibia relative to the femur and are classified as anterior, posterior, medial, lateral, or rotatory [8,12]. Using this terminology, anterior dislocation has been the most prevalent type in previous series [8,9,13]. Dislocation invariably leads to extensive ligamentous injury, with the anterior cruciate ligament being consistently torn [8,10]. The posterior cruciate ligament is typically disrupted, although it may be spared in cases of anterior or anteromedial dislocation when the anterior cruciate ligament and one of the collateral ligaments are completely torn [11]. In addition to the cruciate and collateral ligaments, other potentially injured structures include the biceps femoris tendon, menisci, popliteus tendon, peroneal nerve, and most importantly the popliteal artery [11,12]. Popliteal artery injury is highly associated with knee dislocation, having an estimated incidence of 35% to 45% [12,13]. In Green and Allen's series of knee dislocations, 19 limbs with vascular compromise were not surgically explored. Of these, 17 were amputated and the other two survived with severe ischemic changes [13]. Recognition of popliteal artery injury is therefore of paramount importance, in order to salvage the limb by emergent revascularization [12,13].

Traumatic knee dislocation is considered to be relatively uncommon, though some believe it often goes unrecognized due to spontaneous reduction [8,14]. An examining physician may not consider the history of dislocation when faced with a normally articulated knee, despite extensive ligamentous injury and joint effusion [12]. Given the wide range of symptoms and signs resulting from vascular and neurologic trauma, these injuries may go unappreciated leading to significant morbidity.

Although previous studies of knee dislocation have reported injuries to posterolateral corner structures [11,14], the arcuate sign has not been specifically described in conjunction with this injury mechanism. As knee dislocation can go unrecognized due to spontaneous reduction, we propose that recognition of the arcuate sign may allow the radiologist to suggest the possibilities of knee dislocation and associated soft tissue and vascular injuries.
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Figure 4. MR imaging of the left knee in Case 2, obtained 1 day post-trauma. A, Coronal fast spin-echo T2-weighted image and B, sagittal fast spin-echo T2-weighted image show the displaced fibular head avulsion fracture (arrows) attached to the proximally retracted biceps femoris tendon and fibular collateral ligament (arrowheads). Edema in the popliteus muscle is compatible with muscle strain (asterisk in A). C and D, Sagittal fast spin-echo T2-weighted images demonstrate an anterior cruciate ligament tear, with no intact fibers visualized in the intercondylar notch (open arrowheads in C). The posterior cruciate ligament is also attenuated and torn (open arrow in D).

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