Dislocation of the Knee: Imaging Findings

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Abstract

Dislocations of the knee are relatively uncommon injuries. However, the incidence of this injury appears to be increasing.[1,2] Knee dislocations are most often high velocity blunt injuries, with motor vehicle accidents being a frequent etiology. Other causes include falls from height, athletic injuries, farming and industrial accidents, and even low velocity mechanisms such as a misstep into a hole.[2] Likewise, minor trauma in the morbidly obese is increasingly recognized as a mechanism of knee dislocation.

Multiple forms of dislocation exist, with the common factor being disruption of the tibiofemoral articulation. Dislocation can occur in a variety of directions depending on the mechanism of injury. The most common dislocation is anterior, which may be seen in hyperextension injuries such as martial arts kicking.[3] The "dashboard injury" of motor vehicle accidents can result in a posterior dislocation of the knee. Lateral and rotary dislocations are less common.

Knee dislocation is more commonly diagnosed in men, with a mean age of 23 to 31 years old.[4-6] This is the very patient population encountered by Special Operations Forces (SOF) healthcare providers. Given the mechanisms of injury noted above, it is reasonable to conclude that knee dislocations may be seen in a young, active SOF patient population, particularly those engaged in parachuting, fast-roping/rappelling, driving at high speeds during military operations, and mixed martial arts.

Assessment

Clinical

Patients with knee dislocation frequently present with multiple traumatic injuries.[6] A full trauma assessment should be performed on all patients presenting with high velocity knee dislocation, of course observing the tenets of TCCC as the tactical situation dictates. Once life-threatening injuries have been addressed it is critical to assess the affected extremity. Deformity of the affected limb and joint is a sensitive indicator of dislocation; however, many dislocations spontaneously reduce. In these cases, a high index of clinical suspicion is necessary to make the diagnosis and avoid significant morbidity. Dislocation may be suspected based on the history/mechanism of injury, or physical exam findings of joint instability/ligamentous injuries, hemarthrosis, and tenderness to palpation. If available, radiographic examination of the knee is essential. Anterior-posterior and cross table lateral images will document non-reduced dislocations, associated fractures if present, and lipo-hemarthrosis. Obtaining radiographs should never unduly delay reduction of the joint or operative intervention in cases of overt neurovascular compromise.

Dislocation of the knee often results in a multitude of ligamentous injuries. The posterior cruciate ligament (PCL) and anterior cruciate ligament (ACL) are most commonly injured; however, the medial collateral ligament (MCL) and lateral collateral ligament (LCL) may also be involved. Although these ligamentous injuries are relevant with regard to long-term joint stability, patient mobility, and quality of life, treatment for these injuries is not imperative in acute management.

In addition to associated ligamentous and vascular injuries, neurological compromise has also been documented. Approximately 10 to 25% of patients will present with a concomitant common peroneal nerve palsy, with long-term residual neurological deficits reported in some cases.[7] Accurate serial documentation of neurological status is vital to assess for potential neurological complications of dislocation.

Fractures about the knee joint also frequently complicate dislocations. In one series, 53% of dislocation had concomitant local fractures.[6] Fracture patterns vary, but tibial plateau fractures are the most common. Distal femur and combined or isolated fractures of the tibia and fibula are also encountered.

The most worrisome complication of knee dislocation is popliteal artery injury, which occurs in approximately 23% of patients.[5,6] Vascular injury can have devastating consequences in these individuals, as irreversible ischemia can occur in as little as six to eight hours. Ischemia can result in long-term morbidity or even amputation of the affected limb. Blunt popliteal artery injury has been reported to result in amputation rates of nearly 30%.[6] Depending on the degree of injury to the vessel, this diagnosis may be obvious or occult.

Signs of vascular injury are commonly divided into hard and soft findings. *Hard* findings include: pulse deficit, obvious distal ischemia (cyanosis, pallor), active hemorrhage, and expanding or pulsatile hematoma. *Soft* findings include: small/stable hematoma, injury to an anatomically related nerve (such as the common peroneal nerve), and history of hemorrhage at the site.

Frank disruption of the vessel with active hemorrhage may be observed in open fractures. Intimal flaps and defects, pseudoaneurysms, and stenosis may manifest in subtle changes including gradually diminishing pulses, exercise/motion induced ischemia, and a slowly progressive popliteal fossa mass. Therefore, in all suspected knee dislocations, a dedicated neurovascular exam of the lower extremities is required. The following parameters should be assessed immediately after injury: distal pulses (dorsalis pedis and posterior tibial arteries), capillary refill, and distal sensory and motor function.

Those patients with *hard* findings of vascular injury require emergent surgical evaluation for revascularization. Those patients with *soft* findings require measurement of the ankle-brachial index and serial observation for a minimum of 24 hours at regular intervals. It is important to distinguish vascular injury from other possible causes of an abnormal neurovascular exam. Steele et al.[8] reported a case of popliteal artery injury after dislocation, which was initially treated as compartment syndrome with fasciotomy. This can lead to a delay in definitive vascular repair and may result in limb ischemia.

The ankle-brachial index (ABI) is a method of noninvasive investigation for vascular injury after dislocation of the knee (See figure 1). The ABI is simply a ratio of the posterior tibial/dorsalis pedis/ankle systolic pressure to the brachial/arm systolic systolic pressure. The ABI is most often performed utilizing a small portable ultrasound device, which some SOF units are now fielding (see the article, "Portable Ultrasound Empowers Special Forces Medics" on page 59 in this edition). Alternatively, the ABI can also be performed with a stethoscope and sphygmomanometer. In general terms an ABI of 1.0 is normal. Mills et al.[9] found that an ABI of 0.90 or higher was 100% accurate in excluding vascular injury. Additionally, they found that an ABI less than 0.90 was 100% sensitive and specific for vascular injury. Other investigators have utilized an ABI of less than 0.80 as marker for vascular injury, with good results when combined with physical exam findings.[10]

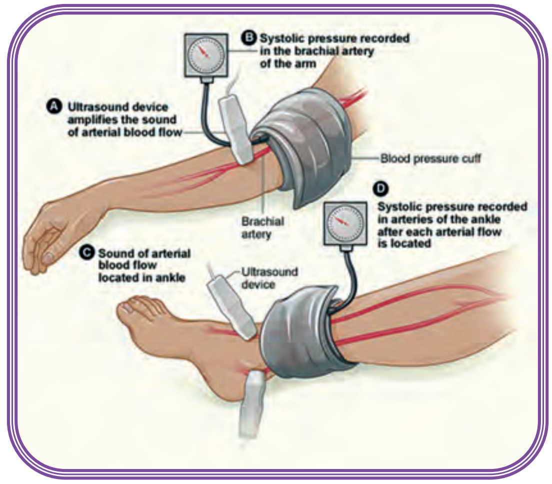

Figure1: *Diagram of ABI assessment. Used with permission from the U.S. National Heart, Lung and Blood Institute*

Technique

1. Measure highest systolic brachial pressure in both arms.
   a) Record first doppler sound as cuff is deflated.
   b) Use highest of the two arm pressures.
2. Measure systolic readings in both legs with cuff applied to calf.
   a) Record first doppler sound as cuff is deflated.
   b) Record dorsalis pedis & posterior tibial pressures.
   c) Use highest ankle pressure (DP or PT) for each leg.
3. Calculate ratio of each ankle to brachial pressure.

Radiographic Findings

As noted before, standard AP and lateral radiographs are very sensitive for diagnosing non-reduced dislocations. However, as many dislocations undergo spontaneous reduction, secondary radiographic findings may suggest prior dislocation, including fractures about the knee (especially avulsion of the fibular head), hemarthrosis, and asymmetrical joint line widening. These findings should prompt further evaluation.

Figure 2: *Cross table lateral and frontal radiographs demonstrate anterior dislocation of the tibia on the femur.*

The multitude of ligamentous injuries, which frequently complicate dislocations are best imaged with magnetic resonance imaging. (see Fig. 3A, B, C, D.)

Figures 3:
A. *Sagittal MRI demonstrating complete tear of the ACL (black arrow).*
B. *Sagittal MRI demonstrating complete tear of the PCL (black arrow).*
C. *Coronal MRI with high signal of lateral and medial collateral ligament tears (black arrows) and bone contusion (gray arrows).*

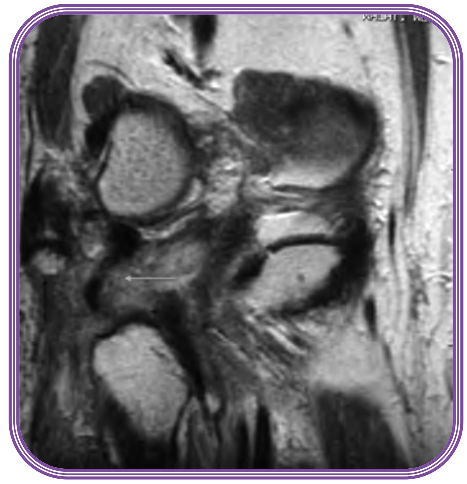

Figure 3:
D. *Fibular head avulsion fragment (black arrow) and asymmetric joint line widening (gray arrow).*

Arteriography has long been the gold standard for evaluation of vascular injury associated with dislocations of the knee, with some authors arguing that all patients with complete dislocation of the knee undergo arteriography.[11] Arteriography may demonstrate a range of vascular injury from minor to severe. Common findings of popliteal artery injury are complete occlusion (see figure 4), intimal injuries (see figure 5) and pseudoaneurysms.

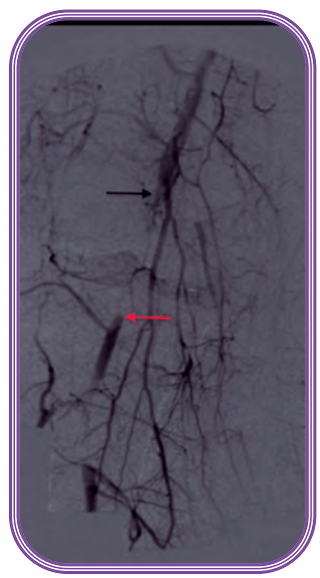

Figure 4: *Arteriogram of a reduced knee dislocation. Abrupt cut-off of the popliteal artery is noted (black arrow). Distal reconstitution is evident (red arrow).*

Figure. 5: *Arteriogram of a reduced knee dislocation. Contrast extravasation consistent with active hemorrhage (black arrow). Intimal flap of the popliteal artery is also noted (red arrow).*

Angiography is an invasive test and obviously may not be available at all medical facilities receiving military casualties. Alternatively, magnetic resonance angiography may also be used to evaluate the popliteal artery. This imaging modality is often times more widely available than a qualified interventional radiologist or vascular surgeon for performance of an arteriogram. Additionally, it is noninvasive. Several retrospective and prospective studies have evaluated the use of the physical exam alone for detecting injury to the popliteal artery. The physical exam findings consistent with vascular injury are diminished or absent distal pulses (posterior tibial and dorsalis pedis), enlarging hematoma, and signs of distal ischemia. Other signs include bruits or thrills over the injured vessel and of course active hemorrhage from an open injury. Evaluation of pedal pulses alone is not adequate for detection of vascular injury. Barnes et al.[12] reported that the sensitivity of abnormal pedal pulses was only 0.79. However, when examination of pedal pulses is combined with evaluation of additional hard findings of vascular injury, the physical examination becomes a potent indicator of vascular trauma. Miranda et al.[5] reported that a physical exam negative for *hard* findings of vascular injury could obviate the need for arteriography, and allow for 23 hours of observation and serial physical exams. Stannard et al.[13] reported similar findings, suggesting that forty-eight hours of observation may be necessary in select cases.

Treatment

Treatment of knee dislocation is variable and depends on the severity of injury. First and foremost, the joint must be reduced and stabilized. Patients with obvious vascular pathology such as active hemorrhage or *hard* findings of vascular injury require immediate surgical exploration. Those individuals without signs of vascular injury or with *soft* signs of injury (related nerve damage, stable small hematoma) can be subjected to serial examinations and observation for 24 to 48 hours. An ABI assessment should also be performed if feasible.

Treatment of associated fractures will vary depending upon the nature of the injury. Ligamentous injuries should undergo orthopedic referral and surgical repair as necessary.

Conclusion

Disruption of the tibiofemoral articulation is associated with high velocity blunt injuries, such as motor vehicle accidents and falls from height, as well as athletic injuries. Given the nature of SOF operations and activities of SOF personnel, this patient population may be at risk for this form of musculoskeletal trauma. Knee dislocations frequently spontaneously reduce, making the diagnosis difficult. A high index of suspicion is necessary in the appropriate clinical setting. This injury is frequently complicated by vascular injury to the popliteal artery with potential associated severe morbidity. In cases where knee dislocation is suspected by mechanism of injury and/or physical exam findings, a complete trauma assessment is warranted. Dislocation mandates immediate reduction of persistent malalignment, careful assessment of neurovascular status, and immediate CASEVAC for further evaluation and definitive treatment.

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