REVIEW ARTICLE

KNEE DISLOCATIONS AND MULTI-LIGAMENT KNEE INJURIES: A REVIEW

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Abstract:

Acute knee dislocations are a relatively rare type of injury that can lead to serious neurovascular compromise and ligament instability. These injuries can be potentially limb threatening if not properly identified and managed. The following review discusses the relevant anatomy of the knee joint and different classification systems of dislocations in order to highlight the complications that could occur. Timely evaluation and management, including reduction, is paramount to ensure stability and determine the need for additional imaging or urgent consultation. Knee dislocations are also associated with the unique presentation of a multi-ligament injury. This text provides an overview of multi-ligament knee injuries and the various surgical modalities currently being used. Finally, considerations are given on the role of the osteopathic approach in restoring function of the knee in the context of a dislocation.

TERMINOLOGY, EPIDEMIOLOGY AND ANATOMY OF THE TRAUMATIC KNEE DISLOCATION

Acute knee dislocations—although rare compared to other orthopedic injuries[1]—are a serious type of injury that can result in severe neurovascular and soft tissue damage. This injury can be potentially limb threatening. By definition, a dislocation refers to a disruption of the tibiofemoral articulation. Dislocations occur via high velocity mechanisms (such as motor vehicle collisions), falls from heights, crush injuries or via low velocity mechanisms (such as missteps while walking or jogging). Obese patients in particular are at an increased risk for low velocity injuries. High velocity mechanisms are more likely to result in damage to multiple different soft tissue structures within and about the knee. Dislocations tend to occur more frequently in males than females (4:1) and tend to occur more frequently in the second to fourth decade of life.[2]

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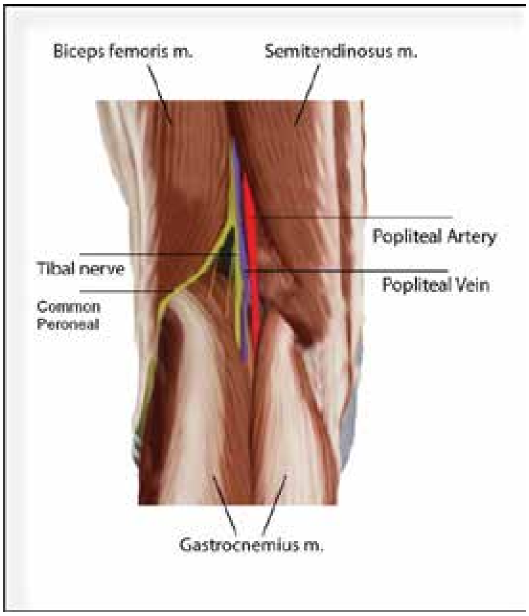
The neurovascular structures that should be of most concern in the context of this type of injury are the popliteal artery and the peroneal nerve, due to the intimate relationship of these structures to the posterior aspect of the knee (Figure 1). The popliteal artery courses deep in the popliteal fossa before branching into anterior and posterior tibial arteries at the lower border of the popliteus muscle. During its course in the fossa, it runs close to the distal femur and is thus vulnerable to injury and can result in significant blood loss during a dislocation. The peroneal nerve courses along the medial border of the biceps femoris through the popliteal fossa and wraps around the neck of the fibula, and given its proximity to the neck of the fibula, it is also vulnerable to injury during a high velocity injury. It is specifically vulnerable during posterolateral corner injuries. This can include a posterolateral force directed at the anteromedial portion of the tibia or a force upon a flexed knee that causes varus angulation. In a varus stress, the nerve is exposed to damage through a stretching type of injury, due to location about the fibula. It has been reported that injury to the popliteal artery occurs in 16% of knee dislocations,[3] while injury to the peroneal nerve has been shown to occur in 25%– 33%.[4] Prompt and accurate identification followed by appropriate treatment is critical in avoiding neurovascular compromise and improving better functional outcomes.

FIGURE 1:



As knee dislocations are often associated with multiple traumas, fracture incidence can be as high as 60%.[5] Tibial plateau fractures, and avulsed or sheared-off bone fragments from either the distal femur or proximal tibial, are the 2 fracture types with the highest incidence in medial or lateral dislocations. Unstable tibial plateau fractures are of further importance as they can be included in the classification of knee dislocation due to their association with capsular or ligament disruption. Moore separated these injuries from pure fractures, defining them as fracture-dislocations.[6] Fracture-dislocations require a combination of both bone stabilization and soft-tissue repair to achieve joint stability and therefore should be treated differently than pure dislocations.

Knee dislocations have been described into two distinct classification systems in the literature. Kennedy *et al* and others[7,8] use a classification system that divides dislocations into anterior, posterior, medial, lateral and rotary dislocation, which are named in terms of direction of tibial displacement with respect to the femur (Table 1). Alternatively, Schenk *et al*[1,8] classify dislocations by the number of structures involved (Table 2). These injuries can further be classified as closed or open, with the latter requiring urgent surgical intervention. These classification systems are useful in helping aid a clinical diagnosis and guide management and treatment decision-making. Regardless of the classification system utilized, it is imperative that the clinical provider properly identifies and reduces knee dislocations urgently.

TABLE 1:

KENNEDY *et al* CLASSIFICATION	MECHANISM	CHARACTERISTICS
Anterior	Hyperextension	Most common (40%) Sequential injury of the posterior capsule, PCL and ACL
Posterior	Posteriorly directed force across proximal tibia	Second most common (33%)
Medial	Valgus directed force across proximal tibia	Comprises 4% of dislocations
Lateral	Varum directed force across proximal tibia	Comprises 18% of dislocations
Rotary	Tibia rotates around femur	PCL remains intact

TABLE 2:

SCHENK *et al* CLASSIFICATION	ACL	PCL	COLLATERAL LIGAMENTS
KD I	Disrupted	Intact	Intact
KD II	Disrupted	Disrupted	Intact
KD III	Disrupted	Disrupted	Only one intact (either medial or lateral)
KD IV	Disrupted	Disrupted	Disrupted
KD V	KD with periarticular fracture		

INITIAL EVALUATION AND ASSESSMENT: KNEE DISLOCATIONS

Identification and diagnosis of knee dislocation is typically not difficult when present on the initial exam. Often these present with gross malalignment and swelling, as well as history of injury, similar to the methods noted above. Neurovascular status should be assessed as soon as knee dislocation is suspected. Closed reduction should be attempted immediately if vascular impairment is found. Pre-reduction radiographs should only be considered if the patient is neurovascularly intact.[9]

Once identified, an urgent attempt at a closed reduction should be made. A closed reduction can be done rapidly in the field or in an outpatient setting. This can be performed by stabilizing the distal femur and applying longitudinal traction to the tibia. Often, traction is sufficient to achieve reduction, though translatory forces to the proximal tibia in the direction that would restore normal anatomy (ie, anterior force for a posterior dislocation) is sometimes needed. Care should be taken not to apply undue pressure on the popliteal fossa to avoid additional injury to the neurovascular structures.[10] Once reduction has been achieved, the knee should be immobilized in 15°–20° of flexion. It is essential to attempt closed reduction prior to obtaining advanced imaging such as computed tomography (CT) or magnetic resonance imaging (MRI), as any further delay lowers the chances of restoring normal function and increases the risk of infection.

In rare cases, closed reduction should not be attempted. Clinicians should be aware of a “pucker sign” or “dimple sign,” as this indicates an irreducible knee (Figure 2). Jang *et al* described this as a puckering or entrapment of subcutaneous tissues, and possibly skin, between the femoral condyles and tibial plateau.[11] Most often, this is due to a posterolateral dislocation which includes an internal rotatory component. These incarcerated soft tissue structures prevent reduction, and these patients should be taken to the operating room for urgent open reduction.

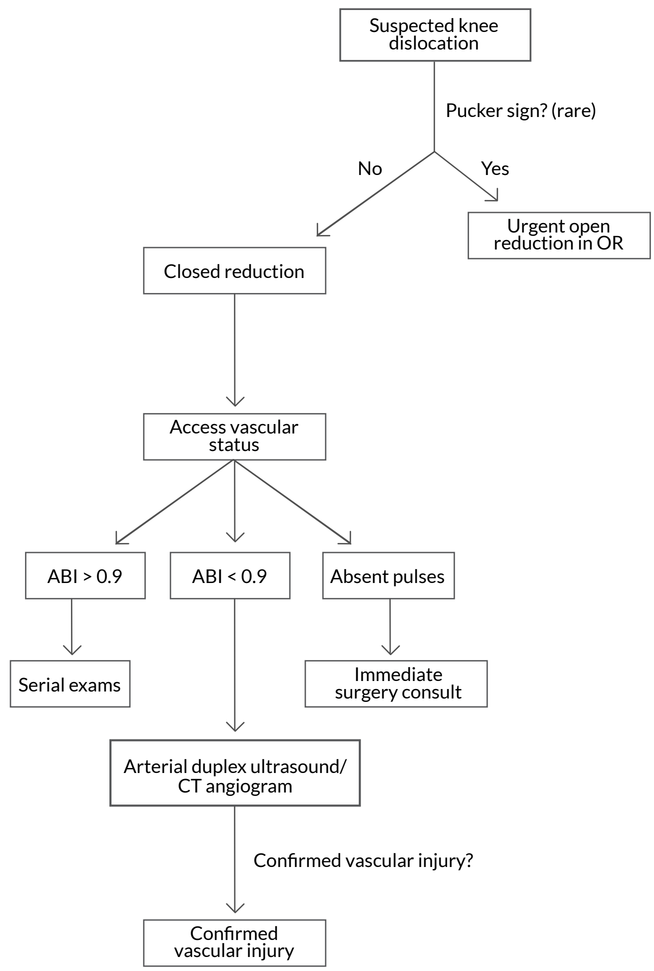
FIGURE 2:

Most knee dislocations spontaneously reduce prior to presentation. Therefore, the clinician must rely heavily on the physical examination. A large effusion is not always present due to capsular disruption, and the exam may also be limited by patient discomfort and soft tissue injury. Multiplanar instability, or substantial laxity of 2 or more of the major ligaments in the knee, is sufficient for a presumptive diagnosis of knee dislocation.

Once successful reduction is achieved, neurovascular status should immediately be reassessed through exam. Previous studies have shown that recognition of occlusive injury beyond 8 hours is likely to result in irreversible limb ischemia and above the knee amputation. Any patient with hard physical signs of vascular injury, including absent pulses, expanding hematoma, hemorrhage and bruit, should get urgent vascular surgery consultation for intraoperative angiogram. However, palpation of pulses is not adequate to rule out vascular injury. In the absence of hard physical signs, an ankle-brachial index (ABI) should be obtained and documented (Figure 3). Normal ABI values range from 1.0–1.4. If a patient is found to have an ABI above 0.9 and within the normal range, the clinician should monitor the joint with serial examinations over the next 24 hours. If a patient is found to have an ABI below 0.9, vascular compromise should be suspected, and a CT angiography or arterial duplex ultrasound should be obtained next. If vascular compromise is confirmed with imaging, vascular surgery should be consulted.

FIGURE 3:

Initial approach to a dislocated knee



Other emergent complications to be aware of with this type of injury include acute compartment syndrome (ACS) of the lower leg or foot. ACS occurs when an increased volume of fluid raises the pressure within a fascial compartment, causing cellular anoxia and ischemia. Significant pain upon passive movement and exquisite tenderness to light palpation to the compartment suggests the diagnosis, and an emergent orthopedic or general surgical consultation for fasciotomy is indicated.

After reduction of the acutely dislocated knee joint, initial immobilization via splinting or external fixation is recommended, followed by expedited treatment of vascular injuries. In the absence of an absolute acute surgical indication, such as irreducibility, open dislocation or ACS, further surgical treatment is typically delayed at least 10 days to 2 weeks. This delay is recommended to reduce swelling, increase preoperative range of motion and decrease the risk of postoperative arthrofibrosis. During this time, additional imaging can be obtained, including CT if osseous injury was detected on prior radiographs or MRI to determine the extent of soft tissue injury. After the delay, a spectrum of definitive surgical treatment options exist that can stabilize the dislocated knee from multidirectional instability, including external fixation, ligament reconstruction and ligament repair.

MULTI-LIGAMENT KNEE INJURY IN THE CONTEXT OF A KNEE DISLOCATION

A multi-ligament knee injury (MLKI) in the context of a dislocated knee is defined as two or more ligaments with or without meniscus involvement, which can be confirmed with MRI. Within the literature, there is limited data describing the diagnosis and complex treatment of this subtype of dislocation.

The knee contains four main ligaments, each of which provide stability to the tibiofemoral articulation: the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial cruciate ligament (MCL) and lateral cruciate ligament (LCL). Injury to 2 or more ligaments is a relatively rare form of dislocation as it requires greater forces applied to the knee. In fact, Shelbourne et al investigated a population of 5583 patients with knee ligament injuries and found that 495 (8.8%) were multi-ligamentous injuries.[12] Mook *et al* report an incidence of multi-ligament knee injuries to be .02% of all other orthopedic injuries.[13] Due to its rare nature, it is likely that orthopedic and sports medicine physicians might not encounter this injury type in their training or practice.

Although rare, clinicians should be prepared to address a multi-ligamentous injury, as it often poses additional challenges for the patient. Kosy *et al* found that 20% of multi-ligament knee injuries were associated with either a medial or lateral meniscal root tear,[14] compared to 10% of isolated ACL ruptures being associated with a lateral meniscus tear[15] and 3% of isolated ACL ruptures being associated with a medial meniscus tear.[16] Meniscus tears that occur with ligament ruptures can further increase knee instability and laxity given their role as secondary translatory stabilizers. Furthermore, Jabara *et al* found an incidence of tibiofibular joint disruption in 129 multi-ligamentous injuries to be 9%, which is a type of disruption that, if gone unrecognized, can lead to persistent instability and dysfunction of the knee.[17] Given the added complexity of having multiple structures damaged with a multi-ligamentous injury, it is essential for the treating provider to understand the treatment strategies to provide appropriate care.

SURGICAL TREATMENT MODALITIES FOR THE MLKI

Multi-ligament injury in the context of a knee dislocation can be managed both nonoperatively or operatively, though nonoperative management is associated with significantly worse Lysholm scores and lower International Knee Documentation Committee (IKDC) percentages.[18] The Lysholm score and IKDC percentages are standardized subjective rating systems used for a variety of knee conditions that consider both symptoms and functionality and are thus useful outcome measures. Nonoperative management is typically reserved for older, sedentary patients or patients with polytrauma that require primary life or limb saving operations.

Ligament reconstruction

Reconstruction of the disrupted ligaments (most commonly the ACL or PCL) in a MLKI is a widely utilized surgical treatment modality. The Achilles, anterior tibialis, patellar, quadriceps, and hamstring tendons can all be used as allografts, whereas the patellar, quadriceps and hamstring tendons are typically harvested in an autograft.[19] Graft selection depends upon both the surgeon and patient's preferences; however, allografts are used more frequently in multi-ligament reconstructions due to limited stock of autograft tissue available for multiple ligament reconstructions and to decrease donor site mortality. Allografts also have the potential benefit of shorter operating room (OR) times due to eliminating the harvesting procedure in autografting.

Despite the consensus that ligament reconstruction provides better outcomes compared to the other surgical modalities, there is conflicting data on the exact timing of when the reconstruction should be performed. A reconstruction performed within 3 weeks of injury is classified as acute. Cases in which extra-articular ligaments (medial and lateral collateral ligaments) are reconstructed acutely while intra-articular ligaments (anterior and posterior cruciate ligaments) are reconstructed at a later date are classified as staged reconstructions. Those performed after 3 weeks of the injury are classified as delayed or chronic.[20] A meta-analysis of 8 studies (260 patients) by Hohman *et al* found that acute intervention resulted in higher IKDC scores compared to chronic intervention. However, another systematic review by Jiang *et al* found that the staged reconstruction, in which intra-articular ligaments were constructed at a later time, resulted in better overall outcomes in 153 knees at the KD-III classification according to the Schenk *et al* classification.[21] Mook *et al* reviewed 396 knees and report more flexion deficits in patients managed acutely compared to patients managed chronically, yet found a significantly increased need for additional treatment secondary to joint stiffness and arthrofibrosis in the acute and staged reconstruction compared to chronic management. Despite this, staged treatments yielded the best subjective outcomes in this systematic review. Given these varied findings, a thorough discussion of the risks and benefits of each reconstruction pattern should be had during the treatment decision making process.

Reconstructing more than one ligament in a MLKI is also a widely utilized methodology. National trends from 2007–2016 revealed that 588 patients underwent a multi-ligament reconstruction and that 30.4% of patients with a knee dislocation underwent a multi-ligament reconstruction.[22] This same study found that in patients undergoing multi-ligament reconstruction, 90-day complications occurred in 5.8% of patients and readmissions occurred in 8.3%. Some of the factors associated with an increased likelihood of needing additional ligament surgery after a multi-ligament reconstruction included concomitant neuroplasty, knee dislocation and prior placement of an external fixator. With this in mind, patients who have a MLKI in the setting of knee dislocation should be counselled on the increased likelihood for reoperation and/or post-operative complications. Furthermore, posterolateral corner (PLC) structures (such as the LCL, popliteus tendon, popliteofibular ligament and iliotibial band) are often injured in multi-ligament injuries and so reconstructing PLC structures using a single-graft technique in addition to the ACL and PCL yielded satisfactory outcomes.[23]

Articulated external fixation

Complementing multi-ligament reconstruction with an articulated external fixation, as opposed to rigid immobilization, has been shown to improve outcomes. A study of 33 knees demonstrated that the addition of an articulating external fixator onto subacute or chronic multi-ligament reconstructions allowed for earlier range of motion, particularly flexion, along with improved Lysholm scores after at least 14 months postoperatively.[24] The control group in this study were knees with subacute or chronic reconstructions followed by rigid cast immobilization in full extension. Another study by Stannard et al found that a group of 157 knees undergoing acute ligament reconstruction followed by articulated external fixators resulted in only 11 failed ligaments (7%), compared to 22 failed ligaments (21%) out of 105 knees undergoing acute ligament reconstruction followed by rigid bracing.[25]

Mook *et al* described aggressive rehabilitation after acute ligament reconstruction in the form of earlier and more extensive post-operative mobility exercises resulting in less severe final range-of-motion deficits. Articulated external fixators seem to be an optimal mechanism by which knee range of motion can be started while providing stability and protection of the recently reconstructed ligaments.

Ligament repair

Ligament repairs have been gaining traction more recently among surgeons with trends of improved outcomes over the past decade. Ligament repair attempts to reattach the remaining ligament to its anatomic origin, often using additional experimental techniques to augment the remaining tissue.

There are a few key advantages of a repair compared with a reconstruction. By avoiding graft harvesting and allografts, repairs seek to preserve native ligaments with its blood supply and to potentially preserve some proprioceptive function. Repairs also avoid boney tunnel drilling, and thus do not contain a risk of tunnel convergence - an unfavorable complication in multi-ligament reconstructions.[26] Many authors have reported good outcomes with repairs. Hua *et al*. performed repairs on all ligaments in 18 multi-ligament knee dislocations and reported Lysholm scores of 87.5, with no knee laxity at 4.8 years follow up.[27] Similarly, Owens et al. performed repairs on all ligaments in 28 multi-ligament knee dislocations and reported high Lysholm scores of 89.28 Others have developed supplemental techniques such as suture augmentation and bridging scaffolds to further reduce residual knee laxity in ligament repair.

Several disadvantages exist for the ligament repair that should be considered. For example, careful consideration must be given to the eligibility of a patient for a primary repair. Repairs are often limited to patients with either a proximal or distal avulsion type tears. Repairs may also only be possible when there is sufficient integrity of the ligament fragment, as well as a sufficient length of fragment to work with. Goiney *et al* found that the ability to perform a proximal femoral PCL repair, as opposed to PCL reconstruction, required a threshold distal tibial PCL length of 41 mm or greater.[29] Moreover, a systematic review by Levy *et al* found that patients undergoing primary repairs experienced decreased stability and range of motion, with none of their patients returning to preinjury levels in terms of those outcomes. This was compared to 33% of patients undergoing reconstruction who achieved the same preinjury stability and range of motion.[30] Levy *et al* also report higher failure rates with repair of PLC structures (37%) compared to reconstruction (9%), suggesting that reconstruction is the best modality for addressing the PLC specifically.

OSTEOPATHIC CONSIDERATIONS

The osteopathic approach to a patient with knee pain, as with patients with any other complaint, is centered upon restoring the overall well-being of the patient through hands-on manipulation and a focus on facilitating the healing process inherent to the body. For patients with non-traumatic knee pain, osteopathic manipulative treatment (OMT) is often incorporated into a comprehensive treatment plan that includes medication, physical rehabilitation and exercises, activity modification, nutrition and lifestyle counseling. For example, the use of various OMT techniques, such as manual lymphatic drainage, in addition to exercise has been shown to improve function and reduce pain from underlying osteoarthritis of the knee compared to exercise alone.[31]

Little is known, however, about whether OMT has been shown to improve outcomes in the acutely traumatic knee injury. Although the evidence is lacking, it is likely that lymphatic drainage and myofascial techniques applied to the lower extremity proximal and distal to the knee joint can help reduce excess inflammation and fluid that accumulates in the joint space post-trauma. In the case of lymphatics, specific “pumping” techniques have been shown in multiple studies to increase the rate at which lymph moves through the lymphatic system, thus reducing excess fluid in the interstitial space and reducing edema.[32] If tolerated by the patient and if the knee has been adequately managed as described above, then lymphatics techniques directed proximal or distal to the knee preoperatively may improve recovery and functionality for the patient.

It also should be noted that a traumatic knee injury imparts a significant psychological toll on patients. Patients face a long and challenging rehabilitation process, and full recovery with restoration of prior function and capability may not be possible. Studies suggest that patients who sustain an ACL injury report higher rates of depression symptoms than national averages, which can lead to worse outcomes.[33] This effect could be exacerbated in athletes as those who suffer a knee dislocation have a lower return to play rate, and struggle to make it back to their preinjury performance statistics.[34] Therefore, the provider should also address psychosocial challenges that arise from injury and changes to the patient's lifestyle and habits.

SUMMARY AND RECOMMENDATIONS

Based on our review of the literature, we recommend that, when presented with an acute knee dislocation, clinicians should urgently reduce via closed or open techniques. After the knee has been reduced, the neurovascular status of the knee must be assessed and ABI should be documented. If the knee dislocation involves injury to more than 2 ligaments, it is deemed a MLKI, and surgical intervention should be strongly considered. The decision to surgically stabilize the knee with either an acute, staged or chronic ligament reconstruction cannot be made definitively based on the current evidence. However, augmentation with an external fixator to allow for more aggressive rehabilitation programs is agreed upon as an effective strategy. Ligament repair should be reserved for select patient populations and injury patterns, though if a patient is deemed eligible and the surgeon has adequate resources and comfort with the technique, it is a viable alternative to ligament reconstruction with similar functional outcomes. It is therefore essential for both the surgeon and patient to come to a joint decision regarding the best treatment plan based on surgical technical abilities, patient preference, and desired outcomes for this rare but complex injury pattern.

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