

How I Manage the Multiple-Ligament Injured (Dislocated) Knee

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The multiple ligament injured knee, or the dislocated knee remains a challenge for any orthopedic surgeon because of the high risk of associated neurovascular injury and potential devastating consequences including loss of limb. Although there are several principles that guide management, optimal treatment strategies remain controversial. Each individual patient and each knee injury is unique; therefore, it is very difficult to perform evidenced-based research because in this heterogeneous patient population. Surgical decision making is influenced by the specific knee injury pattern, but also by the associated polytrauma that these patients sustain from high-energy motor vehicle or motorcycle collisions. Our approach to the dislocated knee is based upon the responses to numerous questions. This review will shed some light on the questions we ask and how treatment decisions are made.

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The multiple-ligament injured knee or the dislocated knee remains a challenge for any orthopedic surgeon because of the high risk of associated neurovascular injury and potential devastating consequences, including the loss of a limb. Although there are several principles that guide management, optimal treatment strategies remain controversial. Each individual patient and each knee injury is unique; therefore, it is very difficult to perform evidenced-based research in this heterogeneous patient population. Surgical decision making is influenced by the specific knee injury pattern but also by the associated polytrauma that these patients sustain from high-energy motor vehicle or motorcycle collisions. Our approach to the dislocated knee is based on the responses to numerous questions. This review will shed some light on the questions we ask and how treatment decisions are made.

Question 1: Are There Any Emergent Issues?

The first question is whether or not there are any emergent issues related to the knee. For example, is there a vascular

injury, an open knee dislocation, a compartment syndrome involved, or an irreducible knee dislocation? A positive response to any of these questions requires emergent surgical management.

Vascular Injury

Vascular injury in the dislocated knee can often be elusive. We now recognize that patients can have a complete arterial occlusion and still have pulses distal to the lesion predominantly because of collateral flow.¹ The angiogram depicted in Figure 1 is an example of a young patient with a dislocated knee and a complete popliteal artery occlusion despite palpable pedal pulses and a well-perfused foot (Fig 1). Stannard et al² have shown that if the patient has symmetric lower-extremity pulses combined with normal foot warmth and color, it is safe to perform serial physical examinations every several hours and avoid the need for further diagnostic imaging. However, if at any time the vascular status changes so that symmetry is lost in any way, then further diagnostic imaging is recommended.

Several other authors have recommended all suspected knee dislocations and/or multiple-ligament knee injuries require supplemental screening for vascular injury.³ This may involve the use of the ankle brachial indices (ABIs), duplex ultrasound, conventional angiography, or computer tomography angiography (CTA).

The use of ABI has come into favor because of its relative

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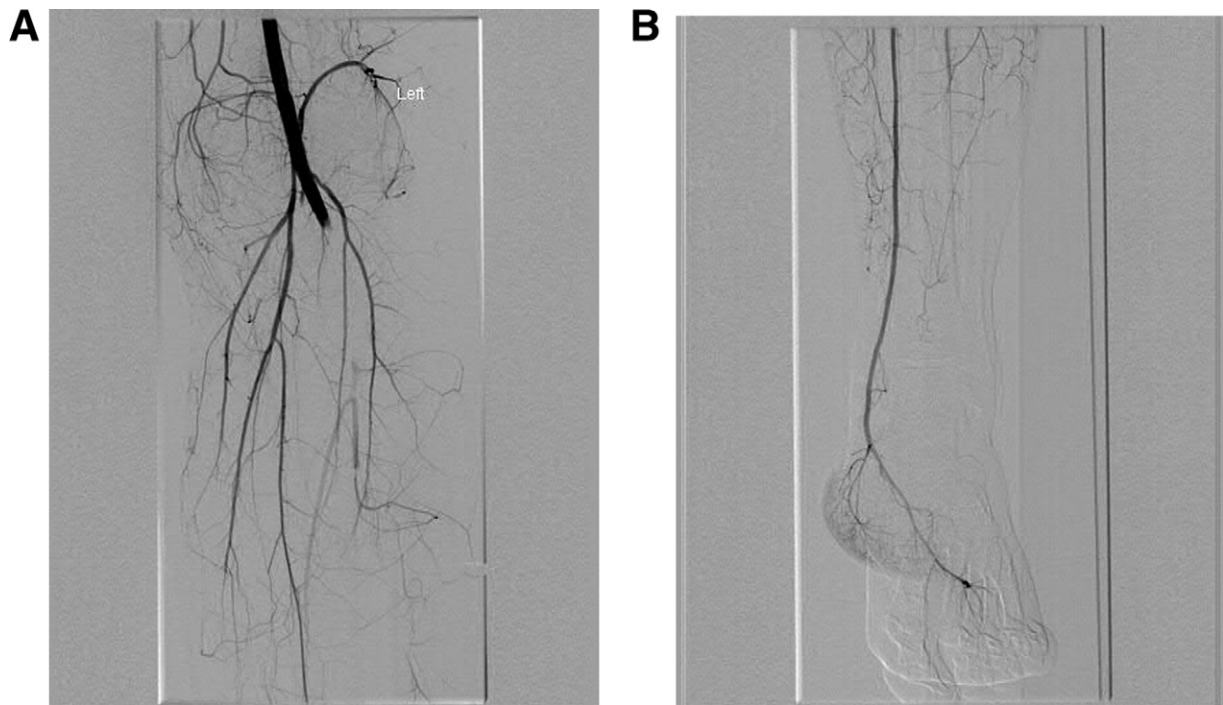


Figure 1 (A) An angiogram showing complete popliteal artery occlusion in a patient with palpable pedal pulse. (B) An angiogram of the same patient showing collateral flow.

ease of use. The systolic blood pressure of the involved lower extremity at the level of the ankle is compared with the systolic blood pressure of the ipsilateral upper extremity (Fig 2). If the difference or the ratio is greater or equal to 0.9, then the risk of having a major arterial occlusion is almost negligible.⁴ An ABI less than or equal to 0.8 should warrant the need for further diagnostic imaging with duplex ultrasound, CTA, or conventional angiography.



Figure 2 ABI.

The use of ultrasound for arterial examination has shown excellent sensitivity and specificity; however, it is technician dependent, and not all centers or emergency rooms have the use of a 24-hour, 7-day-a-week ultrasonographers, and, therefore, the use of ultrasound is not always readily available. Despite these limitations, ultrasound is recognized as an excellent noninvasive screening modality.³

Conventional angiography has long been considered the gold standard for the assessment of a vascular injury.⁵ However, the risks associated with conventional angiography are not benign, including renal toxicity and pseudoaneurysm.⁶ Conventional angiography has excellent sensitivity and specificity in the detection of significant arterial injury in addition to less significant arterial injury like intimal tears.^{5,7}

More recently, CTA has become available. Several authors have shown excellent sensitivity and specificity using the technique.^{3,8} The advantage of CTA over conventional angiography is that the arteriogram portion is performed through the antecubital fossa as opposed to the groin, and there is one fourth the radiation exposure.

Open-Knee Dislocation

If the patient sustains an open-knee dislocation, emergent treatment is required for aggressive debridement and irrigation. With a severe open medial or lateral side injury, the surgeon may elect to repair whatever tissues are obviously torn using suture anchors or drill holes. The open-knee dislocation that requires multiple trips to the operating room and those that sustain vascular injury benefit from the application of a joint-spanning external fixator. We use a magnetic resonance imaging (MRI)-compatible spanning fixator. Al-

though the MRI quality in this setting is not nearly as good because of associated metal artifact, the images are adequate and give the surgeon the amount of information needed to plan for further surgical intervention.

Fixator placement can be achieved in numerous ways. We prefer biplanar fixation with 2 half-pins in the anteromedial tibia 30° off the coronal plane and 2 half-pins on the antero-lateral femur 30° off the coronal plane. This creates a Z-shape configuration and offers a very stable construct. Fixator pin placement is important. The distal femoral pin must not be in the joint or communicate with the joint space. If the pin is placed at least 1 handbreadth proximal to the proximal pole of the patella with the knee in full extension, it will be proximal to the suprapatellar pouch and outside the joint. The most proximal tibial pin should be distal to the planned anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) reconstruction incision sites.

We typically remove the fixator at approximately 3 to 4 weeks postinjury, perform a gentle manipulation of the knee, and proceed with multiligament reconstruction if the soft tissues allow or delay the reconstruction if the soft tissues are not amenable to surgical intervention.⁹ We also recommend obtaining a Duplex ultrasound (US) within 48 hours of fixator removal to rule out a deep venous thrombosis.¹⁰ If the US is positive, then we avoid aggressive knee manipulation, avoid the use of a tourniquet, and have an inferior vena cava filter placed preoperatively.¹¹

Compartment Syndrome

Compartment syndrome requires emergent 4-compartment fasciotomies. This takes precedence over just about any clinical situation. We recommend classic 2-incision 15-cm 4-compartment fasciotomies when indicated.¹²

Irreducible Knee Dislocation

At times, knee dislocations present with the inability to be reduced in the emergency room. The so-called “irreducible knee dislocation” often is a posterolateral dislocation whereby the medial femoral condyle gets trapped or “button-holed” through the medial capsular structures. A dimpling of the medial skin is often the clue. In these rare cases, emergent reduction of the knee either via arthroscopic means or formal open arthrotomy is necessary.¹³

Question 2: Does the Patient Have Any Associated Injuries?

The next question that we ask is whether or not there are associated injuries. For example, is this a polytrauma patient with multiple extremity fractures, or is there an associated knee fracture along with the knee dislocation? Often times a periarticular fracture, such as a fibular head fracture, may dictate a staged procedure as opposed to a single surgical intervention. For a fibular head avulsion, we would often recommend open reduction and internal fixation of the fracture, rehabilitating the knee while allowing the fracture to heal, and then a delayed multiligament knee reconstruction.

If there is a large medial-sided tibial plateau fracture, then we often elect to perform an open reduction and internal fixation of the medial plateau followed by a second staged ligament reconstruction. We typically proceed with fracture surgery in the setting of a closed knee dislocation at approximately 5 to 14 days after injury, provided that the soft-tissue appearance is satisfactory.

In a polytrauma patient, the multiple-extremity injuries dictate the timing of multiknee ligament reconstruction. For example, if the patient has an ipsilateral Pilon fracture, an ipsilateral tibial plateau fracture, or an ipsilateral tibial shaft/femoral shaft fracture (floating knee), we would typically recommend fixing all the fractures first, restoring bony height, length, and width and then perform the multiligament knee reconstruction once all the fractures have healed. In addition, we often remove the fracture fixation hardware before the ligament reconstruction. On occasion, the associated polytrauma precludes the ability to perform a multiligament knee reconstruction because of the inability for the patient to sustain a postoperative rehabilitation program.

Question 3: What Is the Status of the Soft Tissues?

The third question that we ask is the status of the soft tissues. The soft tissues may actually dictate when the surgeon feels it is safe for multiligament knee reconstruction. For example, in the case of a closed-knee dislocation with central pivot, medial-, and lateral-sided disruption, the soft tissues may or may not be amenable to an arthroscopic central pivot and an open medial- and lateral-sided reconstructions within a few weeks from the injury. Although several authors have shown that early reconstruction leads to improved outcomes over delayed reconstruction, the soft tissues take precedence. We recommend waiting until the soft tissues are amenable for surgical repair. This occurs once the bruising has resolved, the skin wrinkles and is not under tension, and all blisters have completely healed.¹¹

Question 4: Is There a Peroneal Nerve Injury?

Peroneal nerve injuries occur in approximately 25% of dislocated knees.¹⁴ Most of these injuries are axonal traction injuries (neuropraxias), but some are complete transections. These nerve injuries are typically associated with lateral-side injuries to the knee. The treatment of peroneal nerve palsy when the nerve is believed to be intact is usually observation, a serial electromyography, and, if no recovery is found, tibial tendon transfer to restore active dorsiflexion.¹⁵ More recently, partial nerve transfers from a healthy motor branch of the tibial nerve to a healthy motor branch of the distal peroneal nerve distal to the area of injury has been described.¹⁶ In a study of 11 patients performed at our institution, almost 50% showed some form of nerve recovery although this took several years in most patients. Although the evidence is lacking, the patients who had improved outcomes had their neu-

rosurgical intervention within a 3-month period from the time of injury. Currently, at our institution, if a patient presents after a knee dislocation with a complete peroneal nerve palsy with no evidence of nerve recovery or documentation of a complete transection, then we perform a partial nerve transfer as early as possible once the soft tissues are amenable and then perform a multiligament knee reconstruction as a second stage. If, however, the patient has had a delayed course of treatment, which has not allowed multiligament knee reconstruction, and the peroneal nerve has been out for over a year, then we typically would do the multiligament knee reconstruction and consider a tibial tendon transfer at a later date.

Question 5: What Ligamentous Structures Are Disrupted?

Radiographic Examination

Routine anteroposterior and lateral radiographs often hold clues to ligament disruption. Because most knee dislocations spontaneously reduce, the radiographs often look normal. However, subtle signs of joint space asymmetry or posterior tibiofemoral subluxation may be present. Therefore, careful scrutiny is warranted, and at times stress radiographs may show and confirm ligament disruption.

MRI

MRI is the imaging modality of choice for the evaluation of the dislocated knee because no other imaging modality offers more detail of the ligament and associated cartilage and meniscal injuries. If a spanning fixator is in place as we mentioned earlier, we still recommend MRI, assuming that the fixator is an magnetic resonance-compatible frame because this will help delineate treatment. When at all possible, we would delay obtaining the MRI until the fixator is removed to

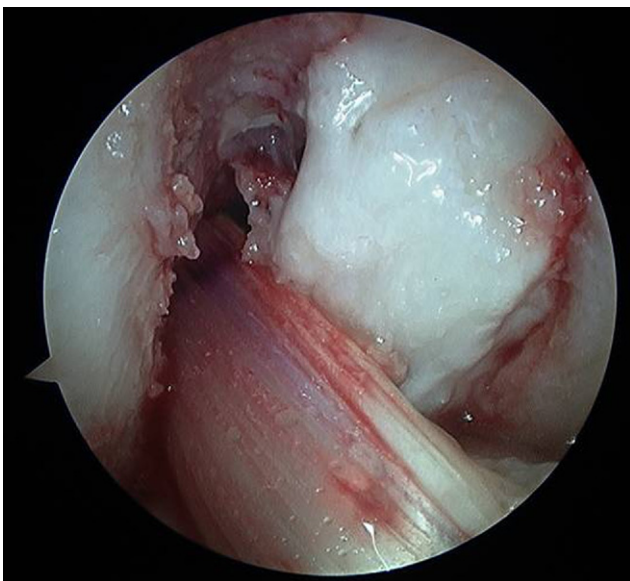


Figure 3 An arthroscopic view of ACL and PCL grafts.

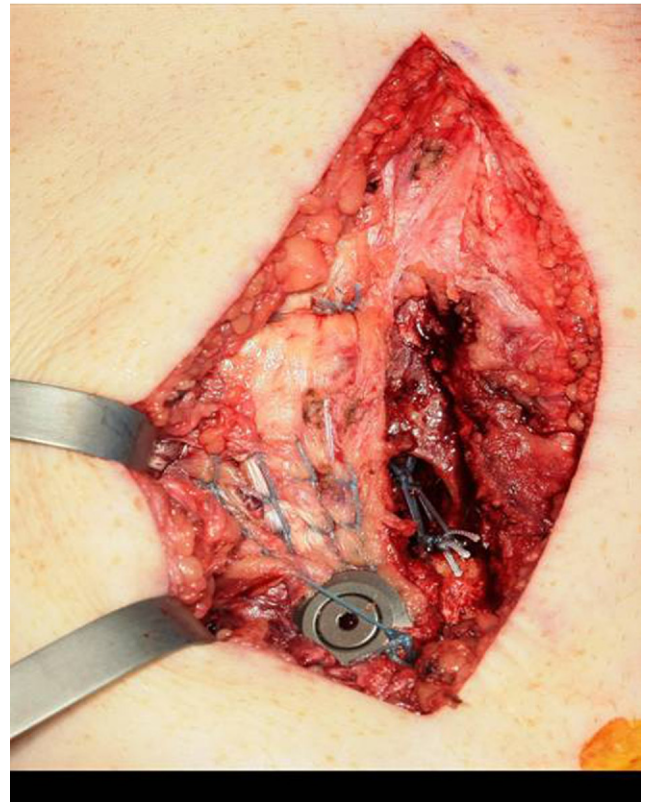


Figure 4 An intraoperative photograph of MCL repair back to the tibia.

get optimal imaging. When it is not feasible to get an MRI, then a clinical stress examination or examination under anesthesia using fluoroscopy is often very helpful.

Question 6: What Is Our Treatment Plan?

The next question we ask ourselves is the treatment plan. Once we understand any emergent issues, associated injuries, or fractures of the status of the soft tissues and MRI// stress examination under anesthesia findings, we devise a treatment plan. This strategy may be a single-stage, 2-stage,



Figure 5 An intraoperative photograph of MCL reconstruction using an Achilles tendon allograft.

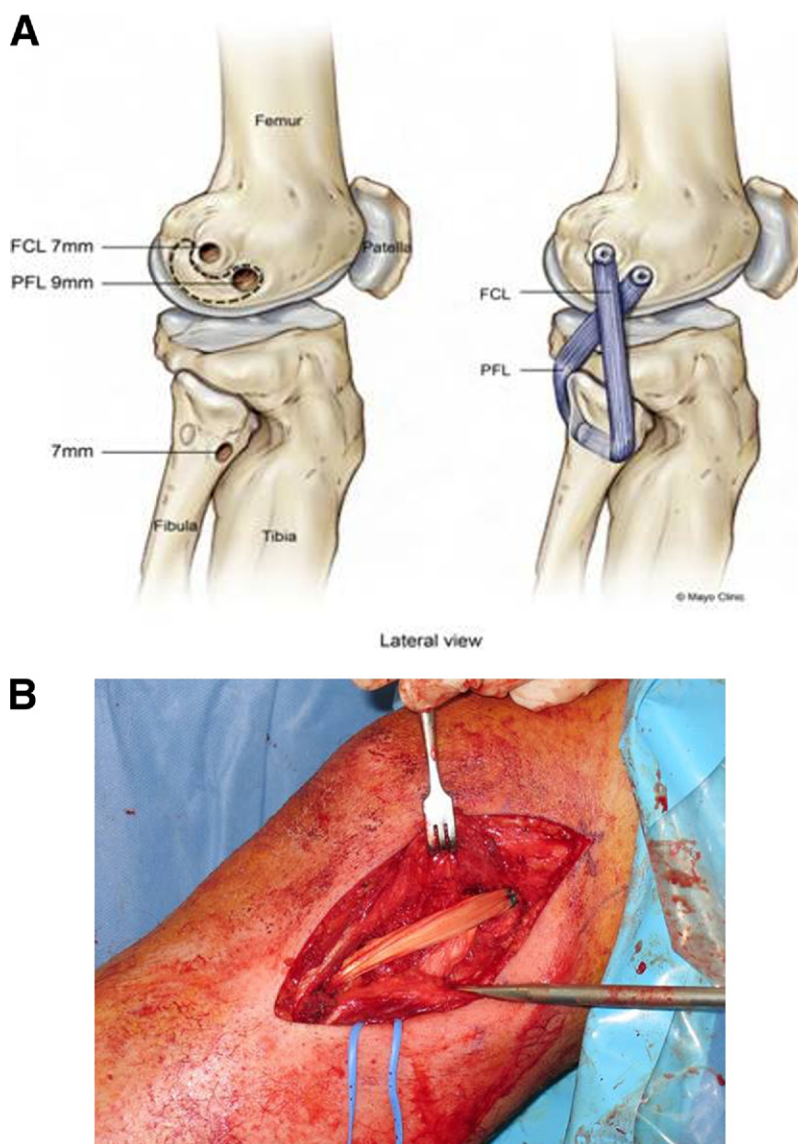


Figure 6 (A) A pictorial representation of posterolateral corner reconstruction. (B) An intraoperative photograph of posterolateral reconstruction.

or even 3-stage procedure but always depends on the factors mentioned earlier as well as the specific combination of ligaments injured. Although many combinations of injury patterns exist, here are a few examples.

ACL/PCL

In the setting of an ACL/PCL injury with no collateral ligament damage, our preference is to regain range of motion, allow the soft tissues to heal, and then perform ACL/PCL reconstructions once the soft tissues allow (Fig 3).

ACL/PCL/Medial-Sided Injury

We performed a systematic review of the literature, which failed to show an advantage for medial collateral ligament (MCL) repair versus reconstruction.¹⁵ The decision to perform a repair or a reconstruction is dependent on the location of the tear, the quality of the tissues, and the chronicity of the

injury. In the setting of an ACL/PCL/MCL/posteromedial corner injury when the MCL is torn from the femur, we typically allow the patient to rehabilitate their knee to allow the MCL to heal and then perform a delayed central pivot reconstruction (ACL/PCL). If the MCL is torn off the tibia, has an associated fracture, or is a so-called “MCL Stener lesion” where it is trapped on top of the pes anserine tendons, we favor either a single-staged MCL repair (Fig 4) and ACL/PCL reconstructions. If the soft tissues are not amenable to the combined surgery, we use MCL repair only with ACL and PCL reconstructions as a second stage. In the chronic setting, we favor MCL reconstruction with an Achilles tendon allograft (Fig 5).

ACL/PCL/Lateral-Sided Injury

The ACL/PCL/lateral-sided injury is the most frequent and sometimes can be the most complex. We have shown a 40% failure rate with repair of lateral-sided structures without

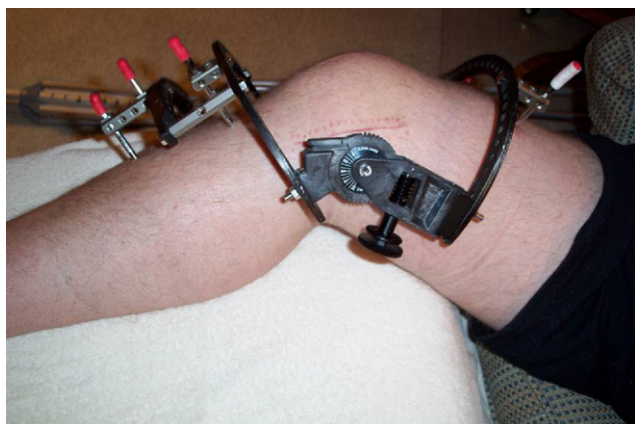


Figure 7 An intraoperative photograph compass joint spanning external fixator.

augmentation and only a 4% failure rate with reconstruction in the setting of the multiple-ligament injured knee.¹⁷ Therefore, when possible, we believe that lateral-sided ligament reconstruction is a better option for the patient unless there are reasons for early repair, such as an open dislocation or fibular head avulsion fracture. When the decision is made to perform an fibular collateral ligament repair, we recommend augmentation with a graft.

Numerous posterolateral corner reconstruction techniques have been described. We have been using a single graft technique for most posterolateral corner injuries¹⁸ (Fig 6), but with severe lateral-sided disruptions we have been using the anatomic technique as described by LaPrade et al.^{19,20} Details of these techniques are beyond the scope of this article.

Question 7: What Rehabilitation Protocol Will We Follow?

The next question is when do we use a postoperative spanning external fixator and how do we decide on our rehabilitation protocol?

Postoperative Spanning External Fixator

For some knees after a 4-ligament knee reconstruction, the spanning fixator postoperatively can help control both sagittal and coronal plane alignment while preventing overloading of 1 side of the knee compared with the other. Stannard has shown a significant decrease in revision rates using a postoperative compass spanning external fixator, which controls sagittal plane and coronal plane alignment with early range of motion and weightbearing.²¹ We have a limited experience with the use of this frame, but in the setting of a 4-ligament knee reconstruction, especially in a large heavy patient, the use of a joint spanning external fixator for several weeks may be indicated (Fig 7).

Postoperative Rehabilitation Protocol

We have been following the protocols described by Fanelli and Edson for numerous years.²² In this protocol, the knee is maintained in full extension in a brace for a 3- to 4-week

period. Progressive knee range of motion is then allowed (predominantly prone in the setting of a PCL reconstruction), and partial weight bearing is initiated. Other authors have noted excellent results with more aggressive rehabilitation protocols that allow immediate range of motion and weight bearing.^{19,23}

Conclusions

The orthopedic surgeon should have a high index of suspicion for a dislocated knee when faced with any multiligament knee injury or periarticular fracture. It is imperative to perform a thorough neurovascular examination along with some form of screening test such as ABI to avoid the dire consequences of a missed vascular injury. Although no single treatment algorithm can help guide management of the dislocated knee, several of the key principles can be helpful. Each knee dislocation represents a unique injury, and each patient has special circumstances because of the high rate of associated polytrauma. Following the basic principles of emergent management will help avoid catastrophic complications.

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