INTRODUCTION

Treatment of knee dislocations remains controversial. There is a paucity of outcome data in the literature which would suggest optimal strategies with regards to timing of fixation, methods of fixation, types of reconstruction, and postoperative rehabilitation. In fact it is not even clear which injury variants should be operated on in the acute setting. Many authors have reported improved outcomes with early surgical repair/reconstruction of all ligamentous structures\textsuperscript{1,2,3,4}.

INITIAL EVALUATION

\textit{Neurovascular assessment}

It is important to recognize that high-energy knee dislocations are limb threatening injuries with a high risk of popliteal artery injury in approximately 40\%, with some reports as high as 59\% incidence\textsuperscript{5,6,7}. Initial assessment when the patients’ present to the Emergency Room is a thorough neurovascular exam. From a vascular standpoint, if the patient presents with hard signs of ischemia (pulseless limb, expanding hematoma, audible bruit), for example a cold, pulseless limb, the vascular surgeon will typically either proceed with angiogram if there is some question of the level of the injury or perform immediate exploration and repair versus bypass graft. The authors\textsuperscript{8} have previously described a treatment algorithm for vascular assessment of such injuries, which includes the use of an ABI (Ankle Brachial Indices). If the ABI is greater than 0.9, it has been shown that the risk of major arterial lesion approaches 0\%. If the ABIs are less than 0.9, then patients are at risk for vascular injury and require subsequent vascular assessment with either Duplex ultrasound or angiogram. It is the patients with the subtle or so-called soft signs of ischemia, with either cool limbs or faint pulses, that require such a thorough vascular assessment.\textsuperscript{9,10,11}

Stannard et al. have contended that physical exam alone can be used as a reliable predictor of vascular injury\textsuperscript{12}. However, others have shown that physical exam alone is unreliable\textsuperscript{13,14}. Therefore, the authors perform an ABI on all knee dislocations, pre- and post-reduction, and follow the treatment algorithm proposed.

STAGED PROTOCOL

For complex periarticular knee fractures, several authors have noted the benefits of "staged protocols" for fracture management. The first stage is the application of a joint spanning external fixator. The fixator brings the fracture out to length, restores alignment and also brings the soft tissues out to their native resting length. Stability of soft tissues prevents spasm, and minimizes tenting. Soft tissue and bony approximation allows for better lymphatic and venous function during resolution of swelling. The second stage is definitive fixation of the fracture when the soft tissues’ swelling has resolved and are felt to be amenable to surgical intervention\textsuperscript{15,16}. 
It is now recognized that a significant amount of these complex periarticular fractures are most likely fracture dislocations with both bony and ligamentous disruptions. Gardner et al\textsuperscript{17}, found 68% of tibial plateau fractures sustained pathology to the posterolateral corner.

It has also been recognized that some knee dislocations present with associated rim and/or avulsion fractures. Moore, added fracture dislocations as part of a knee dislocation classification \textsuperscript{18}. More than likely, pure knee dislocations, fracture dislocations, and pure periarticular knee fractures represent a spectrum of injury patterns dependent on the energy, mechanism, and direction of load.

The same principles of treatment management for complex tibial plateau fractures may have a role in pure knee dislocations. This was the genesis for considering "staged protocols" for knee dislocations.

\textbf{STAGE 1}

After a knee dislocation is reduced, either spontaneously or by manual closed reduction, a thorough neurovascular assessment is performed based on the guidelines above. An exam under anesthesia within the first 24-48 hours after injury should be undertaken, along with fluoroscopic stress x-rays with comparison stress X-rays and clinical exam of the contralateral knee to determine the extent of ligamentous injury. If indicated, MRI compatible spanning joint external fixator is placed at that time. Postoperatively a MRI of the knee is performed. At this juncture, anticoagulation treatment should include low molecular weight heparin beginning 12 hours after surgery and continued until definitive fixation.

\textit{DVT Prophylaxis}

Some form of chemoprophylaxis with or without mechanical measures should be utilized in all of these patients due to the high risk of deep venous thrombosis with these complex injury patterns. Our current protocol is to initiate low molecular weight heparin immediately after determination of injury and after vascular assessment is complete and continue treatment until definitive fixation.

\textit{Indications for initial spanning external fixation}
2. Gross instability in the anteroposterior (coronal) plane.
3. Inability to tolerate immobilization in a knee brace alone.

\textbf{STAGE 2}

Definitive fixation is based on ligamentous involvement and timing of fixation is based on the status of the soft tissues. When the swelling has subsided, the skin wrinkles, and the abrasions look healed, the skin is amenable to surgical intervention. Our current protocol entails definitive repair/reconstruction of all ligamentous structures typically at 3-4 weeks post injury. This allows a time for soft tissue and inflammatory recovery; however is a short enough interval before extensive fibrosis begins.

\textbf{CLASSIFICATION}

We currently use the classification system described by Wascher which is a modification of the Schenk classification. It is an anatomic classification system which is helpful for research purposes and is fairly descriptive. We find this system helpful as it includes the Knee dislocation type five (KDV) for periarticular fracture dislocations, a significant portion of our practice.

\textbf{SURGICAL INDICATIONS}

\textit{Operative versus Nonoperative Management}

Treatment of knee dislocations in the literature remains controversial. In the last two decades several authors have noted improved outcomes with operative management. Richter et al\textsuperscript{19} evaluated
the outcomes of 63 surgically treated traumatic knee dislocations compared to 26 treated nonsurgically. The average follow-up in their series was 8.2 years. Lysholm and Tegner scores were significantly improved in the surgical group which led the authors to recommend early surgical management. Dedmond and Almenkinders performed a meta-analysis compared outcomes of operative versus nonoperative treatment of knee dislocations. They concluded that there was no statistically significant difference in either treatment arm with regards to patients' ability to return to pre-injury employment, athletic activity, or degree of instability. They did note, however, that the surgical group had statistically better results with regards to final range of motion and Lysholm score. Wong et al concluded that surgical treatment of knee dislocations showed improved overall knee function, stability, and patient satisfaction.

Current evidence-based medicine (EBM), although limited to a few level III studies, does support operative management.

SURGICAL TIMING

Early Versus Delayed Repair/Reconstruction

With regards to timing of the surgery several authors have shown improved outcomes with early versus late surgical repair. Liow et al reported improved outcomes in patients treated with early reconstructions (less than two weeks after injury) as it relates to overall knee function, activity levels, and anterior tibial translation. Wang et al evaluated the outcomes of delayed surgical reconstruction (greater than ten months from injury) for combined posterior cruciate ligament and posterolateral corner injuries and found 32% unsatisfactory results. He recommended early surgical reconstruction for this particular injury pattern. Ibrahim conversely reported 87% good and excellent results in a series of 41 traumatic knee dislocations treated acutely with primary reconstruction of the cruciate ligaments and repair of the collateral ligaments. Chhabra et al reported their clinical series of 31 patients, 19 of which were reconstructed acutely (less than three weeks after injury) and 12 patients treated with delayed reconstructions. They found no difference in final knee range of motion between the two groups, however, the group treated acutely had significantly better results with regards to knee stability and subjective scores.

Current evidence-based medicine (EBM), although limited to a few level III studies, does support early semi-acute surgical management of all damaged ligamentous structures.

SURGICAL TECHNIQUE

Repair versus reconstruct

A hot topic in the treatment of knee dislocations, several authors have shown improved outcomes with acute reconstructions as opposed to ligament repairs. Stannard et al, reported on 63 knee dislocations followed for 2 years and found significantly better results with the reconstructed group, specific to the posterolateral corner.

Current evidence-based medicine (EBM), although limited to this level II study, does support posterolateral corner (PLC) reconstruction, as opposed to repair, in the setting of multiligament knee surgery.

GRAFT SELECTION

Allograft Versus Autograft Reconstruction

Stannard et al (16) reported on 15 multiligament knee reconstructions utilizing soft tissue allografts. Fanelli et al (11) reported on a two- to ten-year follow-up of 41 patients utilizing a combination of various allografts and autografts for multiligament knee reconstruction. Talbot et al (17) reported on 21 knee dislocations utilizing all soft tissue allografts.
Satisfactory results have been shown with either allograft and/or autograft reconstructions in this patient population. In an effort to minimize patient morbidity, it is the authors' preference to utilize soft tissue allografts for ACL/PCL/PLC reconstructions and semitendinosus gracilis autograft for MCL reconstruction.

Current evidence-based medicine (EBM), although limited to level IV studies, supports the use of allograft and/or autograft reconstruction, in the setting of multiligament knee surgery.

**POSTOPERATIVE REHABILITATION**

*Standard rehabilitation protocol/role of external fixation*

The postoperative management of knee dislocations remains controversial. Noyes et al\(^{24}\), in their prospective study, reported a 0% incidence of permanent arthrofibrosis and a 0.7% incidence of manipulation under anesthesia to regain knee motion after anterior cruciate ligament reconstructions alone (219 knees) or combined with other procedures (224 knees).

The senior author currently follows the rehabilitation protocols used by Edson et al, Giannoulis et al, and Fanelli et al\(^{25,26,27,28,29,30}\). This rehab protocol recommends maintaining the knee in full extension for three weeks after multi-ligament knee reconstructions and then beginning progressive knee range of motion. Weight bearing typically begins at six weeks postoperatively with return to sports and heavy labor after nine months. The authors recommend hinged knee brace for up to one year after surgery.

Postoperative hinged knee external fixation has gained recent popularity with reports of improved outcomes versus knee brace alone. Stannard et al, have shown a significant reduction in revision rates from 37% to 4% using the compass external fixator postoperatively\(^{31}\). The articulating device allows for immediate range of motion while maintaining coronal, sagittal and rotational stability of the knee. Several other authors have also noted the benefits of compass spanning external fixation in the postoperative phase\(^{32,33}\).

There are currently no reports on the use of postoperative non articulating spanning external fixation after multiligament knee reconstruction, nor are there any reports on the use of preoperative spanning external fixation in the setting of acute high energy knee dislocation.

**TAKE HOME POINTS**

At the present time, there is a paucity of evidence-based medicine, and for the most part, treatment of knee dislocations remains controversial. From initial vascular assessment, to surgical indications, surgical timing, surgical technique, graft selection, and postoperative rehabilitation.

It is important to recognize that high-energy knee dislocations are limb threatening injuries with a high risk of popliteal artery injury.

We currently use a “staged protocol” to manage high energy knee dislocations. *Stage 1* consists of initial vascular assessment, examination under anesthesia, and the application of either a spanning joint external fixator or hinged knee brace locked in full extension. Patients are treated with concurrent low molecular weight heparin while awaiting definitive fixation. *Stage 2* consists of definitive ligament reconstructions usually at three to four weeks post injury if the soft tissues allow. All patients then follow a standard postoperative rehabilitation protocol.

Prospective studies are needed to elucidate whether or not the staged protocols are clearly of merit, and what risks exist with this approach.
BIBLIOGRAPHY


