MINI-SYMPOSIUM: SOFT TISSUE KNEE PROBLEMS

(iii) The dislocated knee

A. Robertson\(^a\), R.W. Nutton\(^b,\,*\)

\(^a\)The Royal Infirmary of Edinburgh, Scotland, UK
\(^b\)Department of Orthopaedics, Royal Infirmary, Little France, Old Dalkeith Road, Edinburgh EH16 4SU, Scotland, UK

KEYWORDS
Knee joint; Knee injuries; Knee dislocation; Dislocations

Summary
Knee dislocation is a rare injury usually resulting from high-energy trauma. Immediate complications can arise from injury to the popliteal artery or the common peroneal nerve. Early surgical reconstruction gives better results than delayed reconstruction, but this is a challenging procedure. The prognosis for knee function should be guarded, as there is a significant risk of long-term secondary degenerative change.

Introduction
Knee dislocation is a serious injury with potential significant long-term implications for return to physical employment and recreational activity (Fig. 1a and b). The clinical presentation of knee dislocation may be either acute—under 3 weeks—or chronic—after 3 weeks. Late presentation with multiple knee ligament injuries is not uncommon, as spontaneous relocation of the dislocated knee may lead to an initial underestimation of the severity of the ligamentous disruption. This is particularly likely when the knee dislocation was part of multiple trauma and initial treatment priorities were focused on long bone fractures, etc. rather than on the stability of the knee.

Epidemiology
Knee dislocation is uncommon representing less than 0.2% of all orthopaedic injuries.\(^1\) It predominantly occurs in younger patients, with a male to female ratio of 4:1. Knee dislocation is reported to be a component of multiple trauma in between 14% and 44% of cases.\(^2\) Half are the result of motor vehicle accidents, sports injuries account for around one-third of cases and simple falls for approximately 10%. Bilateral dislocation is rare occurring in only 5% of patients\(^2\) (Table 1).

Classification
In 1963 Kennedy proposed an anatomical classification based on the direction of tibial dislocation in relation to the femur.\(^8\) Five types of knee dislocation are described:

- anterior,
- posterior,
- lateral,
- medial,
- rotatory.

Rotatory is further subdivided into anteromedial, posteromedial, anterolateral and posterolateral types.
Although attractive in terms of simplicity, this direction-based classification system is an unreliable guide to specific patterns of ligament injury.

An alternative classification system, which addresses the specific pattern of ligament disruption and the presence or absence of associated intra-articular fractures was described by Schenk and modified by others (Table 2). This gives a clearer guide to patterns of knee ligament injury and can thus be used to plan treatment.

Patterns of ligament injury

Using the Kennedy classification, hyperextension of the knee resulting in anterior dislocation of the tibia on the femur is the commonest mechanism of injury, accounting for approximately 40% of reported cases. Posterior dislocation (33%) usually occurs as a result of an anteroposterior force, as in the "dashboard" type of injury. Varus or valgus loads may produce medial (4%) or lateral (18%) dislocations, which are associated with tibial plateau fractures (Fig. 2). A combination of force vectors results in rotatory dislocations.

Under the Schenk classification, the most common injury pattern is a bi-cruciate disruption with an associated medial (MCL) or lateral (LCL) collateral tear depending on the direction of the deforming force (Table 3).

The acutely dislocated knee

Clinical assessment

After initial patient assessment and management under ATLS protocols, particularly if multiply injured, the vascular and neurological status of the injured limb must be carefully and repeatedly assessed for evidence of injury to the popliteal artery and common peroneal nerve. The clinical findings must be clearly recorded. The clinical diagnosis should be confirmed by X-ray and the dislocation should be reduced under sedation as soon as possible and congruent reduction confirmed radiologically.
While patients may present without clinical and radiological signs of a dislocation if the joint has reduced spontaneously, the clinical signs should alert the clinician to the extent of the soft tissue injury to the knee. For example, an uncontained haemarthrosis with extensive bruising and swelling on the medial or lateral side of the knee suggests major disruption of the joint capsule, which should alert the examiner to the possibility of a dislocation. However, acutely a thorough clinical assessment of specific knee ligaments for injury may be difficult due to pain, limited knee flexion, muscle spasm and other associated injuries. Recurvatum on passive limb elevation (Fig. 3) and gross laxity on varus or valgus testing with the knee in full extension (Fig. 4) indicate a major cruciate or capsular disruption as a result of knee dislocation. Plain AP and lateral radiographs should be obtained in all cases of suspected dislocation given the high incidence of associated fractures and avulsions.

Vascular injury and angiography

The reported incidence of vascular injury in knee dislocation ranges from 4.8% in low-velocity injuries to 65% in higher energy trauma. Hence, a patient must be carefully assessed for signs of impaired circulation including ischaemic colour change, diminished or absent pulses with colour or temperature changes below the level of the knee. The ankle-brachial index (ABI) can supplement physical examination and may assist in deciding whether angiography is indicated. However, while very sensitive, the ABI has low specificity. Using a threshold of <0.90; however, it is possible to achieve a 100% positive predictive value for the presence of a vascular injury requiring surgical intervention.

Associated injuries

In association with high-energy trauma, fractures of the distal femur or tibial plateau and damage to the common peroneal nerve can occur. Fractures of either the distal femur or proximal tibia are reported to occur in between 4.5% and 34% of cases of knee dislocation. Bony avulsion injuries of the PCL are not unusual and marginal lateral tibial plateau avulsion fractures (Segond fractures) or fibular head fractures are seen, indicative of significant capsular, collateral and cruciate disruption. Anteromedial tibial plateau fractures in particular are associated with disruption of the posterior cruciate ligament (PCL) and posterolateral ligament complex (PLC).

Common peroneal nerve injury has an overall incidence of approximately 20%, but in dislocations with disruptions of the PCL and PLC the incidence may be as high as 45% due to the varus deforming force. Actual discontinuity of the nerve is present in 28% of cases but even if it is in continuity there may be extensive intraneural damage. When the nerve remains in continuity, spontaneous recovery occurs in 20% of cases with a more favourable prognosis if the nerve is damaged over short distances. Nerve grafting or tendon transfers may be considered as late reconstructive procedures if there is no recovery of nerve function.

Radiology

Plain X-rays of the knee demonstrate peri-articular fractures or avulsion fractures. Marginal fractures around the tibial plateau reflect significant capsule avulsions (Segond fracture) and anterior tibial plateau fractures are seen in hyperextension injuries with extensive disruption of the posterior capsule. Avulsion fractures occur at the tibial insertion of the PCL and at the tip of the fibula when the LCL has been avulsed. These reflect serious soft tissue

<table>
<thead>
<tr>
<th>Classification</th>
<th>Type</th>
<th>Associated ligament injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>KD-I</td>
<td>Dislocation</td>
<td>Single cruciate involved</td>
</tr>
<tr>
<td>KD-II</td>
<td></td>
<td>Bicruciate disruption only</td>
</tr>
<tr>
<td>KD-III</td>
<td></td>
<td>Bicruciate+posteromedial or posterolateral disruption</td>
</tr>
<tr>
<td>KD-IV</td>
<td></td>
<td>Bicruciate+posteromedial and posterolateral disruption</td>
</tr>
<tr>
<td>KD-V</td>
<td>Fracture</td>
<td>Single cruciate involved</td>
</tr>
<tr>
<td>KD-V2</td>
<td></td>
<td>Bicruciate disruption only</td>
</tr>
<tr>
<td>KD-V3M</td>
<td>Dislocation</td>
<td>Bicruciate+posteromedial disruption</td>
</tr>
<tr>
<td>KD-V3L</td>
<td></td>
<td>Bicruciate+posterolateral disruption</td>
</tr>
<tr>
<td>KD-V4</td>
<td></td>
<td>Posteromedial and posterolateral disruption</td>
</tr>
</tbody>
</table>

Figure 2  Lateral tibial plateau fracture associated with knee dislocation.
disruption. The extent of this is best shown by MRI scanning which should always be performed before undertaking surgical reconstruction.

The necessity for routine angiography has been contentious, some authors considering it mandatory\textsuperscript{4,14,15} while others believe that it is only necessary in selected cases.\textsuperscript{16,17} Overall the published evidence suggests that routine angiography in knee dislocation is not necessary, only being performed if there is doubt about the circulatory status of the limb. Magnetic resonance angiography (MRA) is an alternative to standard angiography.

### Early management and surgical reconstruction

Following a thorough neurovascular assessment of the limb the immediate priority is to reduce the knee and provide temporary stabilisation of the knee with an external splint. Following reduction the vascular status of the limb should be reassessed.

If there is any doubt about limb perfusion a vascular surgical opinion should be sought and urgent angiography performed. Surgical reconstruction of the popliteal artery should take priority as delay in restoring circulation is associated with an increased risk of amputation. Under the same anaesthetic as the vascular repair, the collateral ligaments and capsule injury should be explored. The aim is to achieve sufficient stability of the knee to protect the vascular repair. Primary repair of the capsular and collateral structures may be accomplished by ligament reattachment, augmentation or a combination of techniques and associated fractures of the tibial plateau or distal femur should be stabilised. If the knee remains unstable further temporary stabilisation may be obtained by using a bridging external fixator. Once initial stability and limb viability has been achieved, delayed reconstruction of the cruciate ligaments can be carried out as a staged procedure without a tourniquet at 6–12 weeks.

### Table 3 Patterns of knee ligament disruption associated with knee dislocation.

<table>
<thead>
<tr>
<th>Study</th>
<th>No.</th>
<th>ACL/PCL/MCL/PLC (%)</th>
<th>ACL/PCL/MCL (%)</th>
<th>ACL/PCL/PLC (%)</th>
<th>ACL/PCL (%)</th>
<th>ACL or PCL+other/# (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harner et al. (2004)\textsuperscript{5}</td>
<td>19</td>
<td>0</td>
<td>53</td>
<td>37</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Liow et al. (2003)\textsuperscript{6}</td>
<td>22</td>
<td>0</td>
<td>23</td>
<td>32</td>
<td>9</td>
<td>45</td>
</tr>
<tr>
<td>Werier et al. (1998)\textsuperscript{2}</td>
<td>38</td>
<td>21</td>
<td>37</td>
<td>37</td>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td>Wascher et al. (1997)\textsuperscript{6}</td>
<td>50</td>
<td>12</td>
<td>48</td>
<td>16</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Pooled estimate</td>
<td>129</td>
<td>11</td>
<td>41</td>
<td>28</td>
<td>7</td>
<td>12</td>
</tr>
</tbody>
</table>

### Figure 3 Recurvatum following a knee dislocation.

### Figure 4 Varus instability following knee dislocation.
If there is no vascular injury the surgical approach will be determined by the pattern of ligament injury. Immediate reconstruction of all injured ligaments is a major surgical challenge requiring expertise in knee ligament reconstructive surgery and access to essential resources including allograft tendons. Where expertise and such resources are not immediately available, a limited capsular and collateral ligament reconstruction should be performed. This may be achieved by reattaching avulsed structures using suture anchors, ligament staples or screws and ligament washers. Mid substance tears of the collateral ligaments may be repaired directly and augmented with locally available tissue from the medial hamstrings for the MCL and biceps femoris for the LCL.

If cruciate ligament reconstruction is being considered in the acute phase the degree of capsular injury must be considered. Attempts to perform arthroscopic surgery before capsule healing increase the risk of fluid extravasation and may cause a compartment syndrome. If arthroscopic repair is undertaken, a pump should not be used. Cruciate ligament reconstruction (especially PCL reconstruction) in this situation is technically difficult and should not be attempted unless the surgeon has considerable experience in knee ligament reconstruction surgery. In addition access to tendon allografts is an advantage in order to reduce the demand for autogenous tissue from the damaged knee. It is possible to consider harvest from the opposite leg but this is not always practical and the patient may object to his ‘normal’ leg being used for this purpose.

Arthroscopically assisted anterior cruciate ligament (ACL) and PCL reconstruction can be performed when the capsule has healed and the patient has started to regain range of movement. Under these circumstances the patient can be referred to a centre, which specialises in knee ligament reconstruction for the second stage of the reconstruction.

**Chronic knee instability following dislocation**

Chronic knee instability may result from an episode of dislocation. The multiple ligament injuries caused by the dislocation causes complex patterns of instability, which can be very disabling. Such need careful objective assessment to accurately delineate the pattern of ligament damage. A management plan must address whether the patient will benefit from ligament reconstruction surgery, taking into account the complexity of the surgery and the prolonged rehabilitation. Additionally, if secondary changes of altered mechanical alignment and secondary degenerative changes have occurred, then corrective osteotomy may be required before considering ligament reconstruction. This complex scenario could require two operations, firstly to correct malalignment and secondly to perform a multiple ligament reconstruction. Patients must be aware of the implications of this complex and protracted course of treatment.

**Primary and secondary ligament restraint**

The concept of primary and secondary restraint is central to understanding complex knee instability. A primary restraint is the main resistance to a deforming force on the knee, e.g. the medial collateral is the primary restraint to valgus force on the knee. A secondary restraint has a smaller but significant role in resisting a force, e.g. the ACL also resists a valgus force applied to the knee. If a secondary restraint is ruptured when the primary restraint is intact, there will be no discernable instability when a force is applied to the knee. However, if the secondary restraint is ruptured as well as the primary restraint, the magnitude of the instability is greater when the same force is applied, e.g. the degree of valgus instability is greater when the MCL and ACL are torn than when the MCL is torn in isolation. Other important primary and secondary restraints are the PCL and popliteo-fibular ligament (PFL) which restrain external rotation of the tibia and the ACL and PLC in controlling the dynamic instability demonstrated by the pivot shift test. The LCL is the primary restraint to varus force, whereas the PLC, particularly the PFL is the primary restraint to tibial external rotation.

**Clinical examination**

The patient is first observed standing and walking to assess limb alignment at the knee. Increased varus and a lateral thrust on walking suggest varus malalignment. This can be confirmed by taking weight bearing long leg alignment radiographs.

The normal knee should always be examined for comparison. The range of knee movement must be recorded. In particular abnormal hyperextension compared to the uninjured knee may indicate disruption of the posterior capsule. The varus recurvatum test assesses the passive extension of the knee as well as the tendency for the knee to fall into varus when held in an extended position suggesting damage to the LCL and PLC.

The examination should progress in a logical stepwise fashion addressing each major ligament restraints to each of the main deforming forces, varus, valgus and anteroposterior in turn before assessing dynamic instability using the pivot and reverse pivot tests.

The collateral ligaments should be examined with the knee in full extension and with the posterior capsule relaxed with the knee flexed to 20°. The degree of joint line gapping and the quality of the endpoint should be noted.

The cruciate ligaments are assessed with the knee flexed to 90°. The position of the anterior margin of the tibia in relation to the femoral condyles to assess posterior sag is noted, remembering that when both cruciate ligaments are torn, the anteroposterior translation is increased such that it is difficult to determine the neutral anteroposterior position of the tibia.

Abnormal posterolateral or posteromedial rotation of the tibia is then assessed. The Lachman test, so useful for detecting isolated ACL tears, is of less value in multiple ligament injuries. Increased tibial external rotation is an important feature of more severe types of knee instability, as the lateral ligament complex, particularly the popliteo-fibular ligament (PFL), is the primary restraint to external tibial rotation with the PCL a secondary restraint. Tibial external rotation is best examined with the dial test performed with the patient prone (Fig. 5a and b). At 30° of flexion the PFL is the primary restraint, therefore if the tibia (indicated by the medial border of the foot) externally
rotates by more than 10° compared to the uninjured knee, the PFL is damaged. At 90° of knee flexion however, the PCL will act as a secondary restraint and will limit external tibial rotation even if the PFL is damaged. If the dial test is positive at 90° of knee flexion, then both the PFL and PCL have been torn.

The final part of the examination assesses the dynamic stability of the knee by performing the pivot and reverse pivot shift tests. The pivot shift is positive when the ACL is torn but the degree of instability is increased with the tibia tending to ”lock out” when the PLC is damaged along with the ACL. The reverse pivot shift also assesses the PLC but can be positive in normal knees if the patient has a degree of joint hypermobility. A positive reverse pivot shift reflects injuries to the PCL and PLC resulting in a posterolateral rotatory instability (PLRI).

Clinical examination should define the pattern of ligament injury, but MRI scanning is helpful in confirming clinical findings. Correctly advising the patient as to the most appropriate management will depend on many factors including the patient’s age, the physical demands they place on the knee, the degree of disability experienced by the patient and their ability to cooperate with the extended programme of rehabilitation required after surgery. If malalignment of the knee is present, ligament reconstruction surgery will fail and osteotomy should be considered with or without ligament reconstruction.

Surgical reconstruction

Detailed description of the surgical techniques used for ligament reconstruction in complex knee instability is beyond the scope of this review but the basic principles will be described. The principle behind all reconstructive procedures used for complex knee instability is to define all components of the instability and to reconstruct the primary restraints as anatomically and isometrically as possible.

In patients with bi-cruciate injuries or if the PCL alone is ruptured the first objective is to reduce the posterior subluxation of the tibia by reconstructing the PCL. This reconstruction can be performed using autograft from the injured knee or from the opposite leg. Semitendinosus and gracilis, patella tendon and quadriceps tendon have all used for this purpose. In the multiply injured knee in which more than one ligament will be reconstructed it is not advisable to take more than one autograft from the affected leg where the soft tissues are already compromised as a result of injury. In these cases it is advisable to have access to allograft tendons which can be used to reconstruct one or both cruciate ligaments. An Achilles tendon allograft is suitable for reconstruction of the PCL and patella tendon allograft for the ACL reconstruction.

Techniques for reconstruction of collateral ligaments depend on the precise nature of the injury. If the MCL has been avulsed from the medial epicondyle (Pellegrini Stieda type of injury), the femoral attachment can be recessed into the medial condyle of the femur, which should maintain the isometric position of the MCL. This is only effective if there has not been structural lengthening of the superficial band of the MCL, in which case, the superficial band can be augmented using gracilis or semitendinosus. These are left attached to the proximal tibia and fixed in an isometric position to the medial femoral condyle using a screw and ligament washer. Care should be taken not to over tighten the MCL reconstruction, which can ‘capture’ the knee preventing full extension.
As the knee may be unstable in varus or in external rotation, or both, reconstruction of the lateral side of the knee must address either or both components of the instability if present. Advancement techniques as used on the medial side of the knee are less effective for deficiency of the lateral structures and will only address mild degrees of lateral ligament deficiency. Most reconstructive procedures require augmentation of either the LCL or popliteus/PFL using autografts or allografts. The Larson technique using a semitendinosus autograft has been widely used and modified to address deficiencies of the LCL and PFL.20

Rehabilitation

Although accelerated post operative rehabilitation programmes have transformed the recovery process for patients undergoing isolated ACL reconstruction, these regimes are not suitable for patients who have undergone multiple ligament repairs or reconstruction following a knee dislocation.4,5,21–25 In these patients the rehabilitation should be tailored to the particular pattern of injury and reconstruction. The principles of rehabilitation remain the same in the acutely injured knee and following delayed reconstruction. Close liaison with a physiotherapist familiar with this type of rehabilitation programme is essential and a team approach undoubtedly benefits the patient.

In most cases the PCL has been reconstructed and posterior tibial subluxation reduced. Not only is it essential to avoid exercises which will stress the PCL reconstruction, in particular open chain hamstrings contractions, but gravity is also acting on the reconstruction causing the tibia to fall back especially when the knee is flexed relaxing the posterior capsule. Thus if the PCL has been reconstructed as part of the multiple ligament repair it is advisable to splint the knee in extension (but avoiding hyperextension) for the first 6 weeks. Total immobilisation however is not beneficial for capsule repairs or augmentation procedures, which will benefit from controlled movement of the knee during the initial healing period. Many different approaches have been described to address this conflict between splinting the knee straight and starting controlled motion. In the senior author’s practice the knee is splinted in a hinged brace at 10° of flexion to avoid hyperextension. The brace is unlocked regularly to allow passive knee flexion and active knee extension, initially from 10–60° for the first 3 weeks, increasing the range to 10–60° from 3 to 6 weeks post-operatively. During this time the patient is allowed to ‘touch’ weightbear on their toes rather than remaining non-weightbearing. After 6 weeks the brace is unlocked to allow unrestricted knee flexion and is discarded after 8 weeks. From 6 to 10 weeks the patient is advised to increase weight bearing on the affected leg, usually progressing to full weight bearing by 10 weeks. Muscle strengthening progresses gradually after removal of the brace, but it is advisable to avoid open chain hamstring exercises for up to 6 months. Closed chain exercises and active knee extensions are encouraged. The process of recovery is gradual and individual to a particular patient however it is unusual for patients to return to manual work in less than 6 months and sporting activities by 12 months.

Outcomes

Knee dislocation inevitably results in severe soft tissue disruption. Earlier studies suggested that knee dislocation could be treated non operatively with good results.5,27 However, while improvements in surgical techniques allied to a better understanding of the injuries have resulted in an increasing body of evidence demonstrating that early reconstruction, where feasible, will result in better outcomes,5,4,21–23 return to normal function is uncommon. In recent studies where patients were evaluated using the IKDC26 score, no patients were rated as normal at the time of review and overall, 38% were nearly normal, 40% abnormal and 21% severely abnormal.4,6 A recent meta-analysis of studies on the management of knee dislocation concluded that knee ligament reconstruction was associated with better overall results, with a significantly lower risk of residual stiffness and better Lysholm scores.28 Although, ligament reconstruction has improved the range of motion and functional outcome scores some residual impairment of knee function can be expected.28 Common complications after surgical reconstruction are joint stiffness and failure of some component of the reconstruction. Post-traumatic osteoarthritis may be expected in up to 50% of patients in the long term.2

Practice points

- Remain alert to the possibility of knee dislocation in high-energy trauma
- Careful evaluation and close monitoring of the neurovascular status of the limb is essential
- Early stabilisation with primary repair of capsular structures and avulsed collateral ligaments prior to formal cruciate reconstruction may be performed if the facilities and expertise are not available to perform early definitive reconstruction
- The main objective in delayed reconstruction is to identify all components of the knee instability and reconstruct the primary restraints
- A team approach to rehabilitation is beneficial to the patient’s recovery

Research directions

- Epidemiological studies of factors determining outcomes in multiple ligament injuries
- Bioengineering studies on optimum techniques for ligament reconstruction
- Tissue culture research to engineer ligaments for implantation
- Rehabilitation techniques to optimise functional recovery following multiple ligament reconstruction

References


