Knee Dislocation

Jacques Menetrey

Abstract

Knee dislocation is a devastating injury that necessitates a prompt diagnosis. Considering the final position of the tibia with respect to the femur, the dislocation can be classified as anterior, posterior, medial, lateral or rotatory. Reduction must be rapidly performed if necessary. Vascular and neurological status must also be repetitively evaluated. Emergency repair of any vascular injury has to be performed. In general, surgical repair of all ligamentous lesions is recommended in the "therapeutic window" between 10 and 20 days. Proper treatment leads to 80 % good to excellent results.

Introduction

Definition

Knee dislocation is uncommon and defined as the complete loss of contact between the articular surfaces of the tibia and the femur. In fact, knee dislocation is a misnomer, because a true dislocation is rarely encountered. Most of the time, the knee is reduced when the patient presents for medical care and the problem is a multiligament knee injury, defined most commonly as rupture of at least two to four major knee ligaments: anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), posterolateral corner (PLC), lateral collateral ligament (LCL), posteromedial corner (PMC), and medial collateral ligament (MCL). These lesions result in multi-directional knee laxities associated with vascular and neurological injury in about one fifth of cases.

Epidemiology

Traumatic knee dislocation is uncommon and represents less than 0.5 % of all joint dislocations [9, 39]. Schenk reported an incidence of 1.2 % in a series of general orthopaedic trauma [29], while others reported that knee dislocations account for 0.02–0.2 % of all orthopaedic injuries [8–10, 13, 26, 38]. Knee dislocation occurs in younger patients with a male-to-female ratio of 4:1 [9]. Half of them are secondary to motor vehicle

J. Menetrey, MD
Centre de médecine de l'appareil locomoteur et du sport - HUG Service de chirurgie orthopédique et traumatologie de l'appareil moteur,
Unité d'Orthopédie et Traumatologie du Sport (UOTS), University Hospital of Geneva,
Faculty of Medicine,
Rue Gabrielle-Perret-Gentil 4,
CH-1211 Geneve 14, Switzerland
e-mail: jacques.menetrey@hcuge.ch

G. Bentley (ed.), *European Instructional Lectures*, European Instructional Lectures 14,
DOI 10.1007/978-3-642-54030-1_13,

accidents (high-velocity dislocation), approximately 30 % are sports injuries (low-velocity) and 10 % are from simple fall (ultra-low-velocity dislocations) [31]. Bilateral dislocations are rare and occur in 5 % of patients [9]. Several studies have reported ultra-low energy dislocations in morbid obese patients [24, 28, 30]. Five to seventeen percent of knee dislocations are open [12]. In 14–44 % of patients, knee dislocation is one component of multiple trauma [9].

Classifications

Considering the final position of the tibia with respect to the femur, the dislocation can be classified as anterior, posterior, medial, lateral or rotatory [9].

- Anterior knee dislocation accounts for 40 % of all dislocations, usually it occurs after a hyperextension of the knee in sports and in obese patients, and results in 39 % injury of the popliteal artery [5, 11].
- Posterior knee dislocation accounts for 33 % of all dislocations, is often caused by motor vehicle accident, and results in 44 % injury of the popliteal injury [5, 11].
- Medial knee dislocation accounts for 4 % of all dislocations, is caused by a forceful blow on the lateral side of the knee that leads to more ligamentous damage, and results in 25 % injury of the popliteal artery [5].
- Lateral knee dislocation accounts for 18 % of all dislocations, is caused by a forceful blow on the medial side of the knee, is sometimes irreducible by closed method, and results in 6 % injury of the popliteal artery and in neurologic injury [5].

Then, considering the anatomical injury pattern, as well as any associated neurovascular injury, Schenk has proposed the following classification system [29].

- KD1: intact PCL with variable injury to collateral ligaments;
- KD2: both cruciate ligaments disrupted with intact collateral ligaments (rare);
- KD3: both cruciate ligaments disrupted with medial or lateral ligament disrupted;
- KD4: both cruciate ligaments and both collateral ligaments disrupted;
- KD5: knee dislocation with peri-articular fracture.

This classification allows for establishing and organizing the clinical and surgical treatment of these injuries. Recently, another classification was described during the ESSKA's Symposium and redefined in the 10th Journées Lyonnaises de Chirurgie du Genou in Lyon to consider the pentads injuries in knee dislocation. In this system of classification, it is possible to identify the ligament injuries starting from the mechanism of injury and the relative positions of the tibia and femur [20, 21].

Finally, knee dislocation can be congenital, open or close, associated to fracture of the femur, the tibia, and/or the patella.

Clinical Evaluation

For acute knee dislocation, management and effective patient evaluation according to basic Advanced Trauma Life Support (ATLS) principles is the priority. Frequently, the knee is reduced on presentation and the diagnosis is often missed. According to the injury mechanism, one must have a high degree of suspicion about a knee dislocation, especially in the presence of an extensive swelling and bruising, and an uncontained haemarthrosis (Fig. 1). Neurovascular status has to be carefully and serially assessed. In case of a dislocated knee at presentation, close or, if necessary, open reduction must be performed under sedation as soon as possible. Then, a thorough clinical examination should be accomplished by an experienced surgeon. Indeed, ligament testing is difficult to perform in the acute phase due to pain, muscle spams and extreme laxity.

The incidence of associated vascular lesions in knee dislocation has been reported to be of 5–64 % [18, 19], but more recent studies have quoted a range of 7.5–14 % [1, 6, 10]. Pulses and sign of ischaemia must be carefully and repeatedly assessed (2–4 hourly over 24–48 h). In case of decreased pedal pulses, sign or symptoms of ischaemia, ankle-brachial blood pressure index

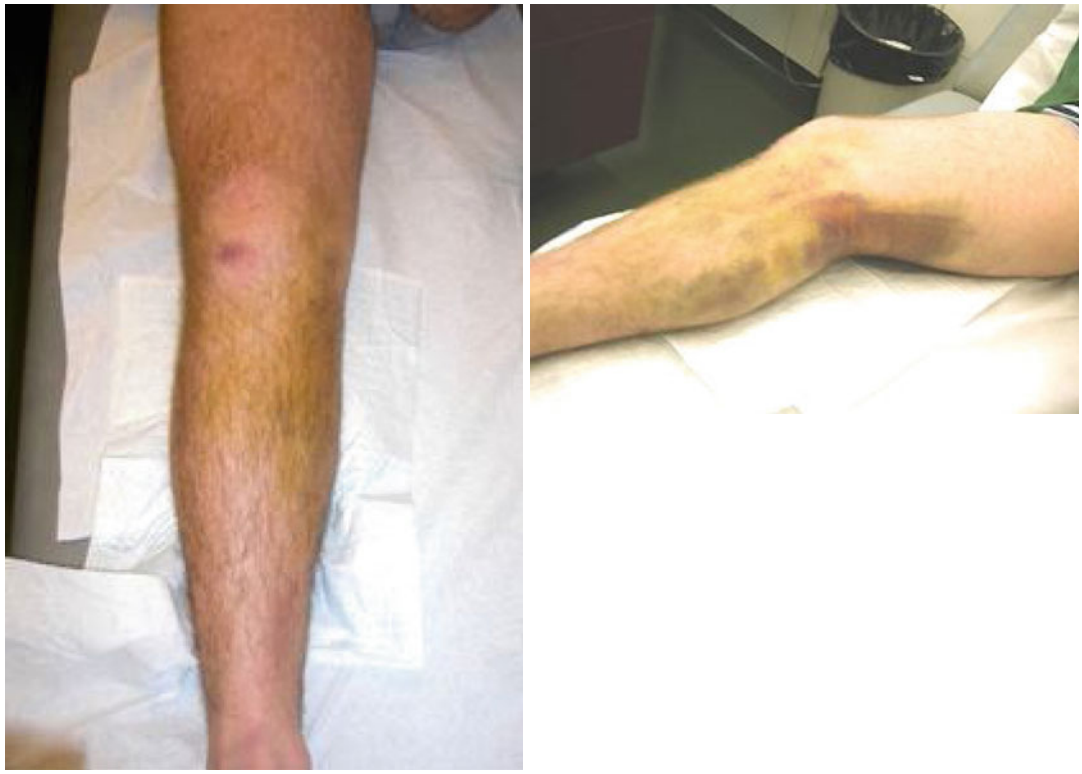


Fig. 1 Large swelling, bruising and uncontained haemarthrosis following a knee dislocation reduced at presentation

(ABI) <0.8, an immediate duplex ultrasound and/or an arteriography must be organized [36, 40]. Selective arteriography can be reserved if there is symmetric pedal pulses and no sign or symptoms of ischemia. However, careful assessment for signs of impaired circulation, asymmetrical or absent pulse should be performed regularly, repeatedly and documented. Indeed, distal pulse can be maintained for some time despite popliteal arterial injury by collateral circulation [23]. Intimal tear lesions are at least initially not flow limiting and are depicted by arteriography. In the past, this led to surgical exploration. However, recent studies have shown that the vast majority of intimal tears do not progress, and the current vascular surgical management with no flow limitation is simply a period of observation [34].

Peroneal nerve injury has been reported as having overall incidence between 14 and 45 % [6, 22, 27]. Nerve injuries are more frequently associated with posterior, postero-lateral, and medial dislocations. They are pathognomonic of severe lateral compartment injury and can go from neurapraxia to complete nerve disruption [7, 11, 32, 33]. From these neurological injuries, 30 % recover completely, 20 % lead to a residual deficit, and 50 % result in complete palsy and sensory deficit. Neurolysis or grafting have not been proven effective [11, 19, 33, 35].

Imaging

As all knee injuries, multi-ligament knee injuries should be investigated with the classical traumatic knee radiographs series including antero-posterior (AP), lateral and axial views. Radiographs allow for the verification of the congruency between femur and tibia as well the proper alignment of the patello-femoral joint (Fig. 2a and b). They also permit to demonstrate associated fractures or bony avulsions that will influence the strategy of treatment.

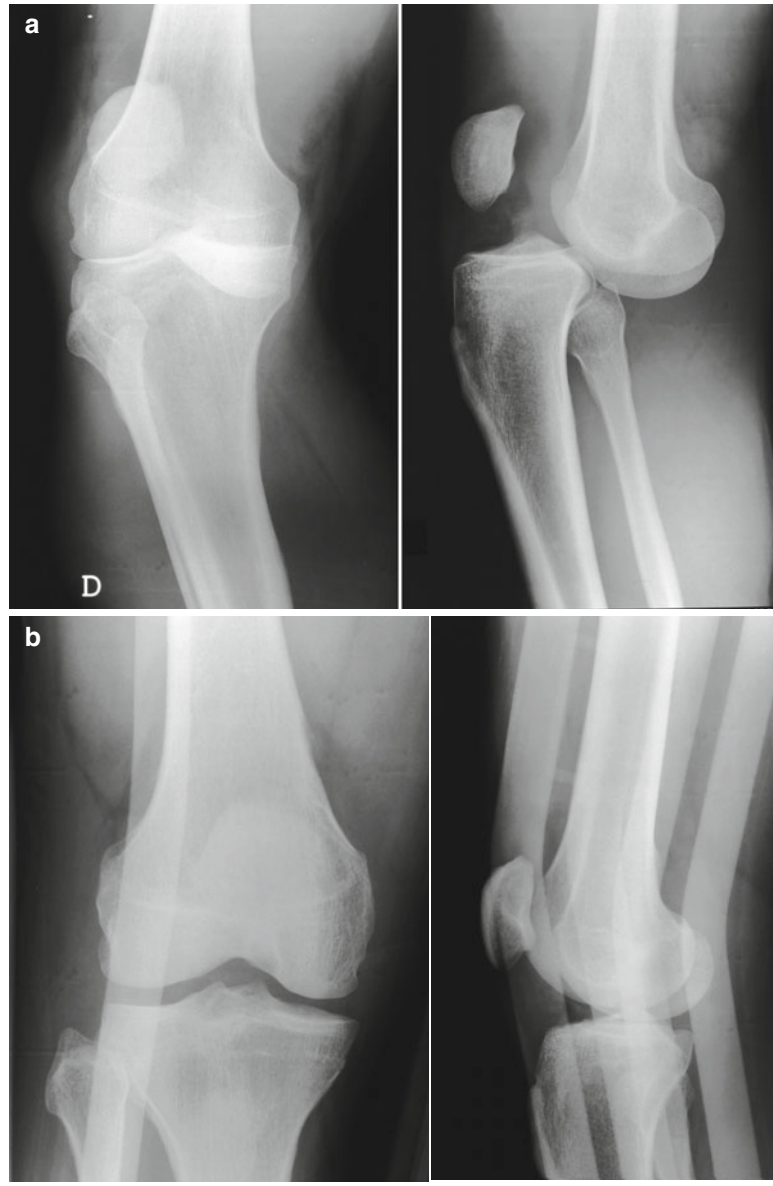


Fig. 2 (**a**, **b**) Antero-posterior and lateral radiographs allow for the verification of the congruency between femur and tibia

In the absence of vascular problems, MRI should be obtained in the first 3–5 days to assess extent of injury and allow for proper surgical planning. For example, if the PCL lesion appears to be a "peel off" lesion (proximal PCL disinsertion), a trans-osseous re-insertion can be performed and harvesting of a graft for the PCL is not required. MRI analysis should be performed methodically for injured structures: Anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), posteromedial corner (PMC), posterolateral corner (PLC), medial collateral ligament (MCL), lateral collateral ligament (LCL), medial meniscus (MM), lateral meniscus (LM), and associated cartilage lesions (Fig. 3a and b). Recently, Walker et al. have clearly stated that a close relationship between radiological findings and surgical considerations is crucial for optimizing the treatment of multi-ligament injury [39].

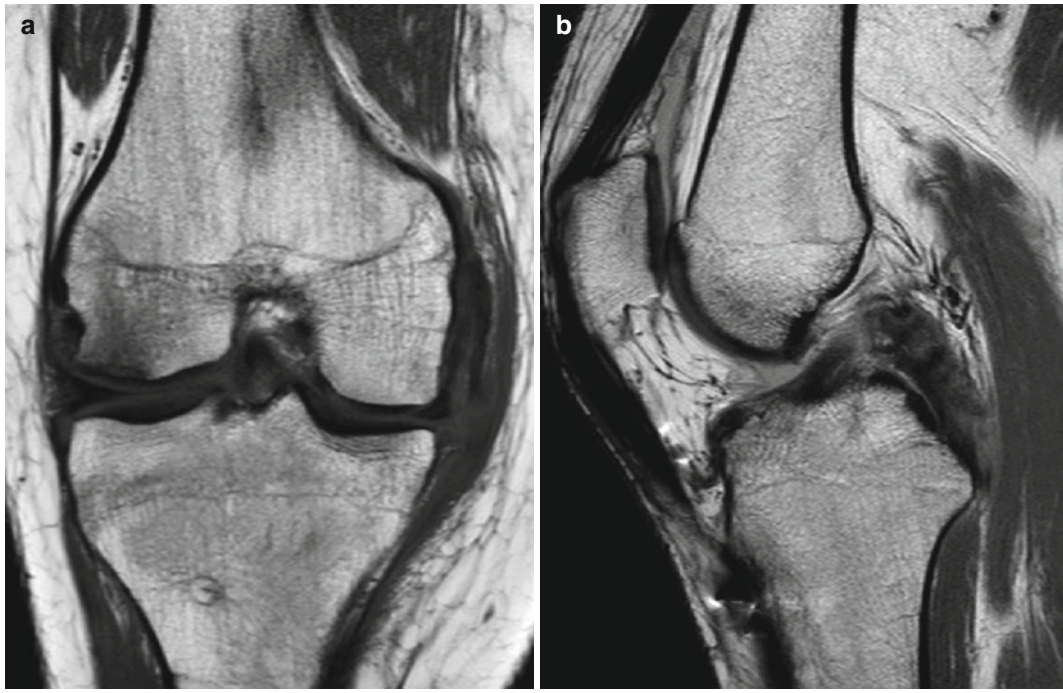


Fig. 3 MRI demonstrates the exact definition of the anatomical injury. (**a**) Mid-substance injury of the MCL with disinsertion of the medial meniscus. (**b**) Mid-substance injury of the PCL and ACL

Algorithm of Treatment

The algorithm we apply at the University Hospital of Geneva is as in Table 1. The only recent change is that we tend now to perform an immediate magnetic resonance (MR) angiography. In a small series of knee dislocations, findings were comparable to angiography [25]. This accelerates the diagnosis of asymptomatic vascular lesion.

Vascular injury must be depicted and treated within the first hours post-trauma (<6 h). If a knee dislocation should occur on a sports field, it is mandatory to rapidly transfer the injured athlete towards a medical institution, in which vascular imaging and surgery is available.

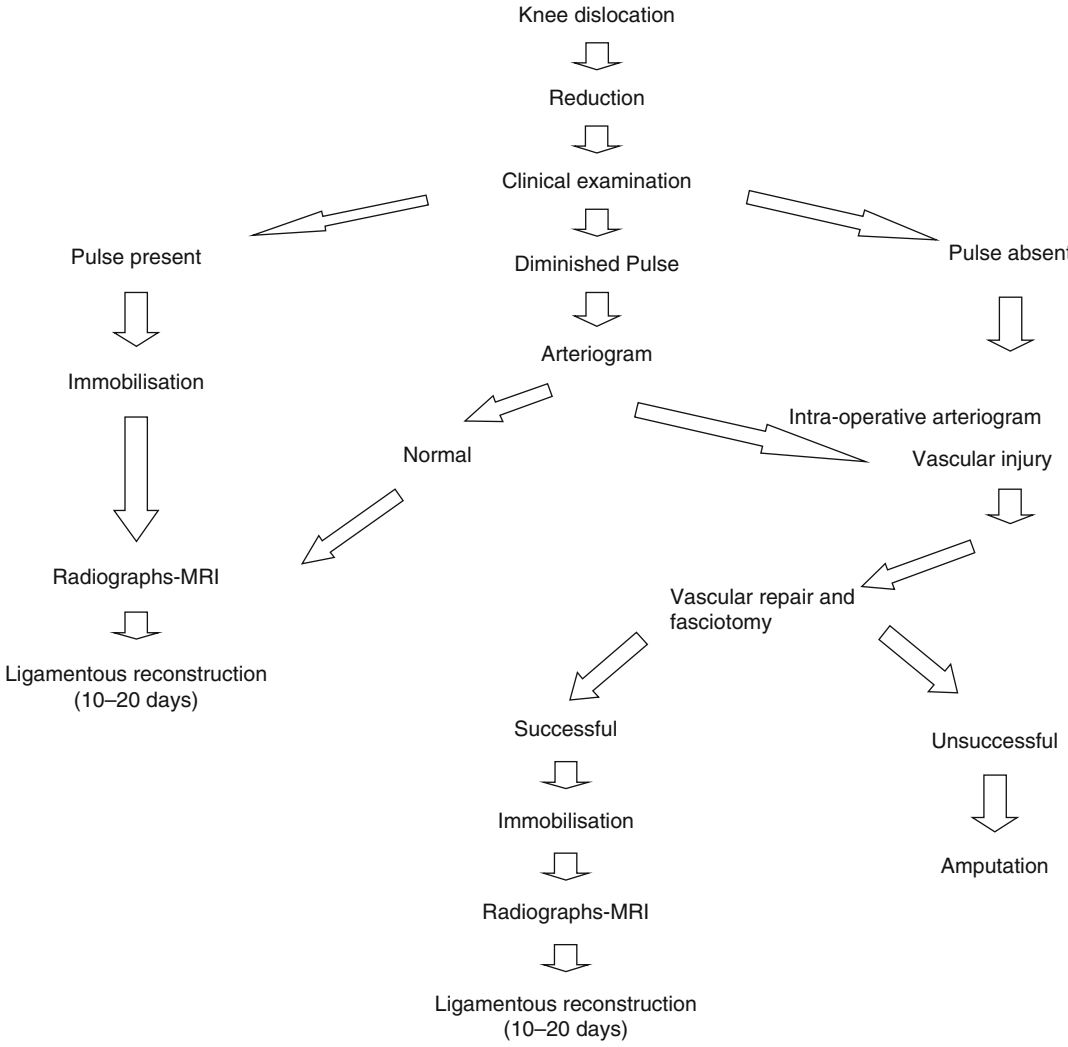
Following reduction and assessment of vascular status, early management consists of immobilization of the limb to provide analgesia, with stability and rest of the soft-tissue [9]. If the patients request vascular surgery, or in case of associated fracture and/or gross laxity, an external fixator can be applied concomitantly.

Treatment

Options of treatment are multiple and include cast immobilization, operative repair, early reconstruction of the PCL with late reconstruction of the ACL if needed, autograft versus allograft reconstruction of the ACL and PCL, and repair versus reconstruction of the LCL and PLC. There has been large debate regarding the most appropriate way to manage these difficult injuries and controversies exist [9, 14].

In young and active patients, the reconstruction of ACL and PCL, and repair/reconstruction of the PLC and/or PMC between 10 and 20 days post-trauma is recommended. In mid-age and low-demanding patients, the reconstruction of the PCL and repair/reconstruction of the PLC and/or PMC, with a delayed ACL reconstruction if needed, can be recommended. However, each case should obviously be discussed individually and a treatment "à la carte" proposed. In older patients with no demand and practicing no sport, the treatment may be conservative and functional.

Table 1 Algorithm of treatment applied at the University Hospital of Geneva



Open knee dislocations require an emergency reduction, a lavage-debridement, a "repair all that is possible" approach, and antibiotics. Secondarily, when soft-tissue lesions have healed, all clinically significant residual laxities can be corrected by ligamentous reconstructions.

In knee dislocation associated with fractures, we recommend first to restore the bone frame by fixing the fractures and to repair/reconstruct peripheral ligamentous injuries. The technique chosen for the fracture fixation should permit ligamentous reconstructions later. However, immediate mobilization should be possible in the post-operative period in order to prevent stiffness. Once the range of motion has been regained, and only in case of obvious residual laxity and instability, cruciates ligament reconstruction can be performed.

Conservative Treatment

In a selected category of patients, conservative and functional treatment has a place in the care of knee dislocation. Usually the treatment begins with immobilization in extension for 4–6 weeks. The treatment should be adapted to the injury pattern and be focussed on the PCL, posteromedial

Fig. 4 Dynamic customized PCL-brace is used from the sixth week to 6 months post-operatively. (**a**) Front view; (**b**) Side view; (**c**) Back view

and/or posterolateral lesions. Patients are non-weight-bearing or just "toe touching" for a period of 6 weeks. The mobilization of the knee can start in the second week in the prone position with a flexion initially limited to 30°. The flexion angle will be progressively increased by about 30° every 2 weeks. From the sixth week, the patient will progress to full weight-bearing and will start his muscle reconditioning focusing first on the quadriceps muscle. At the same time, the patient is put in a PCL dynamic brace (Fig. 4) that will protect the PCL graft from untimely posterior drawer. The flexion angle will be progressively open to full range of motion. After 3–4 months, it will be critical to work on the dynamic stability of the injured limb.

Surgical Treatment

Surgical treatment represents the best option in young and active patients or in patients with high physical demands. This is a complex surgery that should be performed by an experienced team.

Timing of Surgery

Reconstructive surgery should be performed in one-stage in the so-call "therapeutic window" from the first to the third week after the trauma. The timing depends upon the soft tissue status. Bruising, swelling and skin condition should permit several approaches around the knee. The correlation between early surgery and stiffness is still a matter of debate. We know that the incidence of stiffness increases with the repair of the MCL and a prolonged limited motion in the post-operative period. We also know that results are better when the surgery is performed at the sub-acute phase (<3 weeks) compared to the chronic one [15]. However, if acute or sub-acute surgery has a higher incidence of stiffness, surgery at the chronic phase has higher incidence of residual laxity. This information should be part of the discussion with the patient when the strategy of treatment is discussed.

Fig. 5 Longitudinal incision for the harvesting of the quadriceps tendon, one incision for the PCL and ACL tibial tunnels, and one lateral approach for the lateral compartment

Techniques

Surgical technique can be arthroscopically-assisted or open, the surgeon may utilize autografts and/or allografts. Advantages of allografts in this surgery are a decreased tourniquet time, a strong graft, fewer skin incisions and less dissection, and no graft site morbidity. The aim is to minimize the iatrogenic insult of this extensive surgery. The surgeon should perform the techniques with which he has the most experienced, and a technique that is well adapted to the injury pattern and to the grafts available.

In our institution, we favour a quadriceps tendon autograft for the PCL, a BPTB allograft for the ACL, and a semi-tendinosus tendon autograft and/or allograft for the lateral compartment.

We do also prefer several limited incisions rather than a long centralized one (Fig. 5).

We usually "fix all that is torn" in one-stage, beginning with the PCL and ACL, and following with peripheral lesions. PCL and ACL reconstructions are carried out arthroscopically while peripheral lesions are treated through open approaches. The use of a fluoroscopic control to ensure a proper placement of the different tunnels is recommended especially in chronic lesions (Fig. 6). Lesions of menisci and/or cartilage are addressed at the same time, with the preservation of the meniscal tissue and the stimulation of the intrinsic repair capacity of the cartilage. In most of the cases, avulsion injuries of the medial compartment can be repaired using sutures, sutures anchors, screws and washers. For mid-substances injuries, an augmentation procedure can be required and we usually use a semi-tendinous or gracilis tendons allograft. Lesions of the lateral compartment need to be finely analyzed in order to determine the proper technique between re-insertion of a distal avulsion upon the fibular head, reconstruction of mid-substances injuries of the LCL, arcuate complex, popliteofibular ligament and popliteus tendon, as well as eventual repair-re-insertion of the proximal attachment upon the femur. Lesions at the musculoskeletal junction of the popliteus muscle can be repaired, but the functional recovery of such a repair is limited. Repair of the posterolateral corner and lateral collateral ligament has shown a significantly higher failure rate in comparison with reconstruction, and a lower rate of return to sports activities [15, 16].

Post-operative Rehabilitation

After the operation, the knee is immobilized in a brace locked in extension. The treatment should be adjusted to the injury pattern and aiming at the protection of the PCL graft. Patients are usually non-weight-bearing or just "toe-touching" for a period of 6 weeks. The mobilization of the knee can start on the second post-operative day in the prone position with initial flexion limited to 30°. The brace is then unlocked and the mobilization can be made with the support of the brace. The flexion angle will be progressively increase by about 30° each 2 weeks. From the sixth week, the patient will progress to full weight-bearing and will start his muscle reconditioning focusing on the quadriceps muscle recovery. At the same time, the patient is put in a mobile PCL dynamic brace (Fig. 3) that will protect the PCL graft from untimely posterior drawer. The flexion angle will be progressively open to full range of motion. From the third to fourth month, exercises aiming at the recovery of the static stability are begun. Then, from the fifth month, the rehabilitation focuses on the recovery of the dynamic stability of the injured limb. Return to activity is usually slow and gradual return to physical work and sporting activities at 9–12 months at earliest [9].

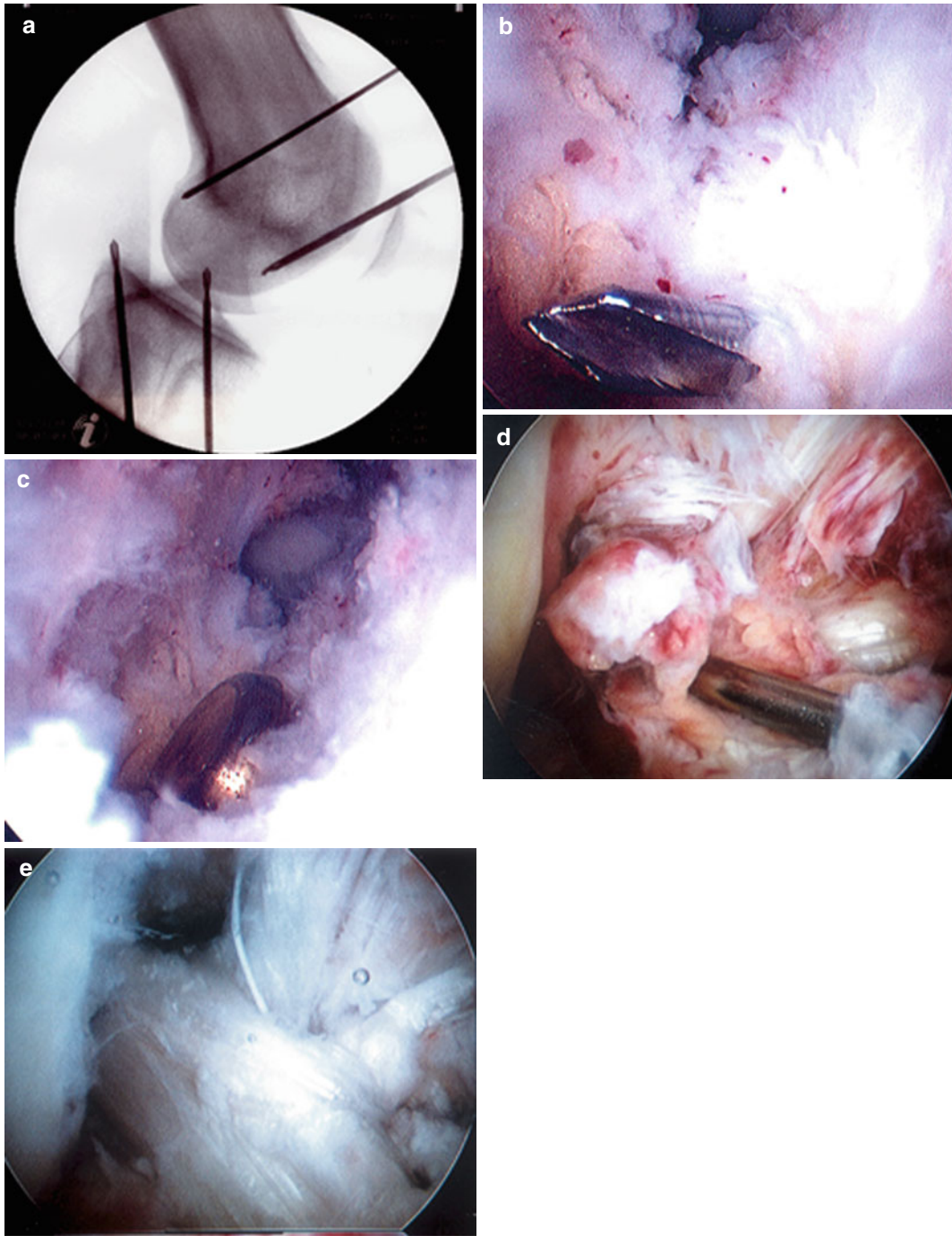


Fig. 6 (**a**) Fluoroscopic control of the proper placement of the ACL and PCL tibial and femoral tunnels. (**b**, **c**) Arthroscopic view of the PCL tibial tunnel position from the posteromedial portal. (**d**) ACL and PCL post-injury. (**e**) ACL and PCL graft after reconstructions

Sports and physical activities can be extended in the absence of knee effusion, an almost complete range of motion, good knee stability, and an excellent muscle strength and control.

Results

Most of the studies related to multi-ligament-injured knee are retrospective case series with a level of evidence of grade IV, but recently some studies of level II and meta-analysis have been published.

According to Dedmond et al. [2] meta-analysis (n = 205 patients) of operative and non-operative treatment of knee dislocation, the surgical treatment group resulted in consistently higher mean Lysholm scores (85 vs 67) than the non-operative one.

In 1999, Mariani et al. [17] made a comparison between reconstruction and direct repair of knee ligaments. They found that direct repair of knee ligaments had higher rate of posterior sag sign and lower rate of return to pre-injury activity level ($p < 0.05$). However, Frosch et al. [4], in a recent meta-analysis, have examined suture versus reconstruction of cruciate ligaments with respect to injury pattern. They found no significant difference between suture repair and reconstruction of the ACL and PCL. Both showed good clinical results and they concluded that suture repair of cruciate ligament can serve as an alternative option for multi-ligament knee injury [4].

Harner et al. [6] reported on 31 patients who underwent surgery following knee dislocation, including 19 patients treated <3 weeks after injury (acute) and 12 patients treated >3 weeks after injury (chronic). Mean follow-up was 44 months. Patients treated in the acute period had a higher Knee Outcome Score, Survey Sports Activity score (89 versus 69), less positive Lachman test at the post-operative physical examination, and a better final Lysholm score (91 versus 80). Final knee range of motion was similar regardless of time to treatment, although four acutely reconstructed patients required manipulation under anaesthesia for arthrofibrosis (21 %) [14]. In a recent study, Tzurbakis et al. [37] reported about 44 knee dislocations, including 35 patients operated in the acute (<3 weeks) and 9 patients in a chronic setting. Mean follow-up was 51 months. A statistically greater percentage of patients treated in the acute period rated their outcome as normal (A) or near-normal (B) on the IKDC knee subjective form (86 % versus 56 %) and symptom (85 % versus 56 %) subgroups. Overall IKDC normal or near-normal rating (77 % versus 55 %), mean Lysholm score (88 versus 82), and final ROM were not significantly different. Levy et al. [15] realized a systematic review in 2009 and demonstrated that an acute surgical treatment (<3 weeks) showed better functional and clinical results than a delayed treatment, with higher Lysholm and IKDC scores and better sports activity scores using the Knee Outcome Survey.

Recently, a large prospective series of knee dislocation with a minimum 2-year follow-up has demonstrated that patients could achieve a good Lysholm score (median 83) and show good functional level (83 % of hop test comparable to the other knee) and level of general activities [3]. They also found that high-energy knee dislocations have less favourable results than low-energy dislocations. In addition, those who injured all four ligaments (KD-IV) had worse outcomes in comparison to those who injured two or three ligaments (KD-II, KD-III) [3]. Finally, open dislocations have worse outcomes with a reported 43 % infection and 17 % amputation rate [9].

The most common problems of these knee dislocations are stiffness or failure of repaired and/or reconstructed ligaments. In the long-term, more than 50 % of patients may develop post-operative osteoarthritis [41].

Conclusions

Knee dislocation is a devastating injury that necessitates a prompt diagnosis. Associated vascular injury must be diagnosed and treated urgently. A precise anatomical definition of all lesions should be determined by thorough clinical examination and imaging. Then, the treatment has to be tailored according to the injury pattern and the patient profile. In young active patients, all ligaments and associated injuries should be fixed in a one-stage procedure when possible. Reconstruction of the multi-ligament-injured knee provides satisfactory subjective

functional assessment, range of motion and stability while the ability of patients to return to high demand sports and heavy manual labour is less predictable.

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