Dislocations and Bicruciate Lesions

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Introduction

Knee dislocations usually involve both anterior and posterior cruciate ligament injury (except in some rare anterior or posterior dislocations) and injury of the lateral and/or medial knee structures. Dislocations imply a high risk of neurovascular lesions, and an angiogram is often indicated. This chapter does not deal with knee dislocations where one of the two cruciate ligaments is not torn.

Classification and Diagnosis

It is not always possible to be precise about the mechanism of these injuries, nevertheless there are definite patterns of injury, and it is therefore possible to anticipate ligamentous lesions and associated complications. A classification helps to identify these patterns; ours was developed with F. Rongieras in 1998 and inspired by the successive works of the Lyon School of Knee Surgery. In addition to the tears of the cruciates, it takes into account the elementary lesions of the peripheral structures, which may be either

- Tearing (associated with rotation in coronal, sagittal, or axial planes) or
- Periosteal stripping (associated with translation).

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The limb injuries result from either prolonged application of force, with patterns of escalating severity, or high-velocity injury from motorcycle accidents, avalanche, etc. (Fig. 10.1).

Simple bicruciate injuries, or 'Pentades' are a result of this sustained progressive force application. Three typical types exist, caused by valgus, varus, or hyperextension (Fig. 10.2). There is opening (gaping) from tearing of the structures on convex side, as well as bicruciate injury. These injuries may originate with a "triad." The medial pentade, for example, is most often the result of an unhappy Don O'Donoghue's triad (Fig. 10.3). The lateral pentade follows the same principle, but is associated with common peroneal lesions (Fig. 10.4), and the posterior pentade with vascular injury (Fig. 10.5).

If the force continues and is not spent, a dislocation results. In addition to tearing and gaping on the convex side, there is periosteal stripping on the concave side and associ-

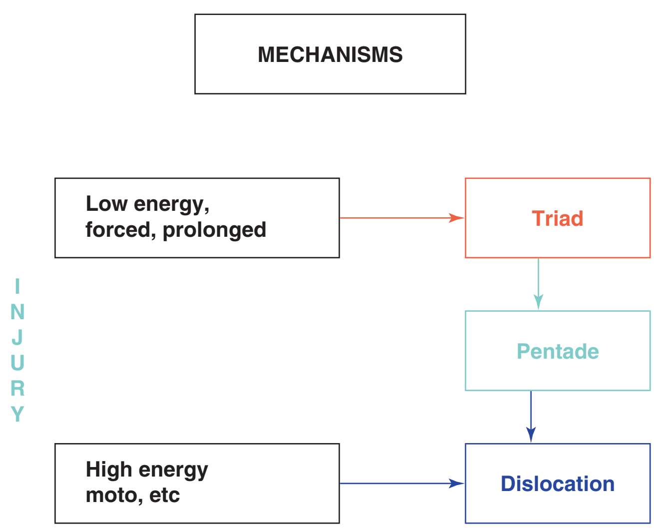

Fig. 10.1 Injuries result from either prolonged application of force, with patterns of escalating severity, or high-velocity injury

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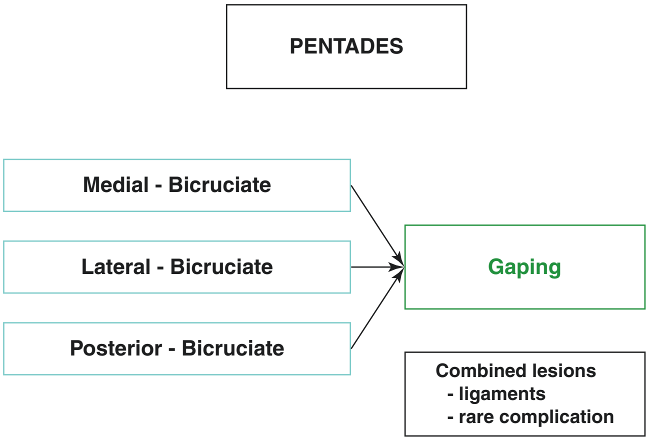


Fig. 10.2 Simple bicruciate injuries or "Pentades" are a result of a sustained progressive force application. Three typical types exist

ated translation (hence dislocation). There are five types (Fig. 10.6); two are the natural progression of the medial and lateral pentades (Fig. 10.7). Another involves tearing of all the peripheral structures, with only one corner intact, around which there is rotational dislocation (Fig. 10.8). In the last two, there is stripping of the peripheral structures on two sides, allowing translational dislocation (Fig. 10.9). With the anterior dislocation, there may be injury to the extensor mechanism, and with the posterior variant, vascular injury.

In the case of knee dislocation, reduction under general anesthesia with fluoroscopic control is an emergency. Radiographs are repeated after immobilization of the lower limb in a posterior knee–ankle splint to confirm that the joint remains reduced. Completely torn structures impart no stability, but stripped structures remain longitudinally functional in tension, providing an intact hinge

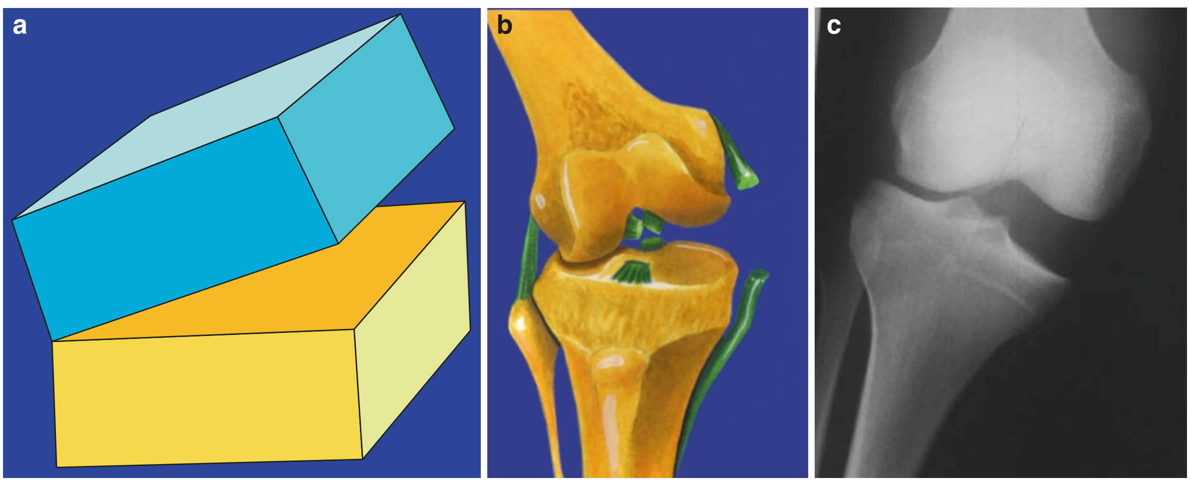


Fig. 10.3 (**a**–**c**) A medial pentade comprises tearing of the medial structures, both cruciates and medial compartment injury. Typically there are no complications

Fig. 10.4 (**a**, **b**) The lateral pentade involves tearing of the lateral peripheral structures and often includes a common peroneal lesion. The MRI shows lateral soft tissue injury and evidence of medial compression with bone bruising

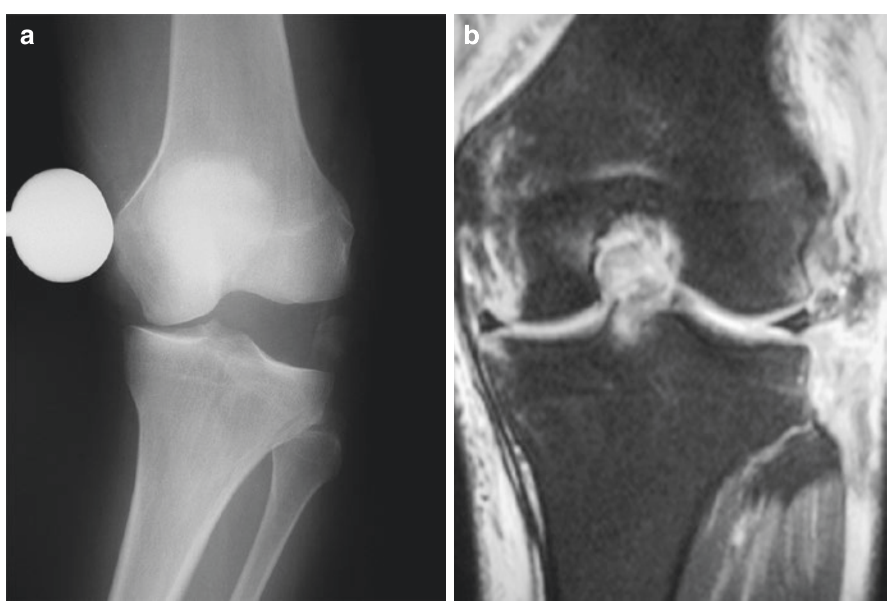


Fig. 10.5 Traction injury to the tibial vascular structures is common with the posterior pentade. Anterior tibial impaction is an important sign of this injury

BICRUCIATE LESIONS	
Simple (Pentades)	**Combined (Dislocations)**
Medial Lateral	Medial (lateral dislocation) Lateral (medial dislocation) Rotatory
	Pure (Dislocations)
Posterior	Anterior Posterior

Fig. 10.6 Classification of bicruciate lesions

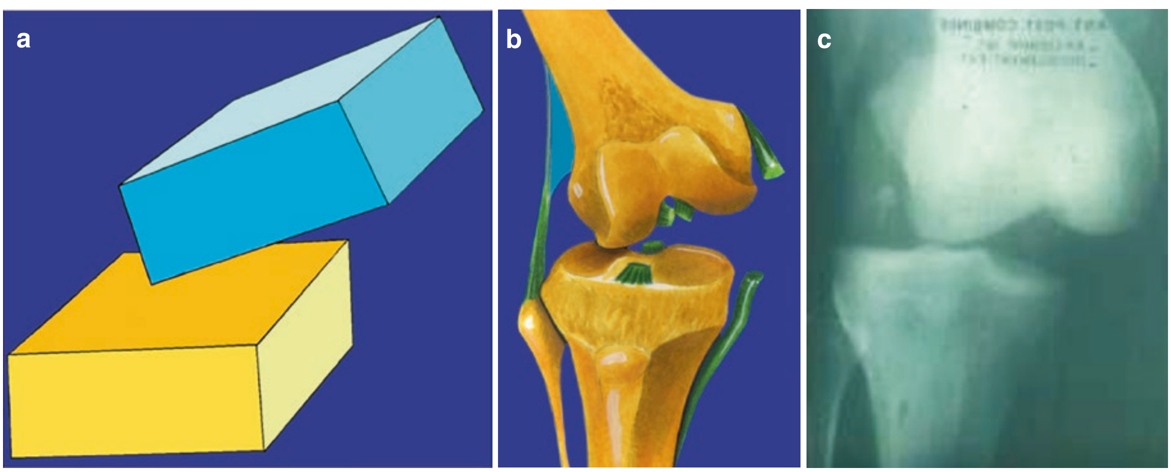


Fig. 10.7 (**a**–**c**) Lateral and medial dislocation. In these injuries, there is dislocation of the tibia toward the opposite side of the gaping. In this case, there is medial gaping and lateral dislocation. When there is lateral gaping, the tibia will dislocate medially

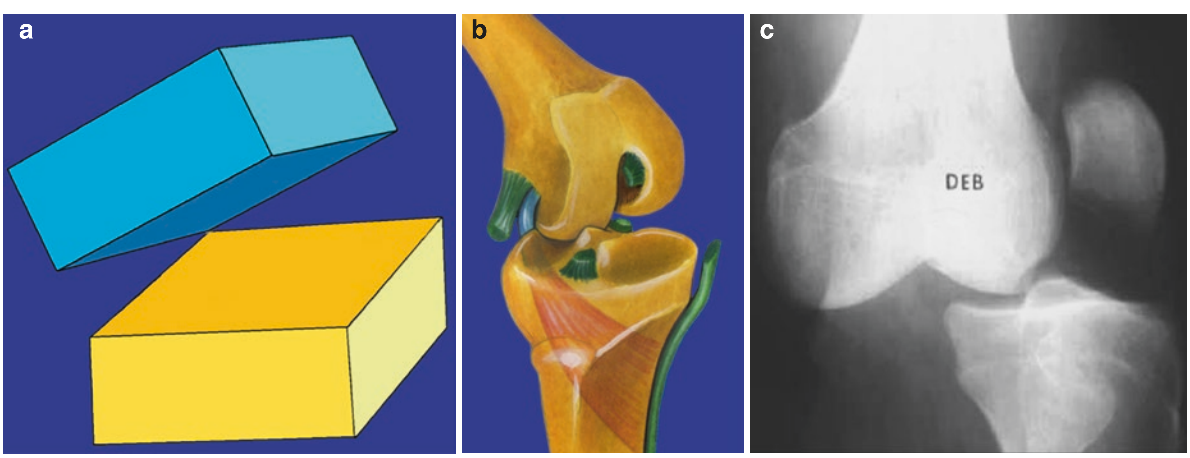


Fig. 10.8 (**a**–**c**) Rotational dislocation. Tearing of almost all peripheral structures, apart from at one stable point

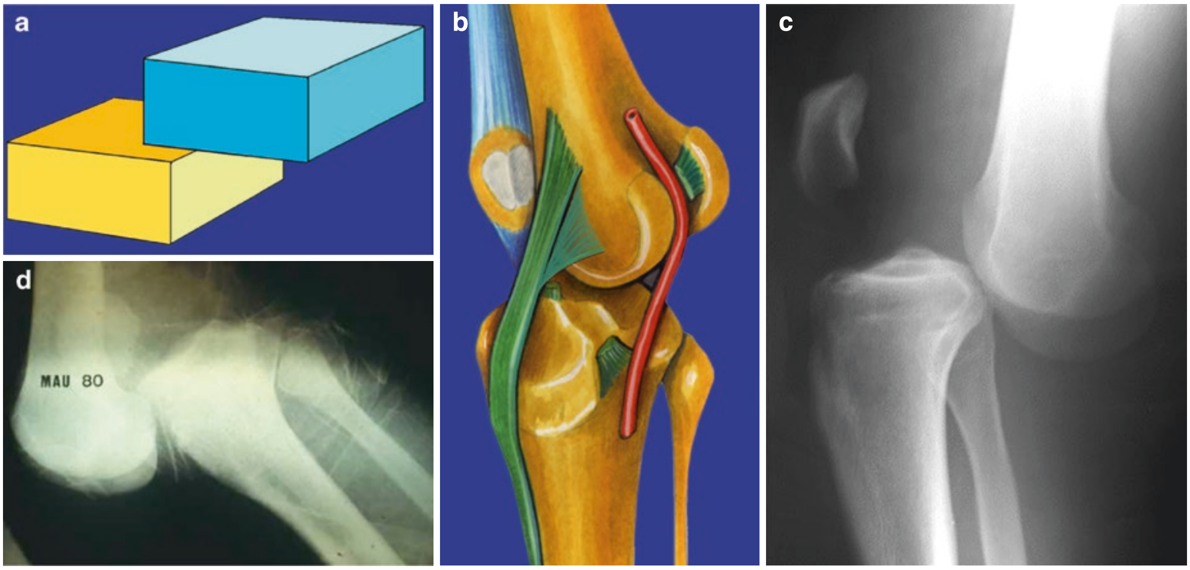
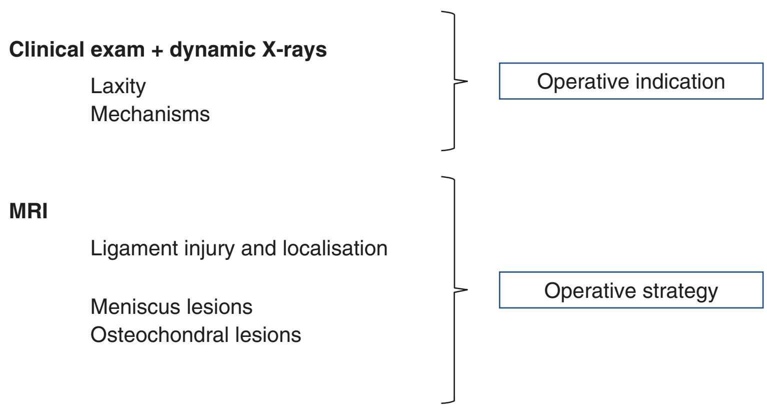


Fig. 10.9 (**a**) Pure dislocation from stripping on both sides. (**b**, **c**). Anterior dislocation produces traction injury to the posterior vascular bundle. (**d**) Posterior dislocation causes extensor mechanism lesions. The dislocated patella is visible

Fig. 10.10 Dynamic x-rays and MRI give complimentary information



once the joint is reduced. The surgeon can exploit this residual stability in the acute post injury period with three-point external support, as with a periosteal hinge in fracture surgery.

The identification of the mechanism and type of lesions of the peripheral structures is by clinical examination of the joint, and reference to the radiology, including stress x-rays and MRI (Fig. 10.10).

- Stress x-rays provide functional information about the character of the lesions, and thus the indications for surgery.
- MRI provides the localization of anatomical defects and informs the strategy of the surgery (Fig. 10.11).

The stress x-rays may be performed with the patient awake, under anesthesia at the time of the reduction, or at the start of a surgical intervention, and should specifically include

- Valgus and varus laxity
- Anterior and posterior translation
- Medial and lateral translation.

Without performing the last of these stress tests, the stripping capsular-periosteal detachments typical of dislocations may be missed (Fig. 10.12).

In addition to localizing the ligamentous lesions, MRI is useful to identify and localize meniscal and cartilaginous injuries (Fig. 10.13).

A definitive treatment plan can finally be established, taking into account the number, type, and location of lesions, as well as the limb alignment and other patient factors such as age and activity level.

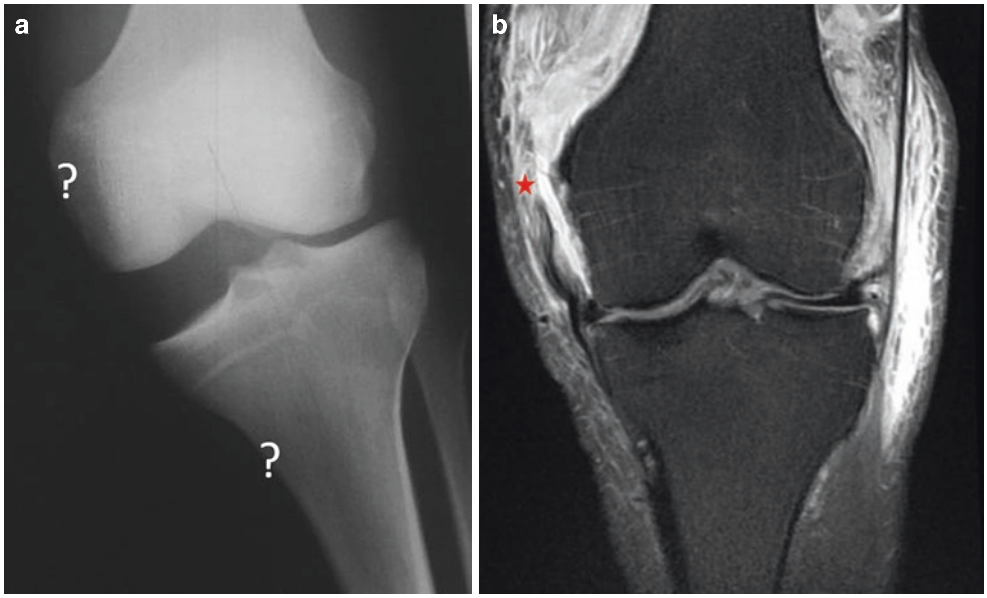


Fig. 10.11 Stress x-ray gives a functional diagnosis and indication for surgery—in this case MCL injury (**a**). MRI provides the site of injury to help plan the surgery—confirming in this case injury at its proximal origin (*star*) (**b**)

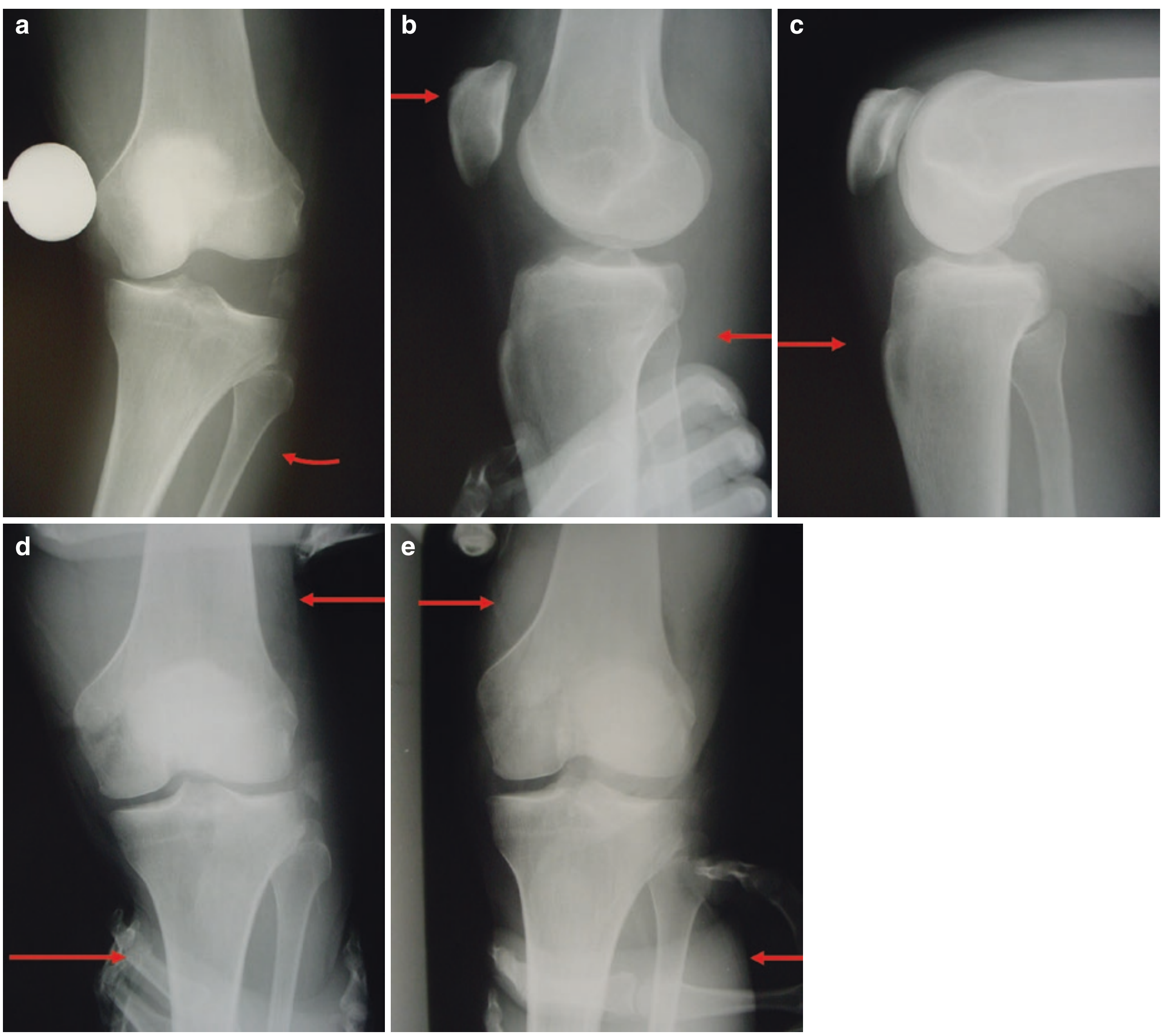


Fig. 10.12 Stress x-rays identify a lateral bicruciate lesion and exclude a dislocation. Varus stress view reveals laxity of the lateral structures (**a**). Although anterior and posterior stress lateral x-rays reveal bicruciate insufficiency (**b** and **c**), the translation stress views reveal no periosteal stripping, specifically on the medial side (**d**, **e**). These tests should be performed carefully to prevent further injury to the common peroneal nerve

Fig. 10.13 MRI also reveals pathology of the chondral surfaces and menisci (*circle*)

Operative Timing

If possible, surgery is done 5–15 days after the initial trauma, when the soft tissues are less swollen. Indications for urgent intervention include vascular injuries, unreducible dislocations, incarceration of the MCL, and extensor mechanism rupture.

The PCL and collateral ligaments are reconstructed in the first operative procedure. The ACL is reconstructed in a delayed manner in order to prevent stiffness and to decrease operative time as multi-ligament surgeries are long and complex.

However, simultaneous ACL and PCL reconstruction is sometimes indicated, particularly when a lateral laxity is associated, as late instability follows if the ACL is not reconstructed.

Setup

Patient positioning is the same as is utilized for isolated PCL reconstruction as is described in detail in prior chapters. Fluoroscopy is utilized for the PCL.

Cruciate Ligament Reconstruction

The first step is PCL reconstruction, by arthrotomy or arthroscopy. We prefer arthroscopic reconstruction.

PCL reconstruction in multi-ligament injuries is the same as in cases of isolated PCL injury. One must be vigilant for the risk of extra-articular fluid leakage because of associated capsular injury, and careful control of the pump pressure is critical.

Joint irrigation is the first step of the procedure to clean out the hemarthrosis. Intercondylar notch cleaning is minimal to preserve residual PCL fibers that could heal in the presence of the PCL graft. PCL graft fixation must be done with careful attention to the position of the tibia relative to the femur in the sagittal plane. The tibia should be positioned in its reduced position (approximately 1 cm anterior to the femur) or even with a slight anterior tibial translation of 1–2 mm. ACL reconstruction technique is the same as the one used for isolated ACL reconstruction. If slight posterior laxity persists after PCL reconstruction, care must be taken not to induce a posterior tibial translation during ACL graft tensioning and fixation.

Reconstruction Sequence

In case of multi-ligament injury, we recommend fixing first the PCL graft, then the posterolateral corner, and finally the posteromedial corner. The ACL may be reconstructed in a second operation, after recovery from the first surgery (6 months–1 year later). However, when both the PCL and ACL are reconstructed in the same surgery, the fixation sequence is PCL graft first, then ACL graft, and finally lateral knee structures.

Lateral Knee Structure Reconstruction

Lateral collateral ligament (LCL) injuries are rarely isolated. Acute repair or reconstruction of LCL is often done in association with PCL and/or ACL reconstruction.

Clinical examination is very important for the diagnosis. The LCL is palpated when the patient is positioned in the "figure four" position and comparison with the non-injured knee is important. The presence of an LCL tear is confirmed by the presence of lateral opening with varus stress testing.

The exact location of LCL tear is sometimes difficult to localize. Standard radiographs, CT, and especially MRI can help distinguish between a mid-substance tear and a ligamentous avulsion injury with or without bony avulsion from the femur or fibular head.

Surgical Exposure

A lateral incision 6–8 cm in length extends from the posterior part of the lateral femoral condyle to the fibular neck. It is similar to the hockey stick incision described in the chapter on posterolateral corner reconstruction.

The iliotibial band is divided parallel to its fibers, until its insertion on Gerdy's tubercle. The next step is to localize anatomical structures including the popliteus tendon, the LCL, and the biceps femoris tendon. The common peroneal nerve is dissected from proximal to distal and protected.

According to the location of the LCL tear, iliotibial band incision can be moved more or less posterior: more posterior in case of LCL avulsion from the fibular head and more anterior in case of femoral avulsion.

Femoral Avulsion

In case of LCL and popliteus avulsion of the femur, osseous fixation is needed. Many techniques are possible including screws, anchors, and wires. If a bony fragment has been avulsed, it can be fixed with a 3.5 mm screw and washer.

In case of LCL avulsion without bony fragment, transfemoral fixation with a femoral socket can be done or the LCL can be reattached to the femoral epicondyle with anchors or with transfemoral sutures. To do so, the femoral footprint is roughened up to create a trough for healing, the proximal part of the ligament is sutured with No. 2 FiberWire®, and two parallel transosseous tunnels directed toward the medial femoral condyle are created. The two ends of the suture previously placed on the LCL are passed through the femur and tied on the medial femoral cortex (Fig. 10.14).

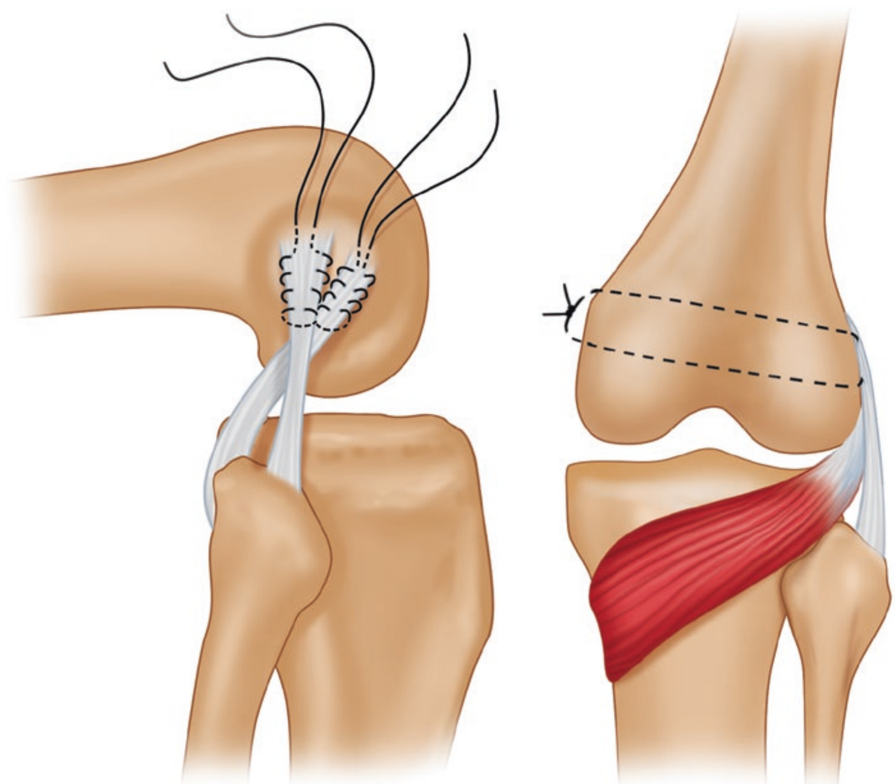


Fig. 10.14 Repair of a femoral avulsion

Fibular Head Avulsion

Fibular head avulsion corresponds to avulsion of the LCL alone or with fabello-fibular ligament, fabello-popliteus ligament, and arcuate popliteus ligament (Figs. 10.15 and 10.16). If the bony fragment is large, the biceps tendon may also be avulsed.

Depending on the bone fragment size and shape, it can be fixed back to the fibular head with a single screw, a wire, or both.

– Fixation with a 3.5 mm screw is easier but sometimes not enough if the biceps tendon is inserted on the bone fragment, as it will apply high traction forces on this fragment.
– A transosseous wire can be used as a suture or a cerclage and is more effective to resist traction forces. A 0.8–1 mm diameter wire is used. It is passed through the bone fragment in a U shape. A tunnel is drilled in the fibular head after protecting the common peroneal nerve. The wire is crossed in an 8-shape and passed through the fibular head (Fig. 10.17). At 20–30° of knee flexion, the wire is tightened until the fragment is reduced and the LCL is re-tensioned. The wire is then cut and the free ends are bent. Cancellous autograft harvested from Gerdy’s tubercle can be used to enhance consolidation.

Fig. 10.15 Fibular head avulsion fracture

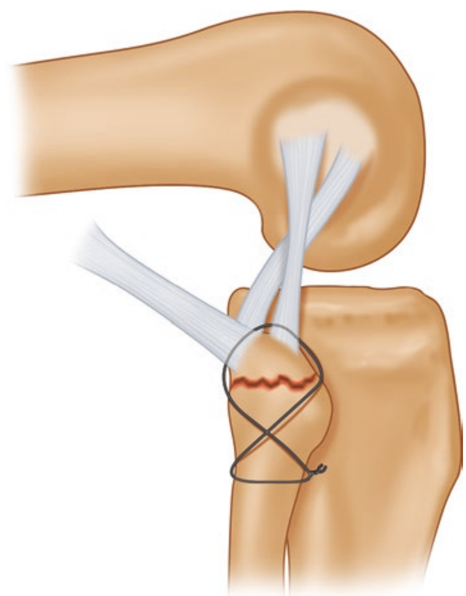


Fig. 10.17 Fixation of a fibular head avulsion fracture

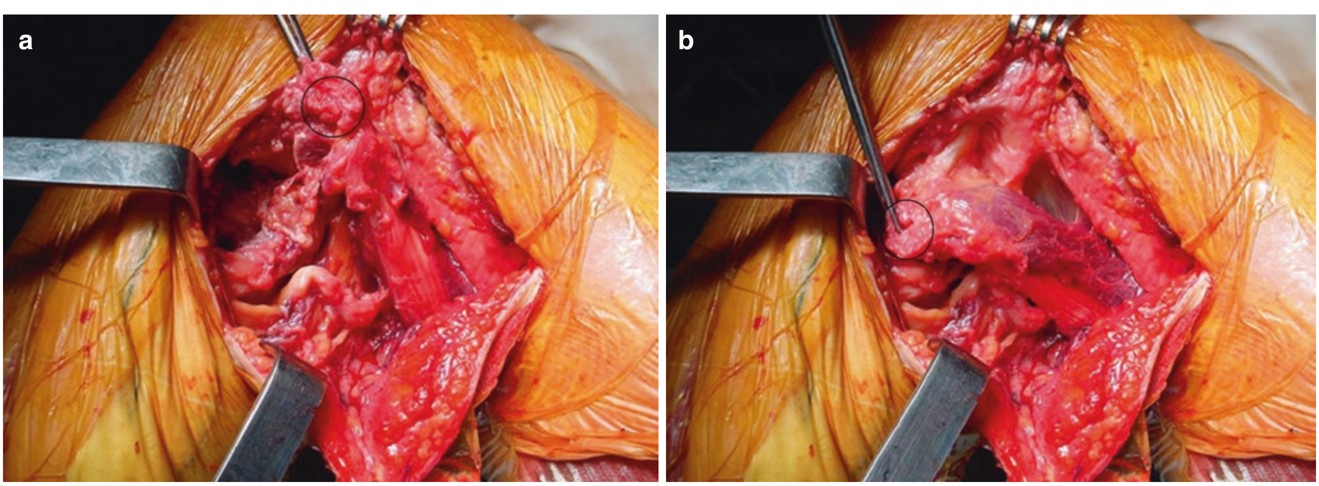


Fig. 10.16 (**a**, **b**) Operative views showing reduction of a fibular head fracture with biceps tendon and lateral collateral ligament avulsions

Mid-Substance Ligament Rupture

Different suture techniques are possible (U-stitch, frame-stitch). However, transverse rupture is rare. Usually, ruptures are Z-shaped. The distal half of the ligament looks like a round cord surrounded by a sheath, as compared to the proximal part which is in the capsular tissue. It is thus difficult to identify the proximal tissue and perform an end-to-end suture of the torn ligament. If it is possible, we prefer non-resorbable, braided suture (e.g., Ethibond®, Mersuture®, TiCron®, FiberWire®) for such repairs.

We usually prefer reconstruction of the lateral structures because repaired tissue is often insufficient. A 6 × 1 cm band of biceps tendon can be harvested and fixed to the lateral femoral epicondyle in a bone socket or with an anchor. Another option is to use an ipsilateral or contralateral gracilis tendon autograft.

Posterolateral Reconstructions

This procedure includes reconstruction of the essential anatomic structures of the posterolateral corner: the popliteus tendon and popliteo-fibular ligament. In case of bony avulsion, with or without a bone fragment, they should be fixed acutely, as for LCL injuries. In case of mid-substance ligament tears, the remnants of torn ligaments can be sutured, but as with LCL injuries, augmentation with a graft is mandatory.

G. Bousquet described a reconstruction of the PLC called the "petit poplité," which prevents tibial external rotation and posterior subluxation of the lateral tibial plateau.

The first step is reconstruction of the popliteo-fibular ligament which is done with a 0.5 × 7 cm band of the biceps femoris tendon left attached on the fibular head. This band is passed under the iliotibial band, around the popliteus tendon, from anterior to posterior and from medial to lateral (in order to pull the popliteus tendon laterally and distally), and is then fixed to the lateral capsule and to the fibular head with the foot in neutral rotation.

The second step is to tighten the recurrent popliteus tendon with two or three resorbable sutures, which tightens the posterior condylar recess to the anterior border of the lateral retroligamentar arthrotomy (and eventually to the LCL).

The third and last step is to tighten the fabello-popliteus ligament with a bundle of iliotibial band measuring 1 × 5 cm left attached on its two extremities. This band is fixed to the fabella or to its fibrous nucleus with single stitches of resorbable sutures.

Reconstruction with iliotibial band has also been described. Jaeger reported a reconstruction with an iliotibial band graft measuring 15–20 cm long, harvested from Gerdy's tubercle. Two tunnels are drilled: a transtibial anteroposterior tunnel of 6 mm diameter from Gerdy's tubercle and a transcondylar anteroposterior tunnel below the femoral lateral epicondyle. The graft is passed in the transtibial tunnel, then through the lateral gastrocnemius, and then into the femoral tunnel. W. Müller has described a reconstruction with a graft of iliotibial band measuring 10–15 cm detached from Gerdy's tubercle, passed in a transtibial tunnel from anterior to posterior, and fixed on the femoral insertion of popliteus.

Postoperative Care

During the first 45 postoperative days, the patient wears a posterior knee splint in extension and remains non-weight-bearing. Knee mobilization is begun on day 1, limited to 60° until day 21, and then to 95° until day 45. Any valgus/varus stress is avoided for 90 days, with the use of a range of motion brace. Weight-bearing is then progressive from day 45, and flexion is no longer restricted. Sports are forbidden for 6 months. Until 9 months postoperative, ligaments may be thick and sometimes painful.

Medial Knee Structure Reconstruction

Type of Injury

Medial knee structure injuries may be a mid-substance ligament tear or a bony avulsion of the ligament insertion.

Mid-substance tears are usually classified into three grades. The surgeon plans his surgery according to the medial knee laxity found during clinical examination and measured on stress radiographs and according to associated cruciate ligament injuries. When medial knee laxity is present in full extension, other ligamentous injuries may be associated:

- Posteromedial corner injury (posterior-oblique ligament (POL) as described by Hughston)
- PCL injury, which may be difficult to diagnose clinically
- Deep MCL avulsion on the femoral side, which may not heal and can lead to chronic laxity if not diagnosed.

As described by W. Muller, deep MCL tears are often not at the same level as superficial MCL tears. MCL lesions are often considered to be a minor injury by the surgeon, but not by the patient who is quite restricted in his physical activities.

Arthroscopy

Arthroscopy may be useful to confirm the diagnosis. It helps the surgeon to determine if the MCL tear is above or below the meniscus. In case of increased space above the meniscus, the MCL is torn on the femoral side, and in case of increased space below the meniscus, the MCL is torn on the tibial side.

Mid-Substance Rupture

The MCL can heal with a knee brace allowing flexion and extension but restricting valgus loading of the knee. Surgical reconstruction is rarely needed except in occasional cases of complete rupture. If needed, an end-to-end MCL repair is done. When associated with an ACL reconstruction, an anteromedial surgical approach is used. The skin incision is longitudinal, 2–3 cm medial to the anterior tibial tubercle (ATT). MCL end-to-end sutures favor healing. For superficial MCL tears, we prefer to whip-stitch the entire ligament to tighten it before suturing and fixing it. Anchors can also be used. An augmentation with the gracilis tendon as described by Helfet can also be done.

Repair of Bony Avulsions

In case of femoral avulsion, an oblique skin incision over the medial epicondyle allows good visualization of the lesion.

In case of a large bony avulsion (e.g., the whole medial epicondyle), fixation can be achieved with a 3.5 mm screw and washer, transcondylar FiberWire sutures, or with a staple.

In case of tibial avulsion, the skin incision is vertical and medial. The sartorius is incised in a reverse L shape, and the hamstring tendons are elevated to expose the avulsed superficial MCL. Anchors can be used to reinsert it on the tibia.

MCL Reconstruction

If a direct suture is not sufficient or not possible, a reconstruction can be done. The patient is supine with a mid-thigh tourniquet in 90° of knee flexion. A medial incision extends from the level of the patella to 3 cm below the ATT. Dissection is done to expose the medial epicondyle.

- Reconstruction with hamstring tendons. The sartorius fascia is retracted and the gracilis tendon is exposed, dissected but left attached to the tibia. An open stripper is used to detach it proximally. A vertical tunnel is created deep to the femoral medial epicondyle by drilling two 4.5 mm holes, 10–15 mm apart. O'Shaw claws of increasing diameter are used to join these two holes and create the tunnel. The gracilis tendon previously prepared and whip-stitched with an absorbable suture is passed through the femoral tunnel and sutured back on its tibial insertion with a similar suture. Note that when we can choose another graft option, we prefer not to harvest the ipsilateral hamstrings, in order not to weaken the medial structures and control of tibial rotation.
- In case of chronic laxity, it is difficult to determine clinically if medial laxity is due to an isolated MCL tear, isolated injury to the posteromedial corner, or both. MRI can help localize the tear, but can be inconclusive in such chronic cases. Usually it is advisable to repair both. The superficial MCL can be whip-stitched over its entire length and sutured in a tightened position. For the posteromedial corner, one or two anchors are inserted on the posterior side of the medial epicondyle via a medial retroligamentar arthrotomy. The surgeon looks for the "lunule sign" described by H. Dejour above the meniscus. It corresponds to an avulsion of the posteromedial capsular recess. It is then anchored on the posterior and proximal side of the condyle, taking care not to overtighten it, which could restrict extension. The POL itself is stitched and anchored back on the posterior side of the medial epicondyle. Finally, in case of major and chronic laxity, an MCL and POL reconstruction with quadriceps tendon autograft as described by Engebretsen can be done.

Postoperative Care

During the first 45 postoperative days, the patient wears a posterior knee splint in extension and remains non-weight-bearing. Knee mobilization is begun on day 1, limited to 60° until day 21, and then to 95° until day 45. Any valgus/varus stress is avoided for 45 days. Weight-bearing is then progressive, and flexion is no longer restricted. Sports are forbidden for 4 months. Until 9 months postoperative, ligaments may be thick and sometimes painful.