6 Posterior Cruciate Ligament

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6.1 Anatomy and Biomechanics

The posterior cruciate ligament (PCL) is an intra-articular ligament within the knee that originates from the intercondylar notch of the medial femoral condyle and inserts on a depression just inferior to the joint line along the posterior central tibia at the PCL fossa [1, 2]. The PCL is comprised of both an anterolateral and posteromedial bundle.

The PCL has been identified as the primary restraint to posterior translation of the proximal tibia. It provides restraint throughout a functional arc of knee motion, exerting an increasing effect with greater magnitudes of flexion, with its greatest effect at 90° where it has been shown to contribute 95% of the total resistance to posterior translation [1, 3–7]. In addition, the PCL serves as a secondary restraint to varus, valgus, and external rotation forces [8, 9].

6.2 Injury Mechanism

PCL injuries have a wide variation in reported incidence, ranging from 1% to 44% of acute knee ligamentous injuries, with 50% to 90% of PCL injuries being combined injuries [10–13]. This range has varied based off the population being studied, with an incidence of 4% among knee injuries in collegiate soccer athletes, 2% of knee injuries in collegiate basketball athletes, and 37% of injuries in a population of patients presenting to the emergency department with hemarthrosis [13–16]. Given the high association with additional injuries, identification of other ligamentous injury about the knee should increase suspicion for a potential PCL injury.

There are a wide variety of reported mechanisms of injury for the PCL, including sudden knee hyperflexion or hyperextension, a posteriorly directed force on the tibia in a flexed knee such as during a dashboard injury, or a fall onto a flexed knee with a foot in plantarflexion [10, 17, 18]. Forced hyperflexion of the knee and posteriorly directed forces on a flexed knee are the most common reported mechanism for isolated PCL injuries, while knee dislocations, hyperextension injuries, and extreme valgus loads are more commonly associated with combined injury patterns [13, 14, 18–20].

6.3 History and Physical Examination

Patients presenting with PCL injuries can also take on a wide variety of presentations due to the presence or absence of associated injuries, ranging from a patient presenting after an isolated fall to a polytrauma after a motor vehicle accident. Patients can also present in either acute or delayed fashions, having varying types of PCL injuries, such as partial tears, mid-substance tears, or an insertional avulsion. Symptoms can range from being mildly symptomatic with manageable pain, an acute hemarthrosis, to a globally injured and limb-threatening associated vascular injury that can occur in the multiligament injured knee or knee dislocation.

A detailed history should be acquired, including the injury mechanism, date of injury, initial symptoms, and current symptoms. Often times, unaware a ligament has been torn at the time, patients who sustain isolated PCL injuries rarely experience a "pop" associated with the ligament injury as typically experienced in anterior cruciate ligament injuries [10, 17, 21–23]. Acutely, these patients can present with complaints of swelling with a mild to moderate effusion, posterior knee pain, or pain while kneeling [21]. Instability is more common in combined PCL injuries, but can be present with activities that involve sagittal-directed forces across the knee, such as with descending stairs or hills [21]. Subacute

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or chronic isolated PCL injuries can present with subtle signs and symptoms with an unknown mechanism or time of injury, with patients oftentimes complaining more of disability rather than instability symptoms of vague knee pain and discomfort, unsteadiness, pain with deceleration and descending stairs, or stiffness [17, 21, 24].

A thorough physical examination is necessary for both isolated and combined PCL injuries and should include an assessment of both the injured and contralateral sides. When possible, gait should be evaluated to assess for a varus thrust gait which might suggest a posterolateral corner injury, particularly in the chronic PCL-injured patient [25, 26]. Standing alignment should be assessed and verified with long-leg alignment films as described below, particularly in chronic PCL injuries. Multiligamentous knee injuries and knee dislocations should involve a careful evaluation of vascular status including assessment of dorsalis pedis and posterior tibial pulses, distal capillary refill, and ankle-brachial indices, in addition to a thorough neurological assessment of the motor and sensory function of the peroneal and tibial nerves.

There are numerous physical examination maneuvers that have been described to evaluate and detect PCL tears, including the posterior drawer test, quadriceps active test, posterior Lachman test, posterior sag test, presence of posterior tibial drop back, false-positive anterior drawer test, and a pseudo-Lachman test [24, 27–30]. The basic function of these tests is to exhibit or induce abnormal posterior translation of the proximal tibia with respect to the femur. The posterior drawer test has been found to be the most sensitive and specific clinical examination maneuver to identify PCL insufficiency [30]. It is also imperative to evaluate for a potential combined injury by assessing the ligamentous integrity of the other ligamentous structures about the knee by assessing ACL integrity and joint line opening with varus and valgus stress, at both 30° and 0° to evaluate the collateral ligaments and the integrity of the posteromedial and posterolateral capsuls. Extension loss of the affected limb can suggest a mechanical block to motion, and increased hyperextension can be a manifestation of posterior capsular incompetence. Performance of a dial test is usually challenging for the patient to tolerate in the acute injury setting but is a supplemental test to perform under anesthesia and is more easily performed in the office on the chronically injured patient [27].

6.4 Imaging Studies

Imaging studies obtained are dictated upon the acuity of the injury, with acutely injured patients likely only tolerating non-weightbearing views. Radiographic assessment of subacute or chronic injuries may include plain radiographs of both knees with weightbearing anteroposterior (AP) and tunnel projections, 30° flexion lateral projections, and axial views of both patellae. Various types of stress radiographs can provide additional information to objectively quantify and grade PCL tears, such as kneeling lateral projections, gravity hamstring contraction lateral projections, lateral projections using the commercially available PCL stressing Telos device, and the Puddu axial view [17, 31–34]. An evaluation of 1041 consecutive patients who underwent PCL stress radiography with the Telos device showed posterior tibial displacement greater than 8 mm was indicative of complete PCL insufficiency, with displacement over 12 mm suggesting PCL insufficiency with additional injury of the secondary restraining structures [35].

Magnetic resonance imaging (MRI) is particularly useful in diagnosing PCL injuries as it facilitates assessment of additional injuries to other structures, including the other ligaments of the knee, menisci, and articular cartilage. The sensitivity of MRI for the diagnosis of complete acute PCL injuries has been estimated to be between 96% and 100% [17, 36–40]. However, MRI for the detection of chronic PCL injury has been in question, with reports of accuracy of 57% and sensitivity of 62.5% [37, 39, 40]. A study by Tewes et al. showed as early as 5 months after injury for isolated, complete PCL tears there can be restoration of a continuous appearance of the PCL suggesting healing; however all of the patients with this finding were found to have PCL insufficiency on clinical examination [41]. This suggests that for chronic PCL injuries, the appearance of a structurally intact PCL does not necessarily correlate with a functional ligament.

6.5 Arthroscopic Evaluation of the Posterior Cruciate Ligament

Examination under anesthesia permits a thorough physical examination of the knee without any guarding that could confound an awake examination. This is a critical time to verify preoperative assessment, in addition to thoroughly evaluate for the presence of any additional instability such as posterolateral or posteromedial rotary instability. Diagnostic arthroscopy serves as the gold standard for diagnosis of intra-articular pathologies, including cruciate ligament tears, meniscal tears, and articular cartilage injuries. During diagnostic arthroscopy, medial and lateral compartment joint space widening can be objectively quantified with a probe during valgus and varus stress to evaluate collateral ligament integrity, if not contraindicated.

Locations of injury along the PCL can be conceptualized using the three-zone method of arthroscopic PCL evaluation, with the femoral attachment, the ligament between the femoral and tibial attachment, and the tibial attachment each representing their own zone [15, 20]. Indications for surgical treatment of PCL injuries include acute or chronic symptomatic grade III isolated PCL injuries that failed non-operative management, combined multiligamentous injuries, and acute or chronic insertional site PCL avulsions [17, 42].

Surgical timing for the treatment of acute PCL injuries is contingent upon the presence of other injuries, including the magnitude of swelling and condition of the skin, systemic injuries, vascular injury, ability to obtain and maintain tibiofemoral reduction, and other injuries about the knee including the capsule, posteromedial and posterolateral corners, and collateral ligaments. Certain ACL/PCL/MCL injuries can be treated surgically in a delayed fashion after the MCL has healed, followed by arthroscopic ACL/PCL reconstruction. In certain situations, the medial structures may warrant repair or reconstruction, and the need for such should be determined on a case-by-case basis.

ACL/PCL/posterolateral corner injuries are typically managed more acutely given a lower capacity of the posterolateral corner to heal without operative intervention compared to the MCL. Acute treatment of posterolateral corner injuries within 3 weeks has been reported to have improved outcomes compared to injuries treated after 3 weeks, which exhibit similar outcomes to chronic injuries [24, 25]. The presence of associated capsular injury poses a challenge, as this can result in fluid extravasation during arthroscopy, potentially resulting in an iatrogenic lower extremity compartment syndrome if performed before capsular healing occurs around 3 weeks. During this initial period of capsular healing, consideration is given for surgical treatment of the collateral ligaments and any associated posteromedial or posterolateral corner injury. The decision to perform repair and repair plus augmentation versus reconstruction should be based off the injury pattern, location of injury, and soft tissue quality. There is limited evidence available comparing failure rates of acute primary posterolateral corner repair to reconstruction, with a relative trend that primary reconstruction may result in lower failure rates [43–46]. This can be done via an acute hybrid posterolateral corner and bicruciate procedure or in a staged fashion. Successful outcomes have been reported for staged bicruciate reconstruction following acute posterolateral corner treatment, and it is important to permit healing of the lateral structures and restoration of range of motion prior to a staged bicruciate reconstruction [47–51].

6.6 Case 1

6.6.1 History/Physical Exam

A 16-year-old male high school track athlete was injured when landing awkwardly during a long jump at a track meet, resulting in a severe hyperextension injury. He was unable to bear weight at the time of injury and was brought by ambulance to the emergency room within a few hours.

Physical examination at the time of presentation revealed his left knee was maintained in near-full extension with a prominent anterior proximal tibia with a large step off at the level of the joint line. He had good distal pulses and a normal ankle–brachial index of 0.97. Distal motor function and sensation were intact. Radiographs revealed anteromedial dislocation of the tibia with respect to the femur, and the patient underwent conscious sedation and closed reduction followed by application of a knee immobilizer. A vascular surgery consultation was obtained, and a CT angiogram was not recommended secondary to normal ABIs, a reassuring vascular exam, and his alert mental status to provide input into changes in his clinical status. He was admitted to the hospital for neurovascular monitoring, compartment checks, and arrangements for magnetic resonance imaging (MRI). DVT prophylaxis was started with low molecular weight heparin.

6.6.2 Imaging Studies

Plain radiographs demonstrated a left anteromedial knee dislocation (Fig. 6.1a, b). MRI revealed complete midsubstance tears of both the ACL and PCL (Fig. 6.2a) and conjoined fibular avulsions of both the lateral collateral ligament (LCL) and long head of the biceps femoris (Fig. 6.2b). Other inju-

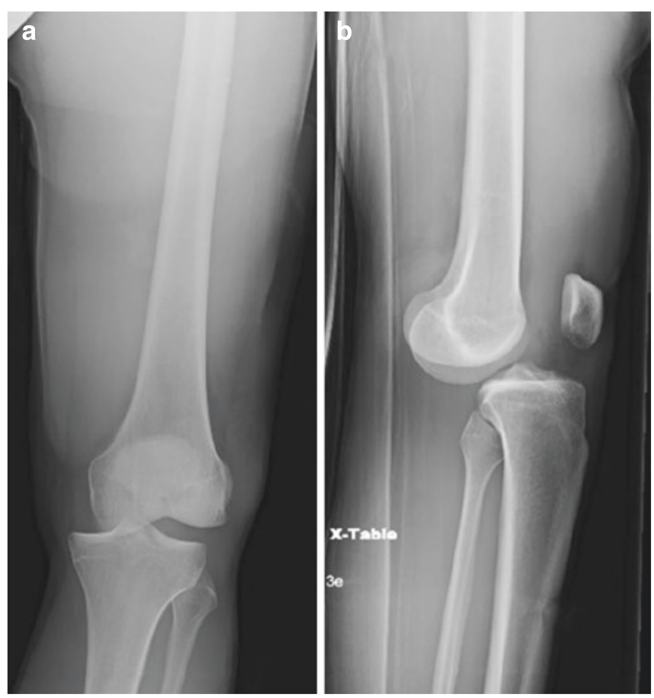

Fig. 6.1 (**a**, **b**) Anterior-posterior and lateral radiographs of the left knee prior to reduction showing an anteromedial knee dislocation with approximately 3 cm of anterior translation of the tibia

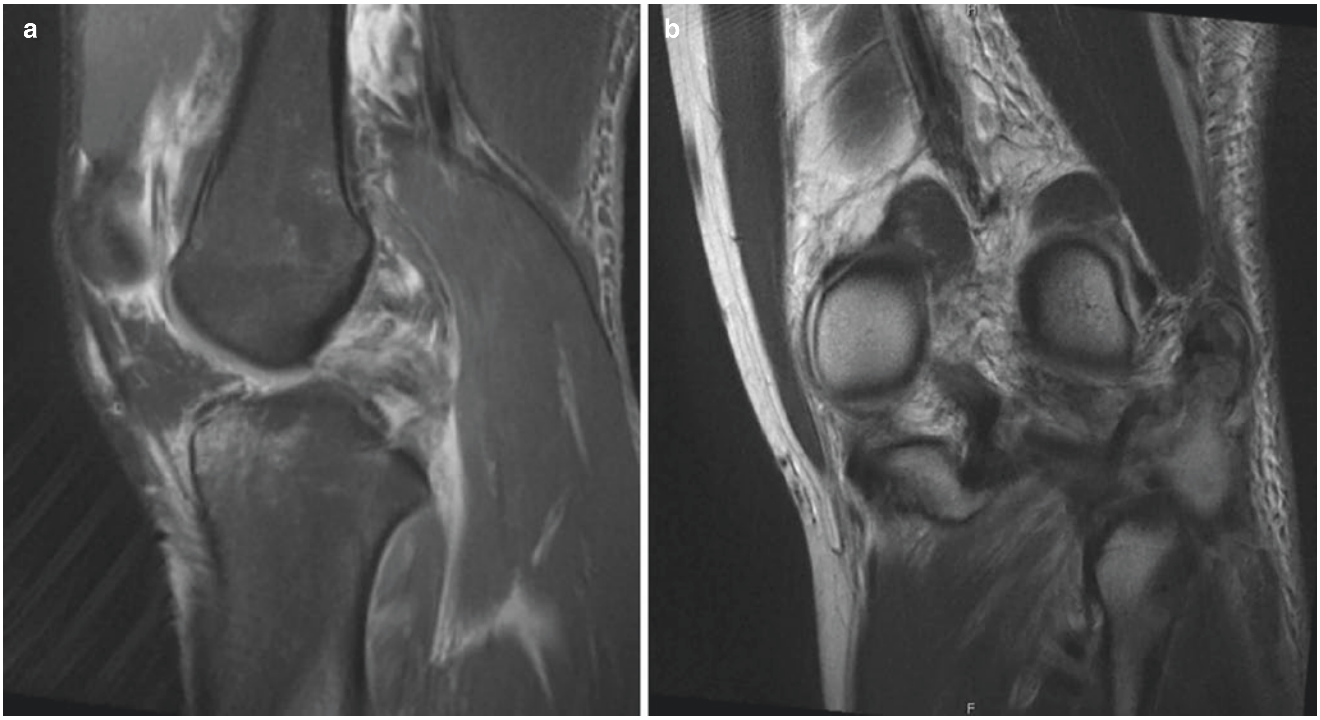

Fig. 6.2 (**a** and **b**): (**a**) Shows a sagittal MRI slice with midsubstance ACL and PCL tears, (**b**) shows a coronal MRI slice retraction of the LCL and biceps fibular head avulsion

ries included a partial popliteus tendon tear, a partial proximal MCL tear, a longitudinal tear of the posterior horn of the lateral meniscus extending into the root, and bone edema within the anterior medial tibial plateau and anterior medial femoral condyle consistent with a varus hyperextension injury.

6.6.3 Treatment Decision

The patient sustained a multiligamentous knee injury from a documented knee dislocation with a repairable lateral-sided injury and cruciate injuries that would benefit from reconstruction. Surgical options consist of:

- Acute combined open repair versus reconstruction of the posterolateral corner injury with open versus arthroscopic bicruciate reconstruction
- Acute repair of the posterolateral corner and staged bicruciate reconstruction
- Delayed posterolateral corner reconstruction with arthroscopic bicruciate reconstruction

Given the large sleeve of ligamentous and tendinous tissue avulsed as a unit off of the fibular head, the decision was made to perform an acute repair of his PLC injury followed by rehabilitation, recovery of motion, and capsular healing prior to delayed bicruciate reconstruction.

6.6.4 Discussion and Surgical Reconstruction

Stage 1 was performed 4 days after injury and included examination under anesthesia confirming MRI findings with grade 3 (>11 mm) widening of the lateral compartment with no endpoint on varus stress at 30°, grade 2 (>5 mm) widening with varus in full extension, grade 2 posterior drawer, and a grade 1B Lachman. During open repair of the posterolateral corner injuries, the lateral collateral ligament, biceps femoris, and popliteofibular ligament were collectively avulsed off the fibula as a single unit, which was repaired with two traction Krackow stitches through the distal biceps and one Krackow stitch through distal LCL, which were then passed through drill tunnels along the anterior and posterior aspects of the lateral fibular head, exiting along the anteromedial tibial cortex. Prior to tying the suture repair over anteromedial tibial cortex, diagnostic arthroscopy was performed to evaluate the lateral meniscal tear and cruciate ligaments, showing a midsubstance ACL tear, high-grade PCL midsubstance tear, and a vertical tear of the posterior horn of the lateral meniscus that was reduced and stable to probing. Given disruption of the posterolateral capsule and the poten-

Fig. 6.3 Shows a coronal MRI slice with a healed LCL and biceps femoris repair on the fibular head 23 weeks after surgery

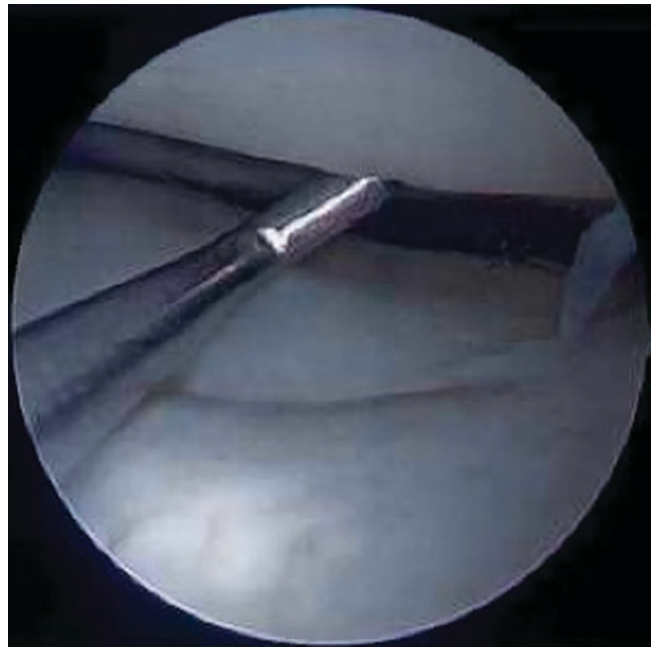

Fig. 6.4 Arthroscopic assessment of the posterolateral corner repair 23 weeks after surgery using a 5 mm probe showing 4 mm of central lateral compartment opening, consistent with functional healing of the repaired LCL

tial for compartment syndrome with prolonged fluid extravasation, the cruciate ligaments and lateral meniscal tear were left in situ to be repaired during the second staged surgery.

Despite extensive rehabilitation, the patient experienced significant knee stiffness and failed to progress beyond 55° of flexion. He underwent manipulation under anesthesia 10 weeks after his stage 1 procedure followed by further physical therapy, restoring knee flexion to 135°. Preoperative MRI prior to stage 2 surgery showed healing of his posterolateral corner repair (Fig. 6.3), and at 23 weeks after injury, he underwent arthroscopically assisted ACL and double-bundle PCL reconstructions. Diagnostic arthroscopy showed the posterior horn of the lateral meniscus tear had healed, redemonstrated the known ACL/PCL tears, and revealed 4 mm of total central lateral compartment joint space opening with varus stress at 30°, indicating successful functional healing of the LCL and PLC repair (Fig. 6.4).

Anatomic double-bundle PCL reconstruction was performed arthroscopically by independent drilling of the posteromedial (PM) and anterolateral (AL) bundles using Achilles tendon allograft with a femoral bone plug for the AL bundle and semitendinosus allograft for the PM bundle (Fig. 6.5a–f) [52–54]. Single-bundle arthroscopic ACL reconstruction was performed with independent drilling of the femoral and tibial tunnels using hamstring autograft (Fig. 6.5e–f).

6.7 Case 2

6.7.1 History/Physical Exam

A 52-year-old female who was a cyclist was struck by a car and presented a polytrauma with bilateral acetabular fractures with posterior hip dislocations, a right sciatic nerve palsy with foot drop, a left greater tuberosity avulsion fracture of the proximal humerus, and a posterior pelvic ring injury with right-sided SI joint widening. Knee radiographs at the time of injury revealed bilateral effusions, but no other abnormality.

She underwent surgical treatment of her multiple injuries and extensive rehabilitation to recover from a devastating injury and presented for initial evaluation 6 months after injury for a chief complaint of right knee flexion loss limited to 90°. At that time, she reported no symptoms in her left knee, but examination on the left revealed a grade 3 posterior drawer (~ 12–14 mm) and increased medial compartment joint space widening of 3 mm in full extension which increased to 9 mm at 30°. Her right knee pain and stiffness, along with her right-sided foot drop, was her higher functional priority. She was found to have heterotopic ossification along the right medial epicondyle consistent from prior MCL injury and was treated with open excision of the heterotopic bone, followed by tendon transfers at a later date for her right-sided foot drop after nerve function failed to return.

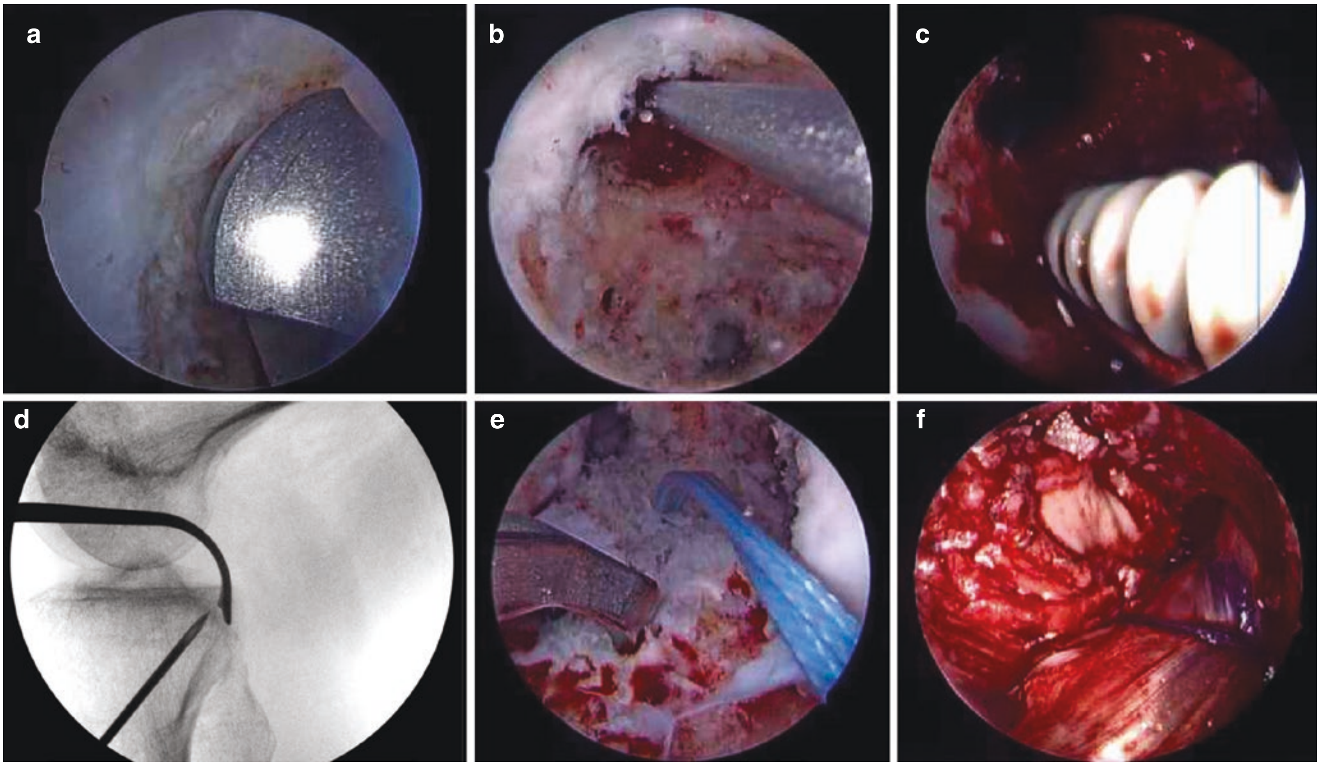

Fig. 6.5 (**a**–**f**): Arthroscopic anatomic double-bundle posterior cruciate ligament reconstruction. (**a**) Reamer positioning for retrograde drilling of the PCL anterolateral tunnel within the notch at anterodistal articular margin of the medial femoral condyle, positioned between notch point and medial arch point. (**b**) Anterolateral bundle femoral tunnel after reaming with Beath pin in place. (**c**) Interference screw fixation of the PCL PM bundle showing PM tunnel positioning approximately 8 mm posterior to the distal medial femoral condylar articular cartilage with at least a 2 mm bone between the ALB tunnel. (**d**) Lateral fluoroscopic image showing PCL tibial tunnel positioning approximately 6–7 mm proximal to the champagne drop off at the native PCL footprint. (**e**) Passing suture emerging from PCL tibial tunnel and ACL tibial tunnel positioning along the downslope of the medial tibial spine just posterior to the anterior horn of the lateral meniscus. (**f**) The ACL and PCL grafts prior to tensioning, with the ACL graft on the right

Once recovered from her right lower extremity procedures (~ 4.5 years after her injury), she now experienced worsening functional limitations secondary to left knee sagittal plane instability and feelings of "looseness." Repeat examination of the left knee now showed a grade 3 posterior drawer, a grade 2B Lachman, a negative dial test, but no increased joint space widening with varus or valgus stress at both 0° and 90°.

6.7.2 Left Knee Imaging Studies

Initial injury radiographs of the left knee did not demonstrate any significant abnormality, but subsequent imaging 9 months after injury revealed thin areas of heterotopic ossification adjacent to both the medial and lateral femoral epicondyles and within the regions of her collateral ligaments (Fig. 6.6a, b) as well as posterior translation of the tibia with respect to the femur on non-stress lateral radiographs (Fig. 6.7). Preoperative MRI of the left knee showed chronic tears of both the ACL and PCL along the proximal attachment sites, evidence of prior injury of the MCL, LCL, and insertional popliteus tendon, and both medial tibiofemoral and patellofemoral compartment partial-thickness cartilaginous defects (Fig. 6.8a, b).

6.7.3 Treatment Decision

This was a polytrauma patient who had multiple injuries and presented in critical condition. Her left knee ligamentous injuries were not symptomatic given the extent of her other injuries, likely due to her distracting injuries and inability to ambulate initially. She had a chronic multiligamentous knee injury on the left at the time of diagnosis but required further treatment for her functionally limiting right knee motion loss secondary to her MCL heterotopic ossification. Once recovered on her contralateral side, her left knee was functionally unstable. By this time, her previously lax MCL had healed and was functional on examination, indicated by the resolution of medial joint space widening with varus stress. Her chronic left knee bicruciate injury was treated with a single-

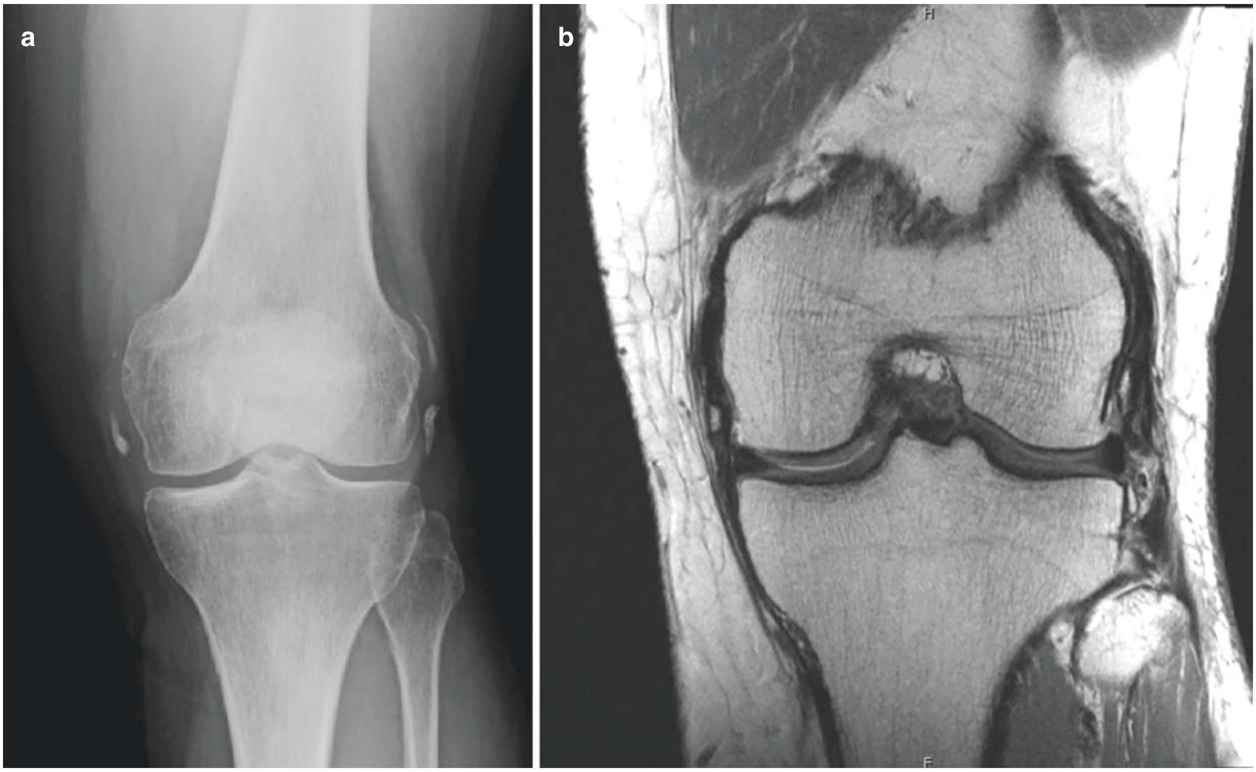

Fig. 6.6 (**a** and **b**): Heterotopic bone formation 9 months after initial injury. (**a**) Anterior-posterior projection showing heterotopic ossification within the medial and lateral collateral ligaments. (**b**) Coronal T1 MRI showing heterotopic bone formation within the MCL

Fig. 6.7 Non-stress 90-degree flexion lateral radiograph of the left knee 9 months after injury showing marked posterior translation of the tibia with respect to the femur

stage reconstruction, with the potential for medial collateral ligament and posterolateral corner reconstruction, if necessary.

6.7.4 Discussion and Surgical Reconstruction

Single-stage surgical reconstruction of her bicruciate injury was conducted 4.5 years after injury. Examination under anesthesia confirmed her most recent clinical examination, with no findings of joint line widening with varus or valgus stress at 0 nor 30° and a negative dial test. Diagnostic arthroscopy revealed 4 mm of joint space centrally in the lateral compartment with varus stress at 30° (Fig. 6.9) which was consistent with a functional LCL, 6 mm of joint space centrally in the medial compartment with valgus stress at 30°, and complete midsubstance tears of the ACL and PCL with remnant fibers at the femoral and tibial insertions. Given the stability of the collateral ligaments, ACL and PCL construction alone was indicated and was performed via an anatomic double-bundle PCL reconstruction and single-bundle arthroscopic ACL reconstruction with independent drilling of tunnels (Fig. 6.10a–c) [52–54]. Achilles tendon allograft with a femoral bone plug was utilized for the PCL AL bundle, tibialis anterior allograft tendon for the PCL PM bundle, and gracillis and semitendinosus hamstring autograft for the ACL.

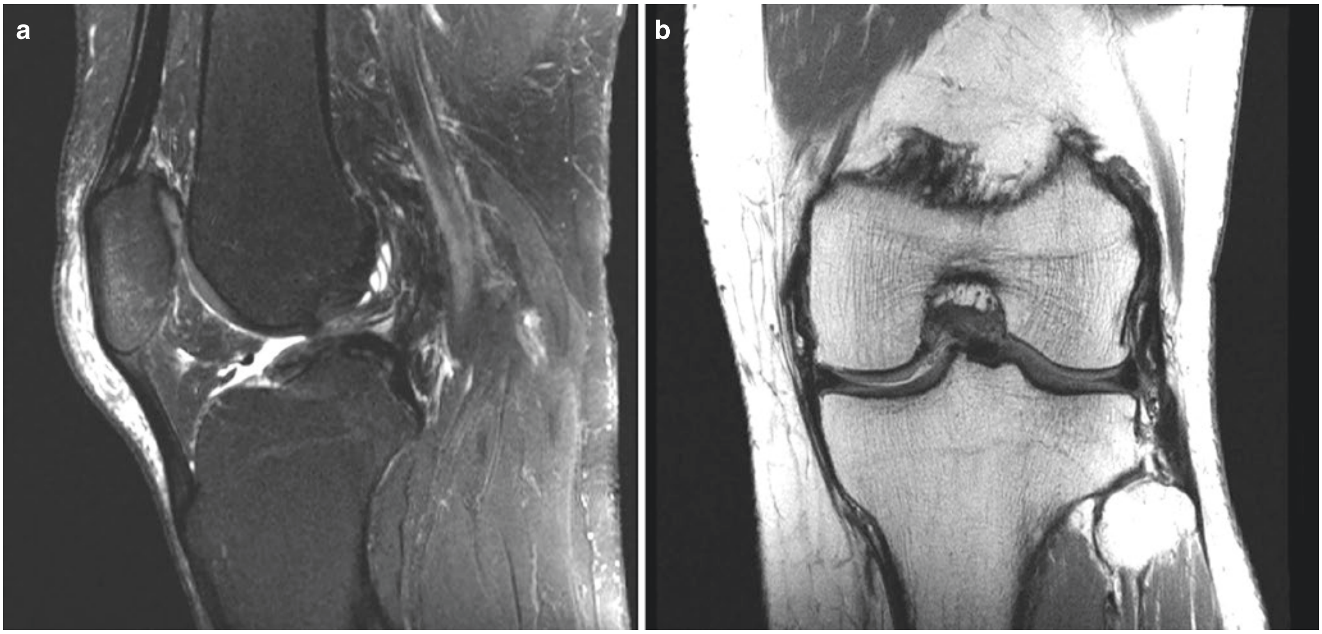

Fig. 6.8 (**a** and **b**): MRI acquires 4.5 years after initial injury prior to bicruciate reconstruction. (**a**) Sagittal MRI slice showing an intact PCL at the tibial insertion, coursing over the tibia anteriorly with no attachment at the femoral insertion. (**b**) Coronal MRI slice showing scarring of the LCL complex

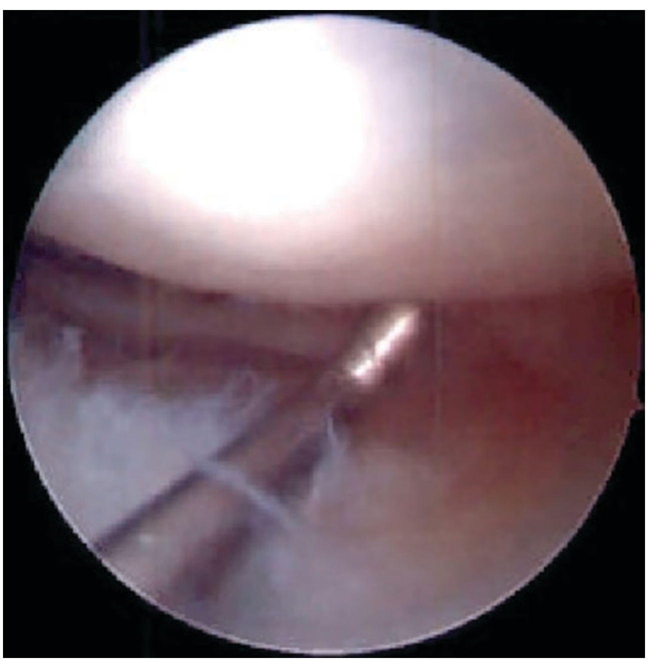

Fig. 6.9 Arthroscopic evaluation of lateral compartment widening at 30 degrees of flexion with varus stress using a 5 mm probe, showing 4 mm of widening centrally consistent with a functional LCL

6.8 Case 3

6.8.1 History/Physical Exam

A 24-year-old female veterinarian technician was riding a horse when she and the horse collectively fell with the horse landing on the medial portion of her right knee while her foot was planted, forcing her knee into varus. She saw an outside orthopedist, and an MRI was acquired when she failed to improve after 6 weeks with partial weightbearing in a knee immobilizer. Without the knee immobilizer on, she described her right knee as feeling "unstable" with "buckling" episodes. Physical examination revealed focal tenderness over the lateral epicondyle, limited range of motion from 0° to 85°, a grade 3 posterior drawer, a grade 1B Lachman with guarding, increased lateral joint space widening with varus stress at both 0 and 30°, and a positive dial test at 30°, but not at 90°.

6.8.2 Imaging Studies

Imaging of the right knee revealed a small avulsion fragment off the lateral femoral condyle on plain films, which on MRI was found to represent both LCL and popliteus tendon avulsions from the femur (Fig. 6.11a, b). Magnetic resonance imaging of the right knee revealed midsubstance ACL and PCL tears, lateral collateral ligament and popliteus tendon avulsions off the lateral femoral condyle, and anterior medial femoral condyle bone edema consistent with her varus-hyperextension injury (Fig. 6.12a–c).

6.8.3 Treatment Decision

The patient had a multiligamentous knee injury with early arthrofibrosis, as indicated by her poor knee range of motion. The decision was made to treat her injuries in a two-stage fashion in an attempt to minimize permanent losses in her

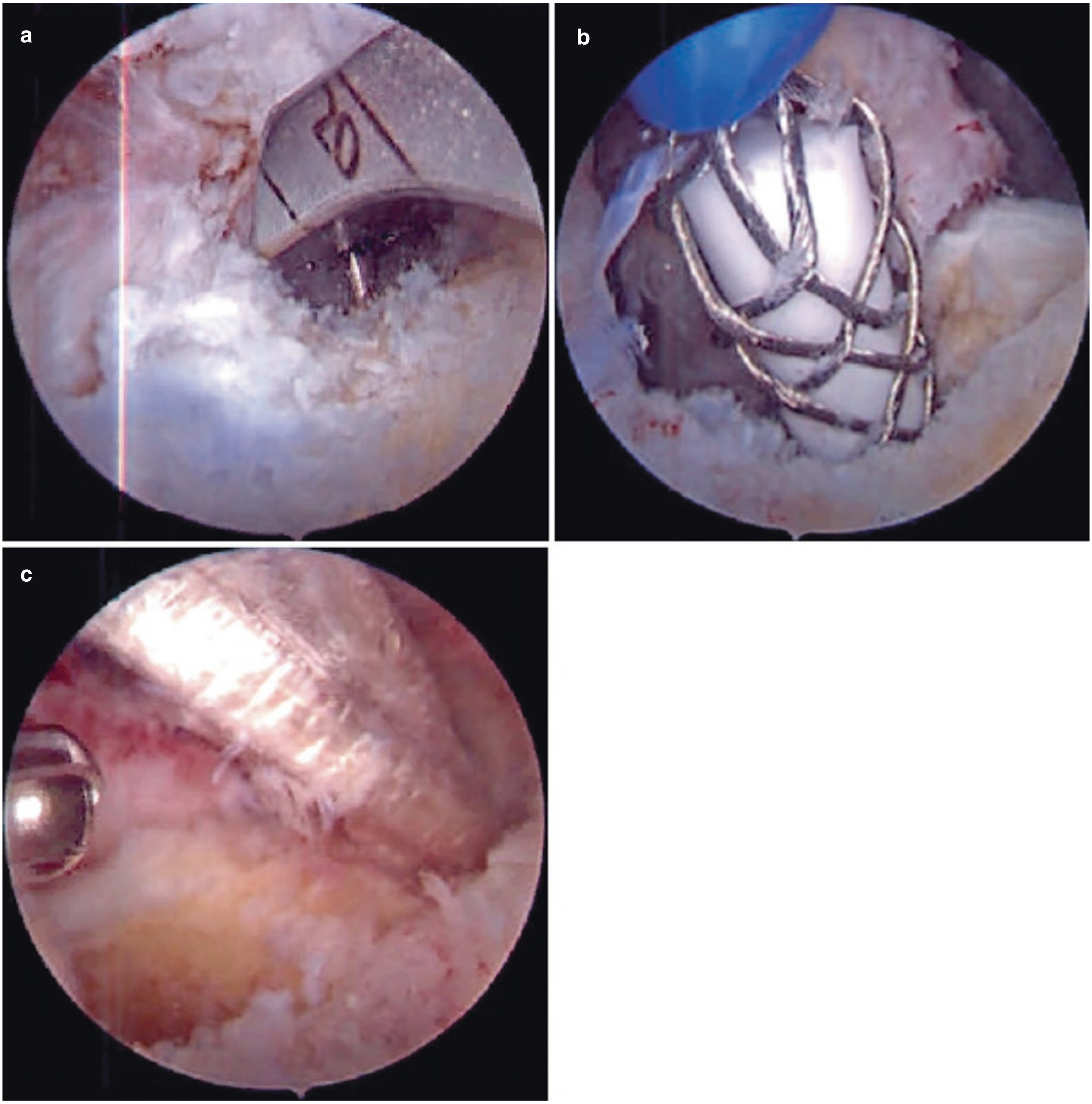

Fig. 6.10 (**a**–**c**): Reconstruction of chronic bicruciate injury 4.5 years after injury. (**a**) The PCL tibial footprint was identified after removal of the remnant PCL fibers posteriorly, and a guide pin was placed along the PCL footprint, with care to avoid damage to the shiny white fibers of the posterior root of the medial meniscus. (**b**) A tunnel rasp is shown being passed through the PCL tibial tunnel to rasp the anterior aspect of the tunnel to facilitate graft passage and smooth sharp bone edges that could damage the graft. (**c**) The PCL graft can be seen posteriorly behind the reamed ACL tibial tunnel

motion. The first stage consisted of diagnostic arthroscopy to evaluate the medial meniscus and open repair of the lateral collateral ligament and popliteus tendon femoral avulsions, followed by protected and cautious early range of motion with physical therapy. Stage two would be delayed bicruciate reconstruction once her range of motion improved.

6.8.4 Discussion and Surgical Reconstruction

Stage 1 consisted of open repair of the lateral-sided avulsions and was performed 7 weeks after injury. Examination under anesthesia revealed no asymmetric hyperextension suggesting an intact posterolateral capsule, grade 1B

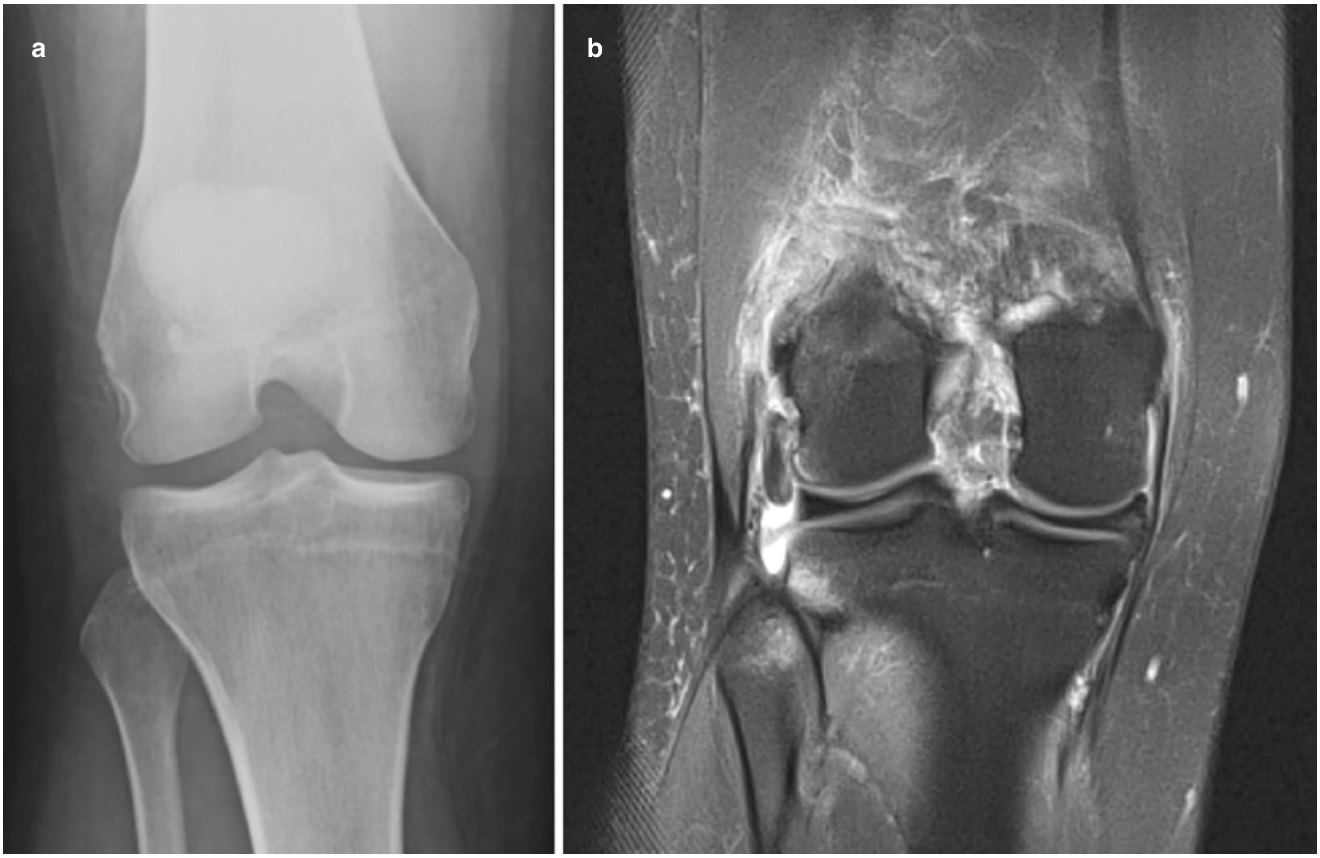

Fig. 6.11 (**a** and **b**): Imaging findings showing both LCL and popliteus tendon avulsions from the lateral femur. (**a**) AP radiograph showing a subtle radiodensity adjacent to the lateral femur in the region of the lateral femoral condyle and popliteal sulcus. (**b**) Coronal MRI slice showing LCL avulsion off the femur with popliteal femoral avulsion

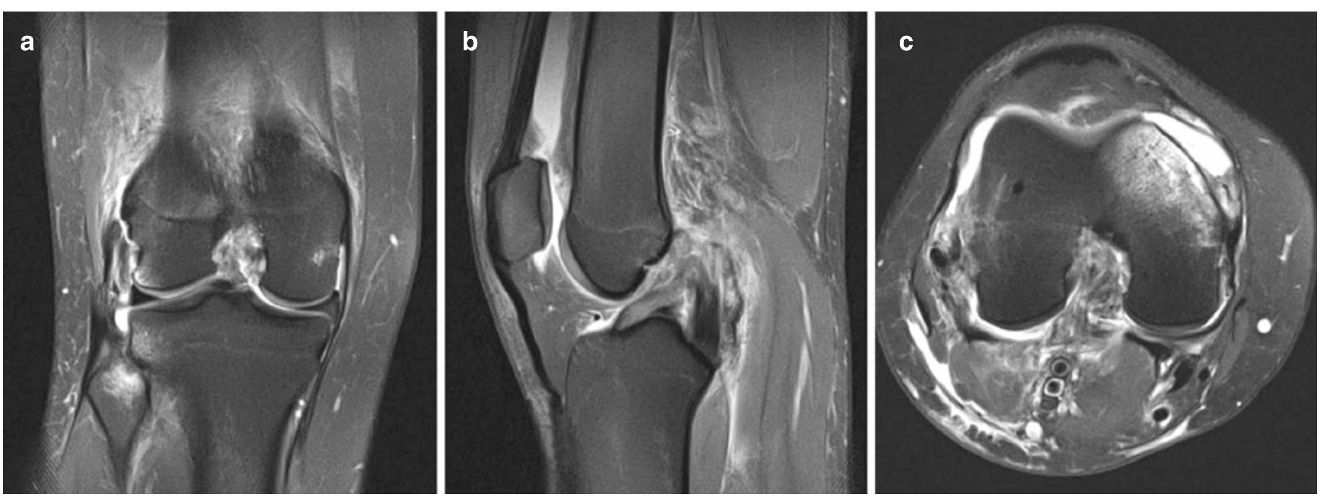

Fig. 6.12 (**a**–**c**): MRI of the right knee 6 weeks after injury. (**a**) Coronal slice showing a fibular collateral ligament femoral avulsion with fluid signal occupying the region of the bone tendon interface. (**b**) Sagittal slice showing both ACL and PCL midsubstance tears. (**c**) Axial slice showing LCL avulsion off the lateral femur in addition to bone edema along the medial femoral condyle

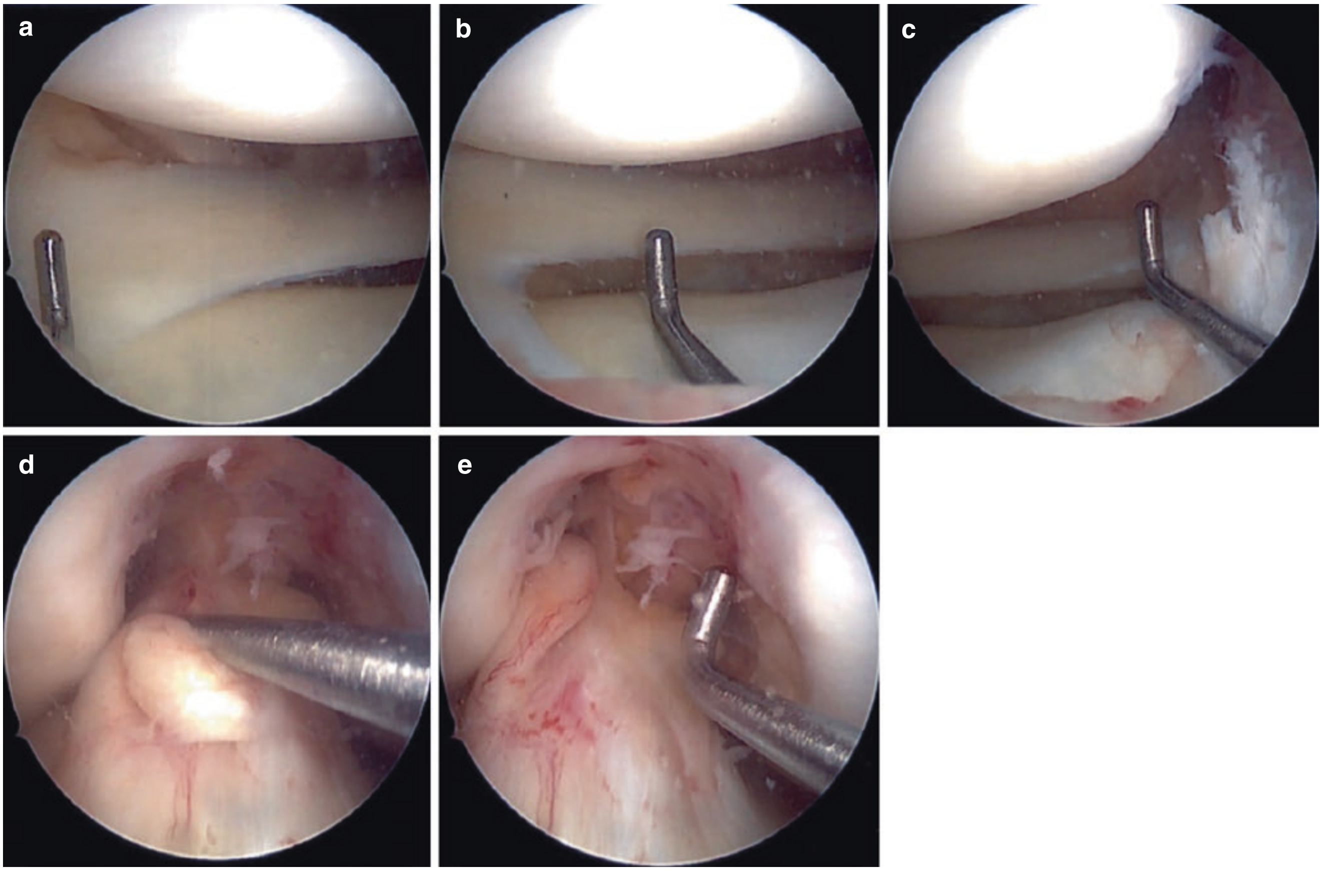

Fig. 6.13 (**a**–**e**): Arthroscopic images from the stage one procedure of the ACL, PCL, and the lateral compartment, while the knee was in 30 degrees of flexion with an applied varus stress. For reference, a 5 mm probe was used. (**a**) At the peripheral margin of the lateral meniscal body, there was 12 mm of lateral compartment joint space. (**b**) Centrally, there was ~10 mm of lateral compartment joint space opening. (**c**) At the lateral tibial spine, there was 8 mm of lateral compartment joint space opening. (**d**) Probe retracting the ACL to reveal the femoral avulsion. (**e**) Absent PCL along the medial femoral condyle at its typical attachment site

Lachman, grade 3 posterior drawer, and 3 mm increased lateral compartment joint space opening in full extension which increased to approximately 9 mm at 30° with a soft endpoint. Diagnostic arthroscopy revealed no meniscal tears or hypermobility, a femoral-sided ACL tear, an absent PCL in the notch with no residual tissue attached to the medial femoral condyle, scar joining the ACL and PCL remnants, and obvious gapping of the lateral compartment (Fig. 6.13a–e). The LCL and popliteus tendon femoral avulsions were repaired using individual Krackow stitches for each of the structures, followed by suture fixation over a cortical bridge on the medial femur created through two bicortical, lateral to medial transosseous tunnels.

Stage 2 consisted of the bicruciate reconstruction performed 20 weeks after injury when she had recovered from her posterolateral corner repair and regained appropriate knee flexion, now up to 120°. Examination under anesthesia verified no lateral compartment widening with varus stress and a negative dial test. Diagnostic arthroscopy showed lateral compartment joint space opening of 4 mm centrally, consistent with functional healing of the lateral structures from the index surgery. The bicruciate reconstruction was done via an anatomic double-bundle PCL reconstruction and single-bundle ACL reconstruction with independent drilling of tunnels [52–54]. Achilles tendon allograft with a femoral bone plug was utilized for the PCL AL bundle, tibialis anterior allograft tendon for the PCL PM bundle, and hamstring autograft with semitendinosus allograft augmentation of the ACL.

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