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Radiographic Workup of the Failed ACLR

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Introduction

A greater understanding of the role of imaging in the diagnosis and treatment of the failed ACLR is critical for all surgeons performing revision ACLR. Plain radiographs, computed tomography (CT), and magnetic resonance (MR) imaging all have various roles and can be helpful for identifying the etiology of a prior ACLR failure, as well as assist in preoperative planning. The focus of this chapter is on the use of imaging in the workup and treatment of the failed ACLR.

Radiographic Landmarks for Anatomic ACL Reconstruction

Multiple studies have shown that non-anatomic tunnel placement, specifically femoral tunnel placement, is associated with higher rates of ACLR failure [1, 2]. While anteromedial portal femoral tunnel drilling was introduced to facilitate a more anatomic and horizontal femoral tunnel position and has been shown to accomplish this goal [3], recent studies have found high rates of non-anatomic tunnel placement with both methods, which highlights the importance of careful tunnel position identification regardless of surgical technique [4].

There are several radiographic landmarks that can be used to evaluate femoral tunnel position. In the coronal plane, whether on an anteroposterior (AP) radiograph or the coronal cut of MRI or CT imaging, the clock-face method is often used to evaluate the femoral tunnel position. Using this method, the femoral tunnel is either placed at the 10 o'clock or 2 o'clock position for a right or left knee, respectively (Fig. 2.1). Of note, this method has been shown to have poor inter-rater reliability, and many, including the authors of this chapter, have moved away from this method as it is not reliable and does not accurately correspond to bony morphology [5, 6]. In the sagittal plane, the quadrant method has been described to evaluate the femoral tunnel position (Fig. 2.2). Using this method, a grid is superimposed on the femoral condyles. The ideal tunnel position is just inferior to the most superoposterior quadrant [7]. This corresponds to a point in center of the ACL footprint which leaves about 1–2 mm of the posterior cortical wall of the femur intact.

With regard to the tibial tunnel, in the coronal plane, the tibial ACL footprint corresponds to a point between the intercondylar eminences about

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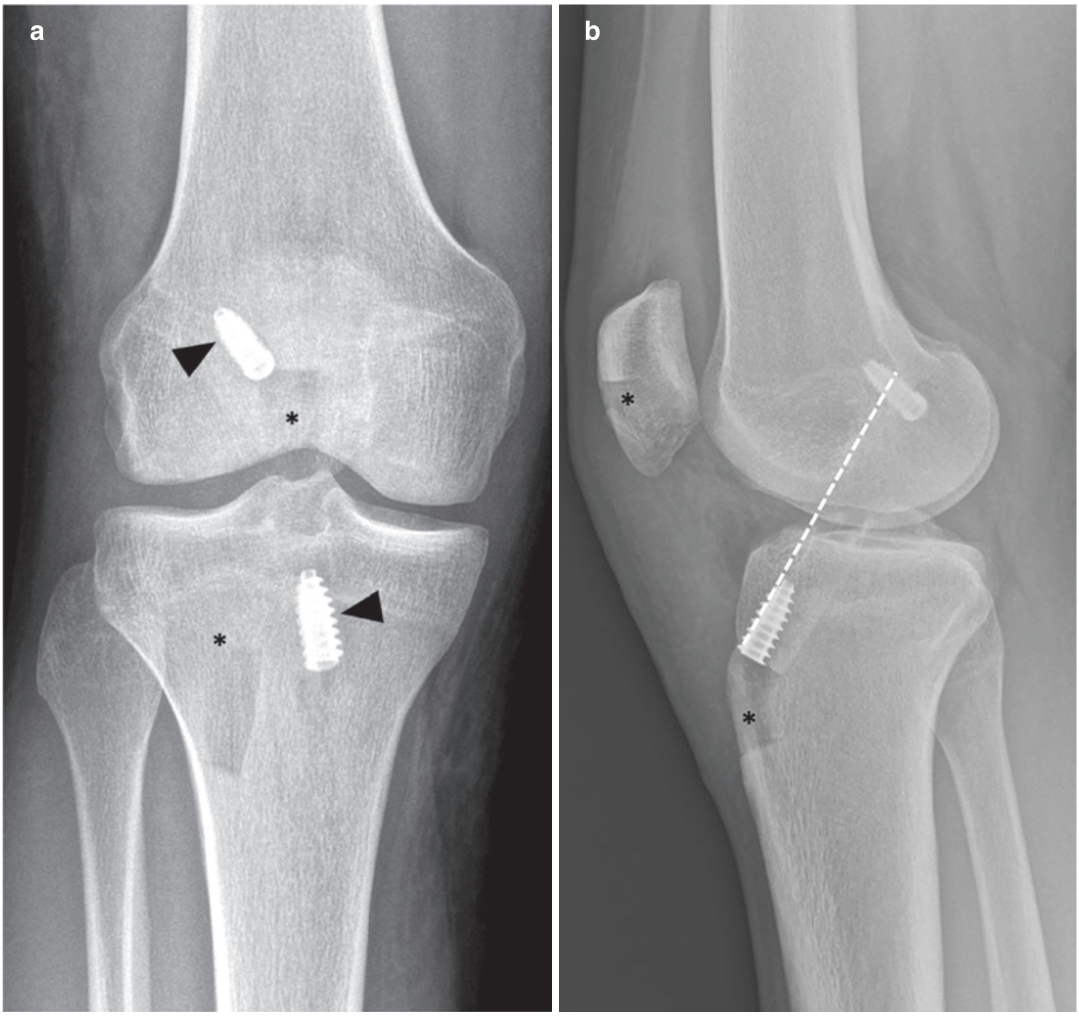

Fig. 2.1 Normal radiographic appearance after anterior cruciate ligament reconstruction. Frontal and lateral radiographs of the knee demonstrate typical postoperative changes after bone-patellar tendon-bone autograft harvesting, with geographic defects along the central patella and the tibial tuberosity at the bone plug harvest site (asterisks). The femoral tunnel interference screw is in standard position, at the 10 o'clock position (femoral arrowhead, **a**). The tibial tunnel should lie posterior to where Blumensaat's line intersects the tibia (dotted line, **b**)

2/5 of the way from the medial to lateral eminence [8]. In the sagittal plane, traditionally the tibial tunnel was recommended to be placed parallel to the slope of the intercondylar roof, i.e., Blumensaat's line [9]. Using this model, the ideal tibial ACL footprint lies just posterior to where Blumensaat's line intersects the surface of the tibia (Fig. 2.1). Recent studies have suggested that use of the intercondylar roof may not always be a reliable landmark, however, and have identified that the center of the tibial ACL footprint can more consistently be located at a point between 43% and 45% of the anteroposterior length of the tibia (Fig. 2.3) [10]. This is based on anatomic studies showing consistency in the location of the tibial ACL footprint relative to the length of the tibial plateau despite variation in intercondylar roof angles. Moreover the tibial tunnel angle will occasionally need to be altered depending on the length of the harvested graft to avoid graft tunnel mismatch [11]. To avoid graft impingement in the intercondylar notch during extension, the tibial tunnel angle is typically recommended to be parallel to the intercondylar roof inclination

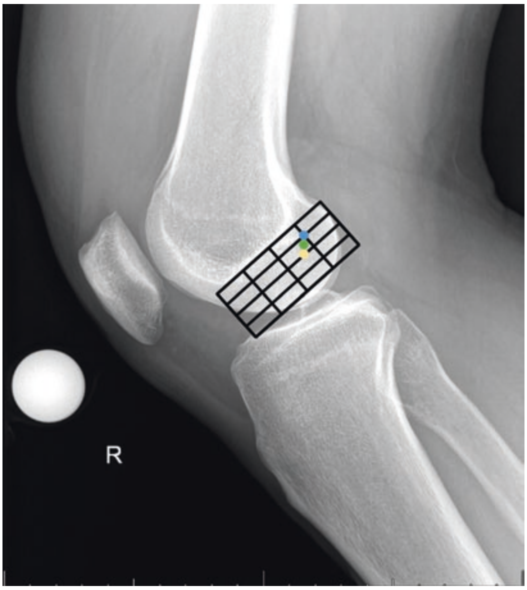

Fig. 2.2 Quadrant method for identifying anatomic ACL origin and correct femoral tunnel position. A grid is superimposed on the femoral condyles parallel to Blumensaat's line. Each dimension is split into quartiles. The anatomic origin of the anteromedial bundle is about 25% anterior and deep to the posterosuperior most aspect of the femoral condyle (blue dot). The anatomic origin of the posterolateral bundle is about 33% anterior and 50% deep to the posterosuperior most aspect of the femoral condyle (yellow dot). The center of the ACL between these two points is shown by the green dot

angle, which has been reported to be, on average, 36.8° in men and 35.2° in women [12].

It is worth noting that, while plain radiographs can provide valuable information, multiple studies have shown poor inter-rater reliability and validity with the use of plain radiographs for the evaluation of tunnel placement when compared to MR and CT imaging. Moreover, it is often difficult to even identify bony tunnels on plain radiograph. Some authors recommend routinely obtaining CT imaging for the most accurate identification of prior tunnel position whenever precise measurements are needed [13]. Three-dimensional CT reconstructions can also be extremely helpful, as they can directly examine the aperture on both the femur and the tibia, especially when the medial femoral condyle is subtracted, as this allows a direct en face view of the lateral femoral condyle wall and the tibial plafond (Fig. 2.4).

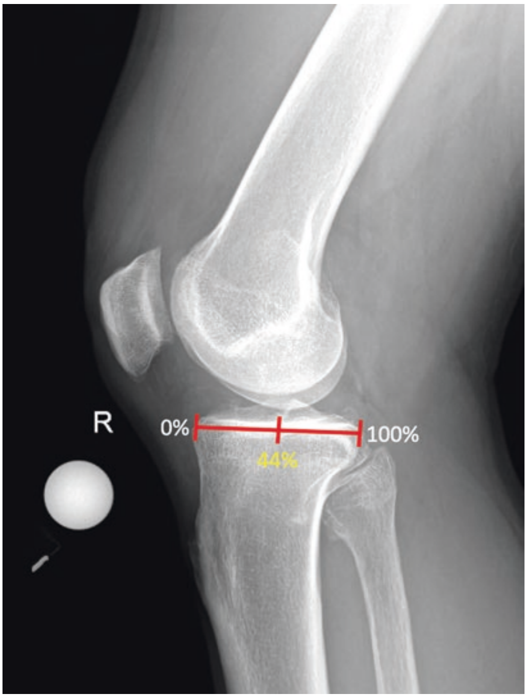

Fig. 2.3 Tibial tunnel location based on the anteroposterior length of the tibial plateau. The method of Stäubli et al. is shown for identifying the ideal tibial tunnel location. A point 44% from the anterior to the posterior edge of the tibia is noted which corresponds to the average location of the ACL insertion

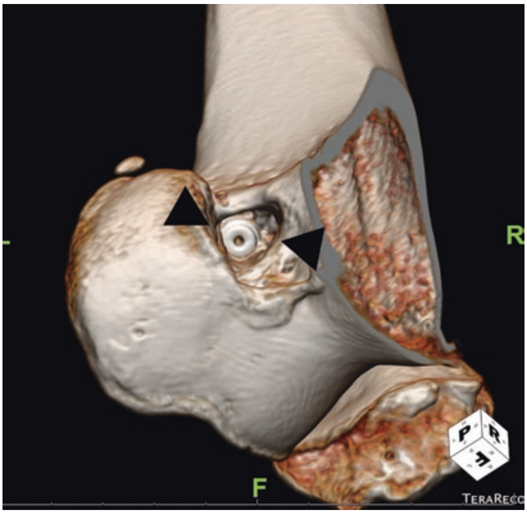

Fig. 2.4 Utility of 3D CT in the evaluation of the ACL graft tunnel. A 3D reconstructed CT image with medial femoral condyle subtraction demonstrates the aperture of the femoral tunnel (arrowheads), which appears widened, with gapping between the tunnel wall and the femoral interference screw

Graft Complications

Graft Integrity

MRI is the preferred diagnostic modality for evaluation of partial and complete graft tear, demonstrating an overall specificity of 86.7% and a positive predictive value of 93.5% [14]. Similar to evaluating the native anterior cruciate ligament, the anterior cruciate ligament graft should be evaluated in the axial, coronal, and sagittal planes on every knee MRI. In the authors' experience, tear of the graft is most readily identified in the axial or coronal plane, typically in close proximity to the femoral tunnel entrance site. Graft tear may appear as frank disruption of graft fibers with an obvious defect on fluid-sensitive images (Fig. 2.5); however, graft fiber discontinuity may be difficult to appreciate in more chronic tears with scarring around the graft. Occasionally in chronic tears, the graft may become largely resorbed and poorly visualized. On sagittal images, orientation of graft fibers should be closely scrutinized. Normally the graft should remain taut and parallel to Blumensaat's line (Fig. 2.6), with a more horizontal orientation and any fiber redundancy being important clues in subtle tears.

Additionally, it is important to distinguish partial graft tear or low-grade sprain injury from the normal process of ligamentization seen in the immature graft. This process is often described as consisting of three phases: an initial healing phase during the first 6 months after surgery, a second remodeling stage which typically continues for another 6 months, and a final maturation phase which starts around 1 year after surgery and has been shown to continue at 2 years after surgery [15]. Ligamentization during the early healing

Fig. 2.6 Normal ACL graft. The normal ACL graft is homogeneously low in signal on fluid-sensitive images, with graft fibers intact and taut, and parallel to Blumensaat's line

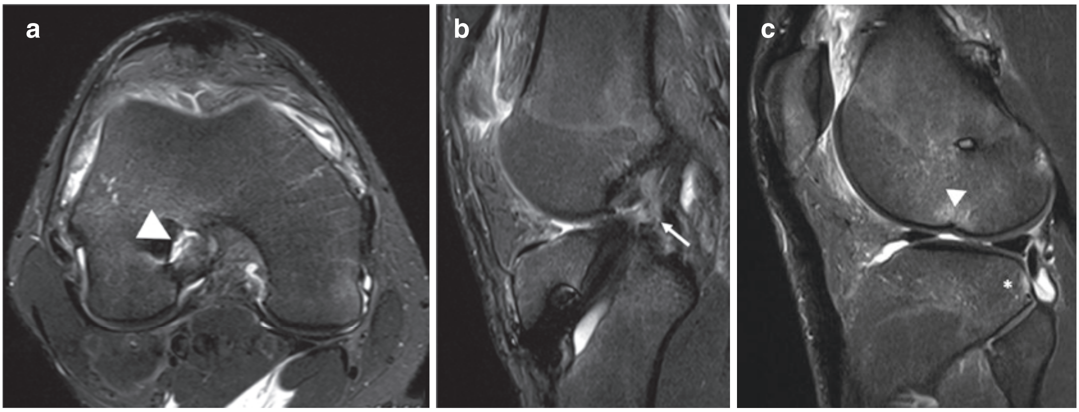

Fig. 2.5 Complete ACL graft tear on MRI. Axial image (**a**) demonstrates a fluid filled full-thickness defect (arrowhead) of graft fibers adjacent to the femoral tunnel. Sagittal image (**b**) demonstrates redundancy of graft fibers, which are normally taut, and important secondary findings, including an impaction fracture of the lateral femoral condyle (arrowhead), contusion of the posterolateral tibial plateau (asterisk), and anterior tibial translation (**c**)

phase will manifest on MRI as focal areas of intermediate signal within the graft that should not be misinterpreted as pathologic (Fig. 2.7). This signal intensity tends to slowly decrease as the graft matures [16]. While numerous studies have found varying timelines for ligamentization, some have reported that ligamentization may persist for up to 4 years following graft reconstruction [9].

Aside from discrete graft tear, secondary findings may be useful in diagnosing a graft tear, including the presence of a large joint effusion, contusion of the lateral femoral condyle and posterior lateral tibial plateau, and anterior tibial translation, imaging findings which are commonly seen in primary ACL tears (Fig. 2.5) [9].

It is important to note, though, that MR imaging is not completely sensitive to graft rupture. One retrospective review of 50 revision ACL cases found that in 24% of cases, the graft was read on MR imaging as intact despite no intact graft on arthroscopic or clinical examination [17]. The sensitivity of MR imaging for detecting ACL graft rupture has been reported to range from 59% to 72% [14, 17, 18]. It is important that any findings on MR imaging are combined with clinical and arthroscopic findings when evaluating for graft rupture after ACLR.

Graft Impingement

Graft impingement is a significant complication of ACLR and can lead to graft rupture, anterior knee pain, knee effusions, and loss of range of motion, particularly extension [19]. Graft impingement occurs when the graft makes contact with the walls of the femoral intercondylar notch, typically during extension. This can occur due to anterior positioning of the tibial tunnel or anterior positioning of the femoral tunnel [19]. Findings of graft impingement on MR imaging include evidence of graft contact with the intercondylar roof, posterior bowing of the graft, and altered signal intensity in the graft, typically in the anterior two thirds (Fig. 2.8) [9, 20]. It is important to distinguish graft impingement from a partial graft tear with anterior tibial translation, as they can have similar findings including

Fig. 2.7 Normal ligamentization of an ACL graft. Coronal MRI image shows thin longitudinal fluid signal along intact fibers of the ACL graft (arrowheads), representing the normal process of ligamentization in this patient 3 months following ACL reconstruction

Fig. 2.8 Roof impingement following ACL reconstruction. Sagittal MRI image shows evidence of roof impingement, with anterior graft fibers (arrowheads) mildly frayed and kinked along the undersurface of the intercondylar notch. The tibial tunnel has an anterior position relative to where Blumensaat's line intersects the tibia, predisposing to roof impingement

anterior position of the tibia relative to the femur, buckling of graft fibers, and altered graft signal intensity. Anterior positioning of the tibial tunnel and the presence of a true cyclops lesion [21] are findings that might suggest graft impingement rather than a partial graft tear. It is important to distinguish a true cyclops lesion from a "pseudo-cyclops" lesion which can occur in partial graft tears when the torn fibers flip into the intercondylar notch and create a mass-like appearance – these can be distinguished from true cyclops lesions as these fibers can be traced back to the femoral or tibial tunnels [22].

A less common form of graft wall impingement is sidewall impingement, which may occur between the graft and the medial wall of the lateral femoral condyle if the tibial tunnel is placed too laterally, which appears as a medial indentation in the graft [23]. It can also occur as a result of osteophyte formation at the site of notchplasty or an interference screw protruding into the intercondylar notch [24, 25].

Hardware Complications

ACLR failure can occur as a result of failure of graft fixation. Fixation devices such as metal or bioabsorbable interference screws can rarely loosen and migrate intra-articularly (Fig. 2.9) [26, 27]. As mentioned above, if the screw is not placed entirely within the tunnel and is slightly protruding intra-articularly, it can lead to graft impingement [24]. Occasionally, the tibial interference screw will have a proud position and may irritate the overlying soft tissues, with potential for formation of an adventitial bursa.

Other Complications

Arthrofibrosis

Arthrofibrosis after ACLR is defined as the presence of scar tissue within the knee joint and is reported to occur in 1–10% of patients after ACLR. There are two main forms: focal arthrofibrosis (otherwise known as the cyclops lesion) and diffuse arthrofibrosis.

A cyclops lesion is a nodular mass of fibroproliferative tissue and can sometimes contain osseous or cartilaginous tissue and, in such cases, are sometimes referred to as "true cyclops" lesions as opposed to cyclopoid scars, which only contain fibrous tissue [28]. True cyclops

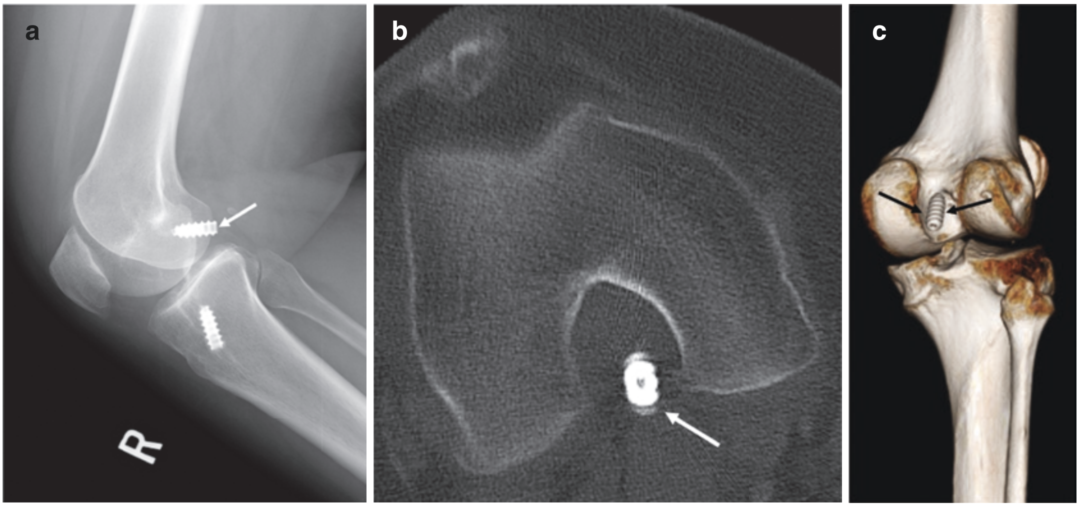

Fig. 2.9 Displaced femoral interference screw following ACL reconstruction. Lateral radiograph (**a**), axial CT (**b**), and 3D CT reconstructed images (**c**) demonstrate displacement of the femoral interference screw into the posterior intercondylar notch (arrows)

lesions are more likely to cause loss of extension since, unlike cyclopoid scars, they cannot be easily compressed. They appear on MR imaging as a well-circumscribed nodule with an average size of 10–15 mm [29] (Fig. 2.10). They are typically located in the anterior intercondylar notch and subsequently can cause impingement in extension and loss of extension. They most commonly occur at 6–12 months postoperatively after ACLR [30]. It is important to distinguish pseudocyclops lesions from cyclops lesions, as stated above [22].

Arthrofibrosis can also occur in a diffuse form and is more common in patients with poor preoperative range of motion [31]. It appears on MR imaging as hypointense fibrous tissue surrounding the graft and extending to the posterior joint capsule and possibly in the infrapatellar fat pad. This is in contrast to a distinct mass-like lesion as in the case of cyclops lesions. The differential for arthrofibrosis includes nodular synovitis (focal pigmented villonodular synovitis) and synovial chondromatosis.

Tunnel Cysts/Osteolysis

Role of CT in Cases of Suspected Tunnel Widening

It is common for small amounts of fluid to be present in the tibial and femoral graft tunnels up to 18 months after ACLR [32]. This fluid is typically reabsorbed within 18 months and does not constitute a true cyst or lead to tunnel expansion, ganglion formation, or graft failure. When tunnel cysts do form, they can occur in the pretibial space, in the tibial tunnel, and in the femoral tunnel. They can also be classified as communicating or non-communicating depending on whether they communicate with the joint space.

While their etiology is not completely understood, tunnel cysts and widening have been attributed to several causes, including excess graft motion in the tunnel, accumulation of osteolytic cytokines from synovial fluid in the tunnel secondary to incomplete graft incorporation, early accelerated rehabilitation prior to complete

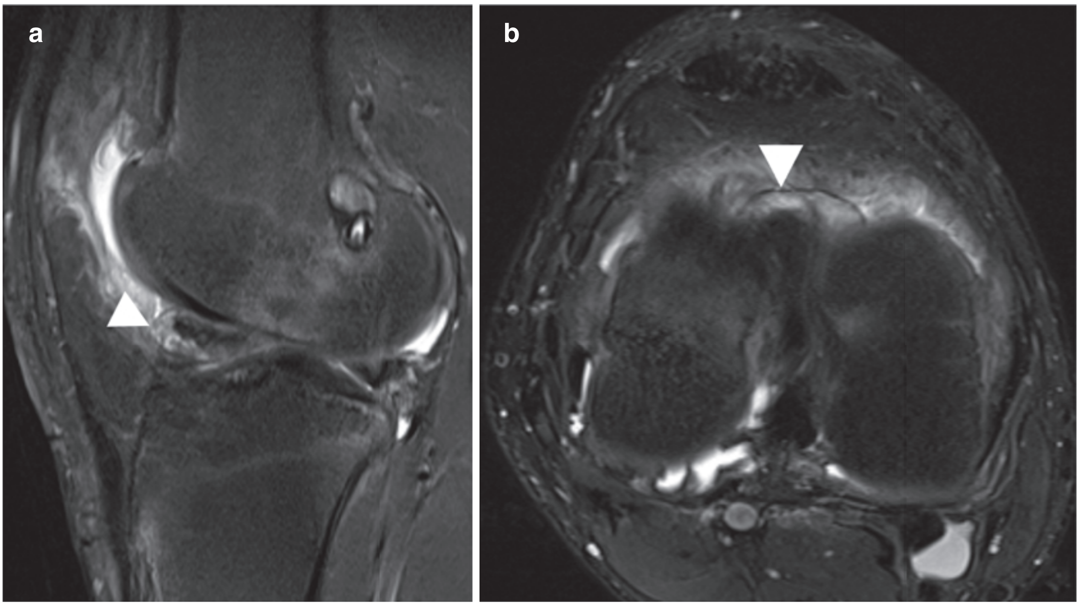

Fig. 2.10 Focal arthrofibrosis following ACL reconstruction. Sagittal (**a**) and axial (**b**) images of the knee demonstrate a heterogeneously T2 hyperintense nodule along the anterior intercondylar notch (arrowheads), compatible with focal arthrofibrosis (cyclops lesion)

graft incorporation, and host response to hardware such as bioabsorbable interference screws [33, 34].

With regard to findings on imaging, plain radiographs may show tunnel widening around the fixation device [35, 36], as well as sclerotic borders identifying the geographic limits of the tunnel. MR imaging can show fluid in the tunnel, tunnel widening, or simple or loculated cysts (Fig. 2.11). These findings are most adequately visualized on STIR or fat-suppressed T2 sequences, especially since STIR images are less affected by metal artifact from certain fixation devices. These cysts extend into the pretibial space, intercondylar notch, or popliteal fossa.

CT imaging is also often used to evaluate tunnel widening and cyst formation (Fig. 2.12). One comparative study found that neither plain radiographs nor MRI was reliable in evaluating tunnel widening and found greatest intra-rater and inter-rater reliability for the evaluation of tunnel widening with CT imaging [37].

The differential for tunnel widening/osteolysis includes foreign body granulomas, which appear as a heterogenous mass that enhance with intravenous gadolinium contrast, and screw extrusion in which there will be a cyst in the tunnel but the screw will be visibly extruded from the tunnel. While there is no evidence that the development of a tunnel cyst is associated with increased rates of graft failure, it is important to note the formation of a tunnel cyst or tunnel widening on imaging for the purposes of preoperative planning for revision ACLR. In some cases, a two-stage procedure may be required with an initial bone grafting procedure followed by a second definitive ACLR once there is adequate bone stock for tunnel drilling.

Fig. 2.11 Tunnel osteolysis on MRI after anterior cruciate ligament reconstruction. Sagittal MRI image demonstrates osteolysis of the tibial tunnel, with marked tunnel cystic widening (arrowheads)

Additional Factors That May Contribute to Risk of Graft Re-rupture or Recurrent Instability

Alignment

Coronal Plane

Assessment of tibiofemoral alignment in the coronal plane is a critical component of the evaluation of any patient with an ACL injury. There are several ways of assessing varus or valgus alignment. Methods include drawing the mechanical axis, which can be depicted as a line from the center of the femoral head to the center of the tibiotalar joint, and assessing whether this line passes medial or lateral to the center of the tibiofemoral joint, indicating varus or valgus alignment, respectively.

Varus alignment has been shown to increase the forces placed across both the native and reconstructed ACL, thus putting patients at risk for increased risk of ACL injury as well as ACLR failure [38]. Varus alignment combined with ACL deficiency can also lead to increased development of arthritis [39]. As a result, multiple authors have advocated for performing high tibial osteotomies (HTO), either combined or in staged

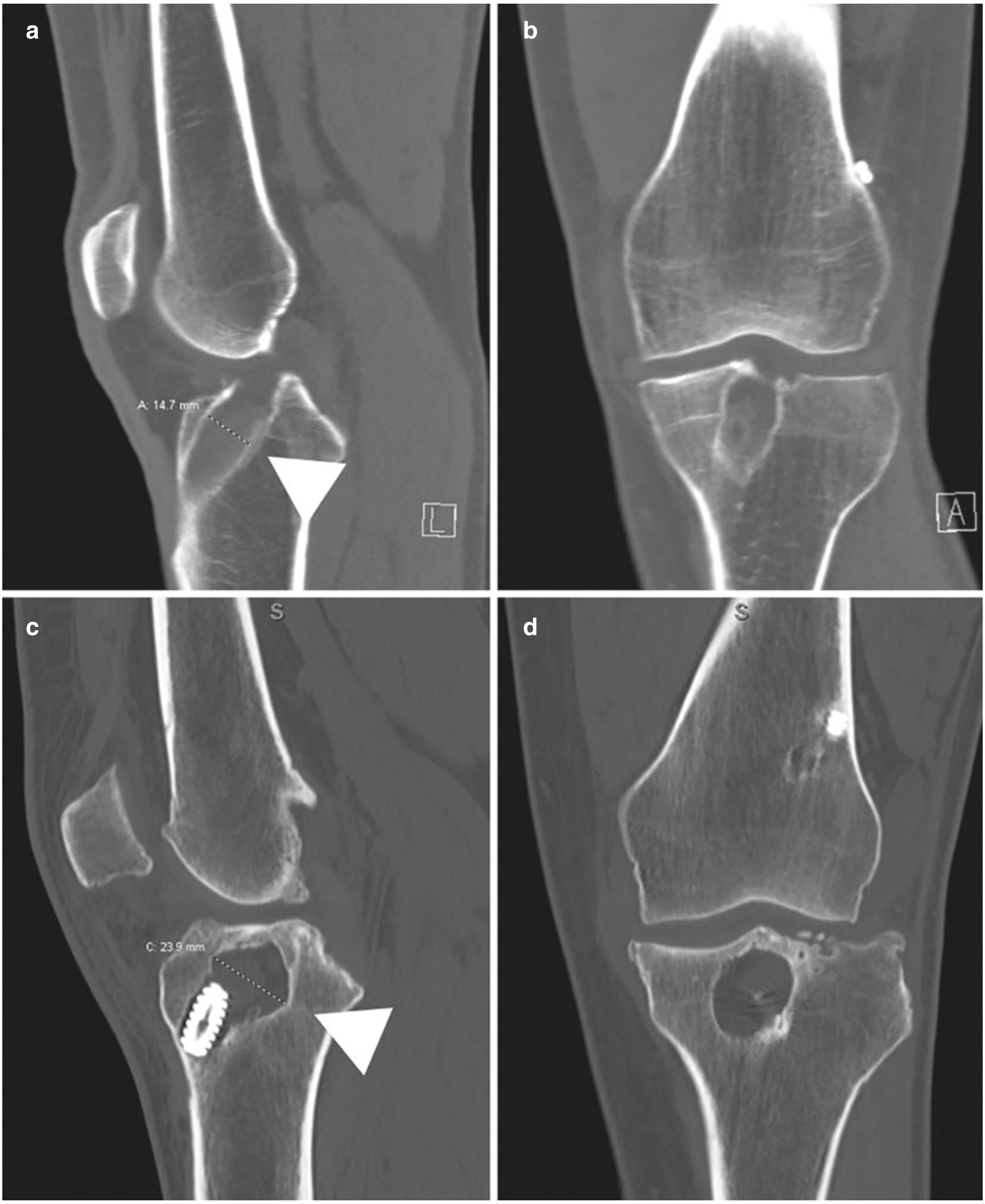

Fig. 2.12 Tunnel osteolysis on CT after anterior cruciate ligament reconstruction. Sagittal (**a** and **c**) and coronal (**b** and **d**) images demonstrate examples of osteolysis of the tibial tunnel in two separate knees. Measurement of tunnels at their widest point are shown on the sagittal images (arrowheads). The first patient (**a** and **b**) was noted to have maintained cylindricity of their tunnel, whereas the second patient (**c** and **d**) was found to have a more cavitary area of bone loss

fashion with revision ACLR, to address ACL deficiency, prevent or delay the progression of medial compartment osteoarthritis, and reduce the risk of revision ACLR failure. Several studies have found favorable functional and clinical outcomes with this approach [40, 41].

Tibial Sagittal Slope

Assessment of sagittal alignment is an important part of the preoperative planning process. The most commonly used parameter of sagittal alignment is posterior tibial slope (PTS), which can be measured as the angle formed by the intersection of a line parallel to the tibial shaft and another line tangential to the articular surface of the tibial plateau (Fig. 2.13).

Multiple studies have found increased rates of ACLR failure as well as primary ACL injuries with increased posterior tibial slope (PTS), with some studies identifying a particularly large increase in risk with a posterior tibial slope of 12 degrees or greater [42, 43]. Biomechanical studies have confirmed that increased forces are seen across the ACL with increased PTS [44]. As a result, several authors have suggested performing proximal tibial slope-reducing osteotomies to decrease the posterior slope in patients with excessive PTS and reduce the rate of ACLR failure [42, 45]. It remains unclear whether there is more value to measuring the PTS on the medial or lateral tibial plateau. While some authors recommended using the medial tibial plateau as it is more recognizable [46], the lateral tibial plateau PTS has also been shown to be associated with increased risk of ACL injury and ACLR failure [43, 47].

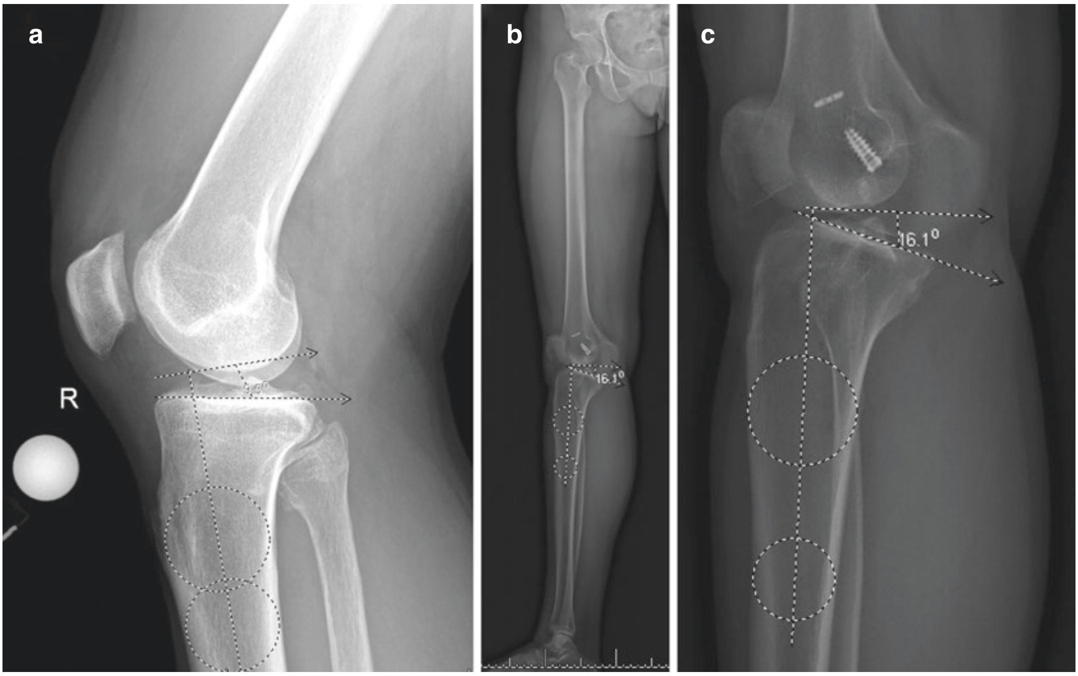

Fig. 2.13 Measurement of posterior tibial slope. A lateral radiograph (**a**) is shown with a measurement of the posterior tibial slope. Briefly, to identify the longitudinal axis of the tibia, a line is drawn connecting the center of the tibia at 2 points about 5 cm apart and with the distal point as distal in the tibia as possible. A second line is drawn connecting the anterior and posterior most points on the tibial plateau. The angle between a line perpendicular to the longitudinal axis of the tibia and the line tangential to the tibial plateaus is the posterior tibial slope angle, which is 9.5 degrees in this radiograph. (**b**) is the full-length standing film from a 24-year-old female who presented with recurrent ACL reconstruction failure after three prior ACL reconstructions. Her posterior tibial slope, which is measured in (**b**, **c**), is 16.1 degrees, and she was indicated for a closing wedge high tibial osteotomy, along with revision ACL reconstruction, to decrease her posterior tibial slope and decrease her chance of recurrent graft failure

Other Sources of Persistent Instability

Meniscus Pathology

The menisci are important secondary stabilizers of the ACL-deficient knee, and meniscal injuries can increase the forces on the reconstructed ACL graft. The medial meniscus has been shown to contribute primarily to anteroposterior stability, whereas the lateral meniscus contributes more to rotatory stability by preventing anterior tibial translation during pivot-shift maneuvers involving a valgus and internal rotation load [48]. Concomitant meniscectomy with ACLR has been shown to be associated with worse clinical outcomes and increased radiographic development of osteoarthritic changes compared to ACLR alone [49]. The combination of chronic anterior tibial translation with posterior meniscus deficiency can specifically lead to increased chondral wear posteriorly. One radiographic marker of this is the "cupola" sign, or an osteophyte on the posteromedial corner of the tibia that develops in response to chronic anterior tibial translation [50]. One study of 103 patients undergoing total knee arthroplasty found that all 43 patients who had a cupola sign on preoperative radiographs were confirmed intraoperatively to have a ruptured ACL [51]. Thus, it is important to recognize meniscal pathology and perform meniscal repair when possible (Fig. 2.14), and studies have shown that lateral meniscus root repair can improve stability in the ACL-deficient knee [52].

There is also now increasing awareness of the importance of identifying lesions involving the peripheral attachment of the posterior medial meniscus, termed "ramp" lesions, which have been reported to be present in 9.3–17% of ACL injuries [53, 54]. These lesions can manifest as a meniscocapsular avulsion, a meniscotibial ligament avulsion, or a combination of these two. Cadaveric studies have found that ramp lesions lead to increased anterior tibial translation and external rotation in the ACL-deficient knee and that ACLR alone did not restore these parameters but ACLR with ramp repair did [55, 56]. On the other hand, one prospective randomized study of ACLR with repair of concomitant stable ramp lesions has found no difference in clinical outcomes or anterior tibial translation [57].

Although only unstable ramp lesions may require surgical intervention, it is important to identify them using MR imaging. These tend to occur in a posteromedial "blind spot," which is difficult to view with the traditional arthroscopic portals. They can, however, easily be visualized through the Gillquist position, which will be discussed in other chapters [58]. Studies of the sensitivity of MR imaging for identifying ramp lesions report widely varying values from 0% to 84.6% [53, 59, 60], which reflects a variety of factors including that some studies only looked at the official reports in the medical record, in which ramp lesions might not have been specifically examined for. One author hypothesized that the low sensitivity of MR imaging might be related to MR imaging being performed when the knee is in extension, which can lead to the meniscocapsular separation being reduced.

Ramp lesion findings on MR imaging include the presence of a thin fluid signal between the posterior horn of the medial meniscus and adjacent posteromedial capsule, representing meniscocapsular separation [61], or may appear as a vertical longitudinal tear in the red-red zone of the medial meniscus posterior horn [62]. This can be accompanied by a high signal irregularity involving the capsular margin of the posterior horn of the medial meniscus on the fluid-sensitive images (Fig. 2.15) [63].

Anterolateral Capsular/Structural Insufficiency

There has been a large amount of interest recently in the anterolateral complex of the knee. There is increasing awareness now that traditional single-bundle ACLR may not reliably restore rotatory stability, which has been shown to have a significant effect on clinical outcomes [64, 65], and that the anterolateral complex significantly contributes to the rotatory stability of

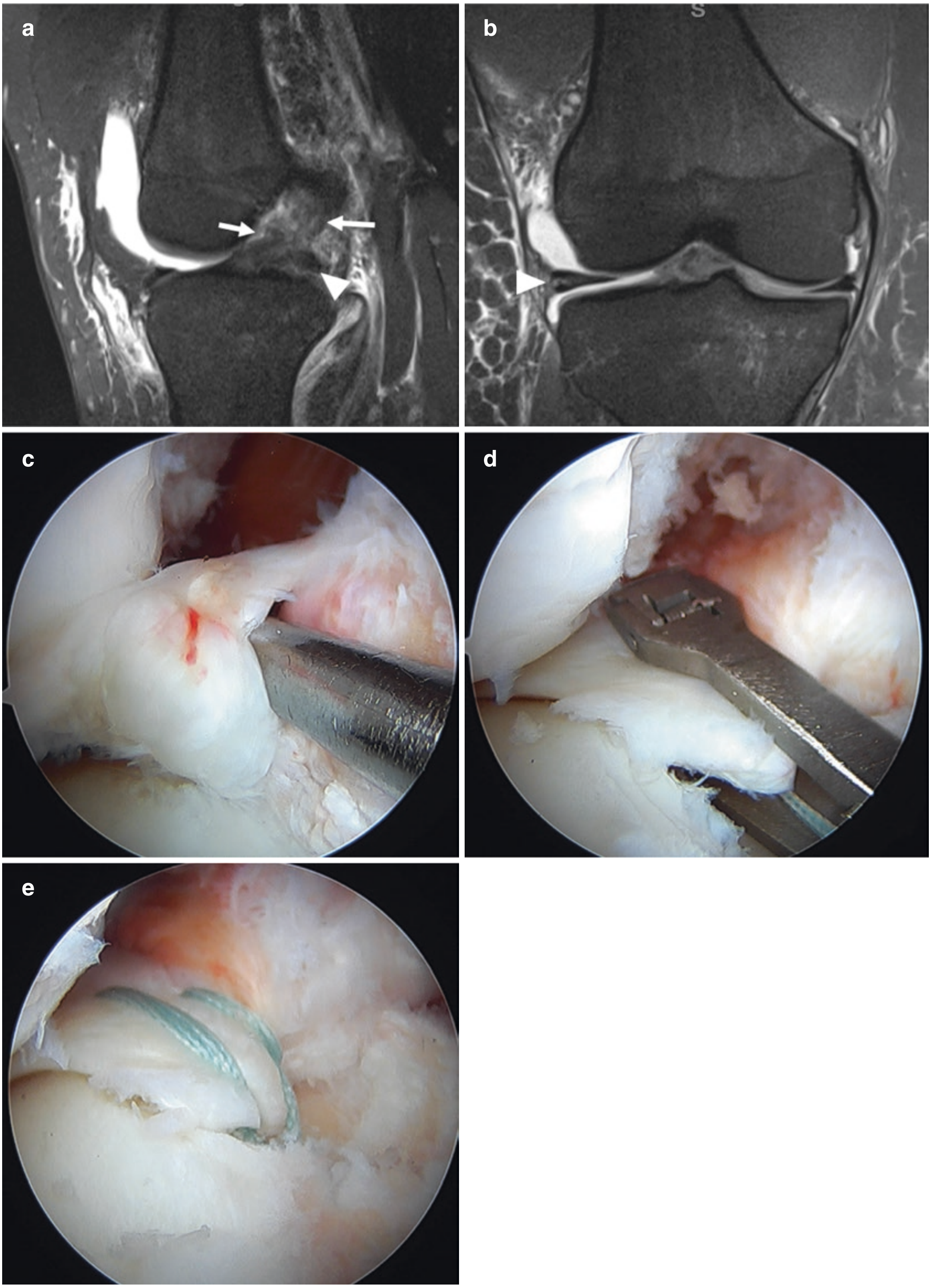

Fig. 2.14 Meniscal root injury with anterior cruciate ligament (ACL) rupture. Sagittal and coronal MRI images demonstrate an ACL tear (arrows, **a**) with meniscal root injury (arrowhead, **a**) with meniscal extrusion (arrowhead, **b**). Intraoperative arthroscopy confirms meniscal root injury (**c**, **d**). Meniscal root repair was performed concomitantly with ACL reconstruction (**e**)

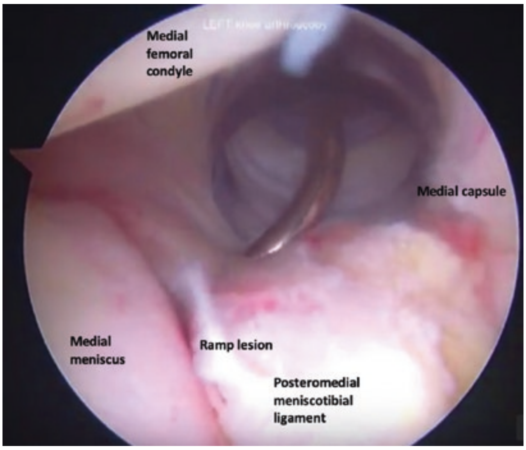

Fig. 2.15 Arthroscopic image of ramp lesion. This image depicts a ramp lesion as seen through the Gillquist view during an arthroscopic anterior cruciate ligament reconstruction. The peripheral attachment of the posterior horn of the medial meniscus, specifically the posteromedial meniscotibial ligament, has been disrupted. MRI has varying sensitivity for detecting these lesions, and it is important to evaluate for them intraoperatively, as unstable ramp lesions may require additional surgical intervention

the knee [66, 67]. The anterolateral complex contains the lateral collateral ligament (LCL), the anterolateral capsule, the iliotibial band, as well as a thickening of the anterolateral capsule that has been termed the "anterolateral ligament" (ALL). While there is controversy on whether this structure constitutes a discrete ligament versus a thickening of the capsule, part of the iliotibial band, or both, evaluation of the anterolateral complex is nevertheless an important component of the preoperative planning process given its critical role in rotatory stability [68]. While there is variation in its reported appearance, the ALL has been described on MR imaging as a sheetlike structure connecting the distal femur to the proximal tibia. There is still some controversy surrounding the ALL's origin, but most people think its origin is proximal and posterior to the LCL attachment and that it courses anteriorly and inferiorly until it inserts on the lateral meniscus and lateral tibial plateau, 6.5 mm below the articular surface [69, 70].

The reported sensitivity of MR imaging for identification of the intact ALL ranges from 11% to 100% [71, 72], and the reported incidence of concomitant ALL abnormalities with ACL injuries ranges from 33% to 90% [73–75]. While ultrasonography has been investigated for its utility in evaluating ALL injuries, prior studies have found contrasting results, with one study reporting 100% sensitivity for identifying ALL injuries on ultrasound [76], while others have found that ultrasound cannot even accurately identify or visualize the ALL [77].

Identification of these injuries is important because it may influence the decision to perform additional procedures during ACLR, such as extra-articular tenodesis or ALL reconstruction [78, 79]. Further work is being done to characterize the anatomy and role of the anterolateral ligament and the entire anterolateral complex, and this is an aspect of ACLR that is continuing to rapidly evolve.

Collateral Ligament Insufficiency

Evaluation of concomitant injuries to the medial collateral ligament (MCL), lateral collateral ligament (LCL), posteromedial corner, and posterolateral corner is an important component of the evaluation of the failed ACLR. Various studies have found that untreated concomitant ligamentous laxity tends to account for 3–5% of revision ACL cases [1, 80]. While these injuries can occur at the time of the initial ACL rupture, it is also important to note that concomitant ligamentous laxity can also develop over time in the ACL-deficient knee in the absence of the stabilizing effect of the ACL. The ACL has been shown to provide both valgus and varus stability, particularly in the absence of a competent medial- or lateral-sided ligamentous structures. In these chronic situations where there is ligamentous laxity without a discrete tear, especially in the setting of a history of subjective instability, stress radiography can be particularly helpful (Fig. 2.16). Prior studies have found that side-to-side differences on stress radiographs of 2.7 mm for isolated LCL, 3.2 mm for MCL, and 4 mm for PLC are suggestive of grade III ligamentous injuries [81].

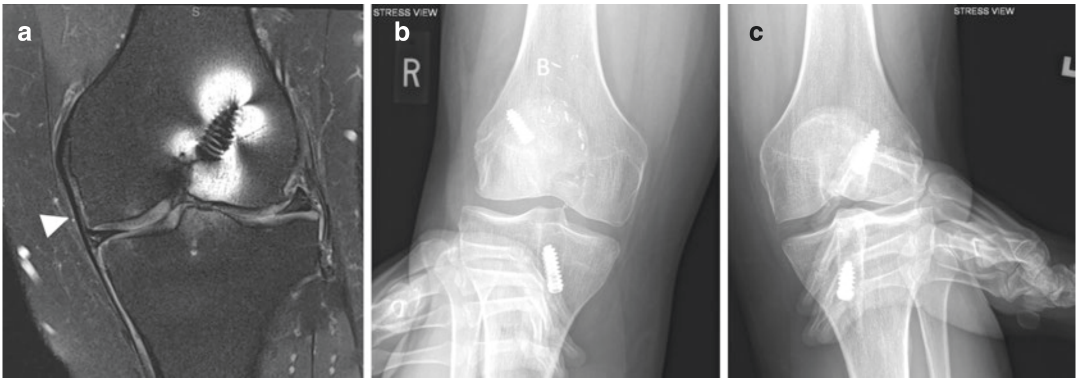

Fig. 2.16 Stress radiographs indicating left knee medial collateral ligament laxity. This patient was a 38-year-old male who had undergone bilateral prior anterior cruciate ligament reconstructions and presented with recurrent left knee instability and laxity to valgus stress on exam. A left knee MRI was obtained and demonstrated complete ACL graft rupture, with nonvisualization of the graft, and intact MCL (arrowhead, **a**). Stress radiographs were obtained and were notable for 8 mm and 12 mm of opening to valgus stress in the right (**b**) and left (**c**) knees, respectively

Conclusion

Surgeons should obtain advanced imaging as a critical component of the preoperative planning process. MR imaging is often the preferred modality for identifying various postoperative complications including graft rupture, impingement, and arthrofibrosis. CT imaging, however, is a useful adjunct and the most reliable method for assessing tunnel location and size. MR imaging can be used to both identify various causes of the failed ACLR and to diagnose additional injuries, such as ALC disruption or ramp lesions, which may require additional procedures.

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