Diagnostic Knee Arthroscopy and Arthroscopic Anatomy

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M. Tyrrell Burrus and Mark D. Miller

Overview and Brief History

Since 1918, when Kenji Takagi used a cystoscope to evaluate tuberculous knees, there have been significant improvements in knee arthroscopic equipment and techniques [1]. Digital high-definition cameras, the fiber-optic light source, smaller but more durable arthroscopic instrumentation, advances in anesthesia medicine, and our understanding of a sterile operative field have made knee arthroscopy into a powerful tool for orthopedic surgeons. Although it was initially met with skepticism, knee arthroscopy has become an extremely common orthopedic procedure in the United States. Of the almost one million performed in 2006, 99 % of those were carried out in the outpatient setting [2]. These numbers represent a 49 % increase in case volume from 1996 to 2006. This boom in the number of arthroscopic procedures appears to be justified as it is now the gold standard for treating many types of intra-articular knee pathology. Compared to open techniques, knee arthroscopy provides many real advantages such as smaller incisions, no violation of the extensor mechanism, decreased recovery time, decreased risk of neurovascular injuries and infections, decreased operative time, and decreased blood loss.

When considering performing an arthroscopic procedure, the surgeon must perform a thorough history and physical, review the preoperative imaging, and develop a surgical plan. This plan does not only include the actual procedure itself, but it should include the appropriate anesthesia option, operating room setup, patient positioning, and portal placement. This chapter will discuss all of these topics with the goal of providing orthopedic surgeons with a useful tool for safely treating knee musculoskeletal disorders.

Anesthesia Options

As with most orthopedic surgical procedures, a variety or combination of anesthetic modalities can be utilized. Some form of general anesthesia, often a laryngeal mask airway (LMA), is used to provide patient relaxation as manipulation of the limb is always necessary. For more lengthy and complicated arthroscopic procedures such as anterior cruciate ligament (ACL) or medial patellofemoral ligament (MPFL) reconstructions, regional anesthesia is provided by the anesthesia block team prior to the procedure. Most regional blocks must cover both the sciatic and femoral nerve distributions to be successful [3]. Depending on surgeon preference, local anesthesia is injected around the portal locations, either prior to incision or at the completion of the procedure [4]. While not commonly performed in the United States, low-dose spinal anesthesia is an option even for ambulatory surgery [5].

Setup and Positioning

Prior to the patient entering the room, the surgeon must communicate with the operating room and anesthesia staff regarding the most logical and efficient room setup. A room of adequate size must be available to accommodate the additional arthroscopic equipment, and the anesthesia team and scrub nurse must have sufficient room at either ends of the bed. Traditionally, the arthroscopic stack and equipment is positioned on the contralateral side of the bed from where the surgeon will stand and will contain the monitor, fluid

M.T. Burrus, MD (✉)
Department of Orthopedic Surgery, University of Virginia Health System, Charlottesville, VA, USA
e-mail: Mtb3u@hscmail.mcc.virginia.edu

M.D. Miller, MD
Department of Orthopedic Surgery, University of Virginia Health System, Charlottesville, VA, USA

Department of Orthopedic Surgery, Head Team Physician, James Madison University, Charlottesville, VA, USA
e-mail: Mdm3p@hccmail.mcc.virginia.edu

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Fig. 2.1 Patient positioning using a well leg holder with the contralateral hip abducted and flexed and placed in a well-padded leg holder. The end of the table has been completely flexed out of the operative field. Also notice the placement of the arthroscopic tower and accessories on the contralateral side of the operative extremity

pump (if desired) and arthroscopic fluid bags, arthroscopic shaver housing, electrocautery unit, and high-definition printer (Fig. 2.1). A Mayo stand will be brought in from this side, and the shaver, electrocautery device, camera, and tubing will be placed here. Prior to draping the patient, ensuring that everything is set up, including placing the shaver pedal at the surgeon's feet, will ensure a more efficient operation and help to minimize surgeon frustration.

Every knee arthroscopic procedure can be performed with the patient supine on the operating room table. If additional lateral or medial posterior knee access is needed, a bump under the ipsilateral or contralateral hip, respectively, should be considered. If intraoperative fluoroscopy is planned, the patient will need to be moved to the distal end of the bed to accommodate a lateral radiograph. Proximal and distal patient positioning is also important if a well leg holder is used as the bed needs to break just proximal to the knee.

Depending on surgeon preference, a table attachment should be placed on the side rails to provide an immobile counterforce to improve visualization of knee compartments. An adjustable side post is commonly used and should be placed at a level that allows the leg to be abducted with sufficient room for the surgeon to stand inside the medial aspect of the leg. Conversely, a well leg holder can be used with the distal aspect of the table dropped and the contralateral hip abducted, flexed, and placed in a well-padded leg holder (Fig. 2.1). More involved procedures might require additional table attachments but must be placed with care to not block access to the knee during instrument passage. Most surgeons use a non-sterile tourniquet inflated to 250 mm of mercury which must be placed high enough on the operative thigh for adequate exposure of the knee.

Pertinent Knee Anatomy and Portal Location

Prior to choosing the appropriate portal location, the surgeon should draw out the pertinent knee anatomy using a sterile marking pen. These structures should be outlined with the knee in 60°–90° of flexion as this is how the knee will look when the incisions are made, and flexion tightens the overlying soft tissues and makes the underlying structures more prominent and easier to palpate. Knowledge of local neurovascular structures is imperative, especially for the more posterior portals. In general, the patella, patellar tendon, medial and lateral tibial joint lines, and medial and lateral femoral condyles are outlined with marker.

Primary Portals

The two primary portals, anterolateral and anteromedial, are the workhorse portals of knee arthroscopy (Fig. 2.2a–c). They do not place any significant neurovascular structures at risk, are easy to identify, and facilitate a wide variety of procedures: diagnostic arthroscopy, medial and lateral meniscectomies, shaving chondroplasty, most microfracture techniques, removal of loose bodies, and all-inside meniscal repair as well as many others. Most surgeons create 1 cm longitudinal incisions which allow for more superior-inferior mobility of instruments versus transverse incisions which allow for more medial-lateral instrument mobility.

Anterolateral Portal

Almost universally, the anterolateral portal is the first portal created and functions as the primary viewing portal. An incision is made distal to the inferior edge of the patella in line with the lateral border of the patella. As further reference, it should be just lateral to the patellar tendon and 1 cm superior to the tibial joint line. These landmarks should place the incision in a soft spot.

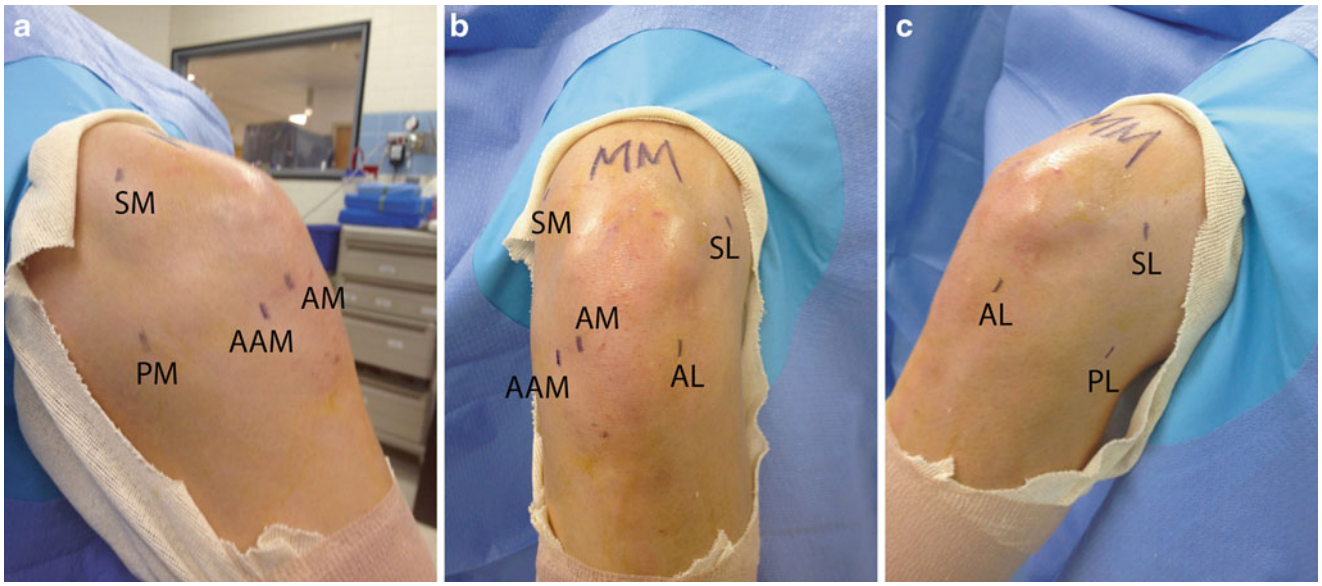

Fig. 2.2 (**a**)–(**c**) The locations of commonly used primary and secondary arthroscopic portals are drawn on the patient's knee. *AM* anteromedial, *AL* anterolateral, *AAM* accessory anteromedial, *SM* superomedial, *SL* superolateral, *PM* posteromedial, *PL* posterolateral

Anteromedial Portal

In almost all arthroscopic procedures, this is the second portal created and, unlike the anterolateral, is often made under direct visualization. The location is essentially a mirror image of the anterolateral flipped to the other side of the patellar tendon: 1 cm distal to the inferior border of the patella in line with the medial border of the patella, just medial to the patellar tendon, and it often falls 1 cm proximal to the medial tibial plateau. However, this basic location should be altered to accommodate the pathology. For a tear of the posterior horn of the medial meniscus, a biter and shaver must be able to slide under the medial femoral condyle which may require a slightly more inferior portal. Conversely, a lateral meniscus tear necessitates a slightly more superior portal in order to slide over the elevated tibial spines. This portal is initially localized with an 18 gauge spinal needle which can be advanced all the way into the involved compartment to determine if this portal location will permit the desired procedure. Then a #11 scalpel pierces the capsule, and a straight hemostat develops the path into the joint. Most arthroscopic instrumentation will be used through this portal.

Secondary Portals

The secondary portals listed below are not created for every knee arthroscopy but rather are used in particular circumstances when the primary portals do not provide adequate access (Fig. 2.2a–c).

Accessory Anteromedial Portal

With the advent of a more anatomic ACL reconstruction and a concurrent departure from transtibial technique, this portal was created to assist in localizing the entry point of the femoral tunnel [6]. Located medial and slightly inferior to the standard anteromedial portal, a spinal needle is inserted in the proposed location and should slide just anterior to the medial femoral condyle and come to rest in the location where the surgeon plans to drill the femoral ACL tunnel. With the knee in hyperflexion, this is the angle in which the tunnel will be drilled and the graft passed and secured. While passing instrumentation in and out of this portal, great care must be taken to avoid iatrogenic damage to the medial femoral condyle.

Posteromedial Portal

This portal is approximately 2½ cm distal and 2½ cm posterior to the medial epicondyle. With the knee flexed to 90°, this location is approximately 1–2 cm above the joint line. Utilizing the modified Gillquist maneuver or view, this and the posterolateral portals are more accurately localized. In this maneuver, the arthroscopic sheath and the blunt obturator are placed in the contralateral anterior portal and are slid along the ipsilateral condyle in the notch until it "pops" into the posterior knee. This can also be gently performed under direct visualization with the scope still in place, which may be a safer technique. Once the arthroscope is in the correct location, the overhead lights can be turned off so that the arthroscopic light will transilluminate the proposed portal location (Fig. 2.3a). Some surgeons recommend using a 70° scope for this maneuver. An

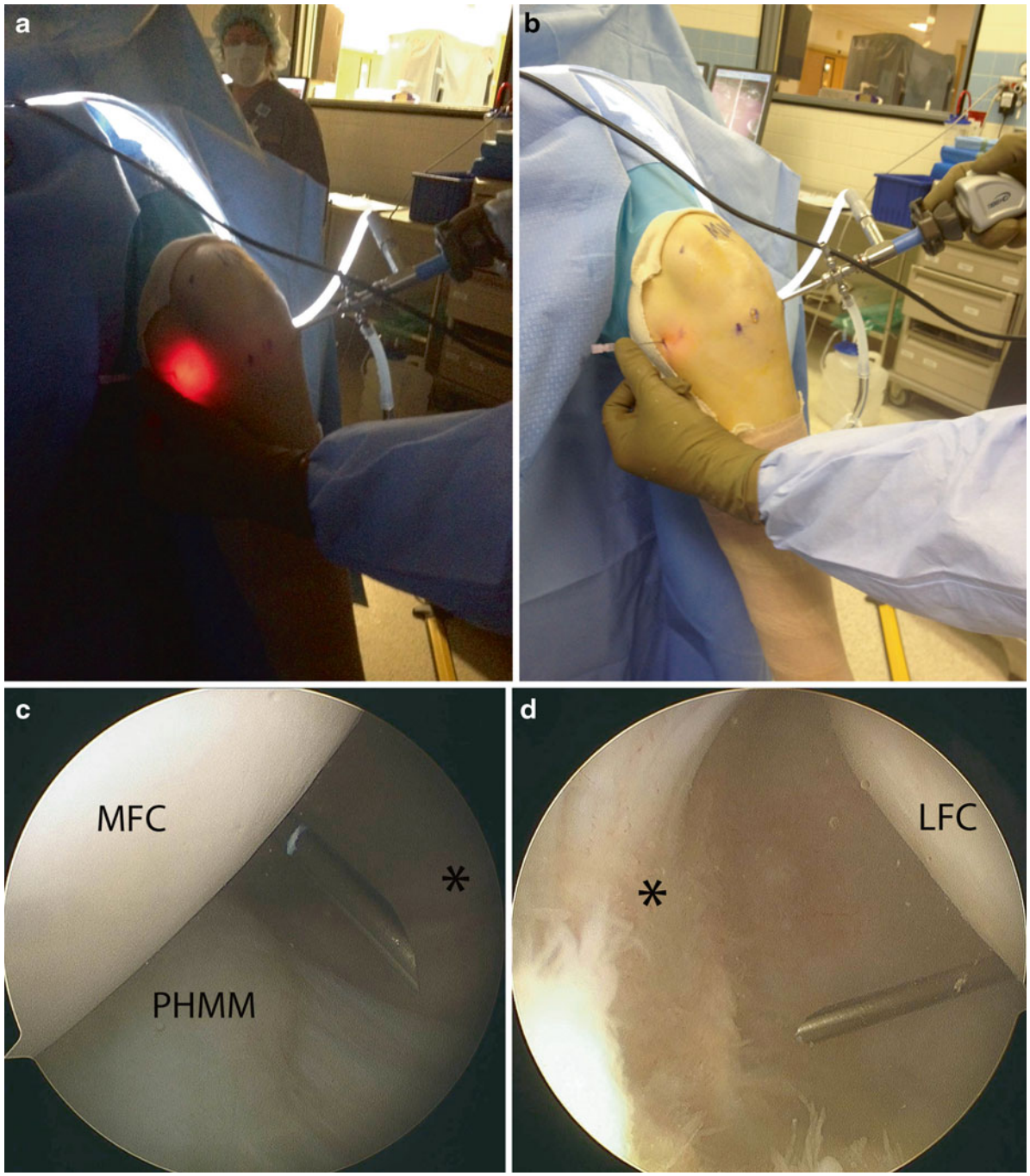

Fig. 2.3 (**a**) After performing the modified Gillquist maneuver to place the arthroscope in the posterior knee, the overhead lights are turned off so that the posteromedial portal location is transilluminated. (**b**) An 18 gauge spinal needle is placed at this location and confirmed arthroscopically. Note that the arthroscope is in the anterolateral portal. (**c**) In the posterior knee, the 18 gauge needle is seen very easily, and this trajectory can be used to address posteromedial pathology. (**d**) This same technique should also be used to establish the posterolateral portal, but the arthroscope is placed in the anteromedial portal. *MFC* medial femoral condyle, *LFC* lateral femoral condyle, *PHMM* posterior horn of the medial meniscus, *Asterisk* posterior knee capsule

additional benefit of transillumination is that overlying neurovascular structures can be visualized as dark lines running in a superior-inferior direction. An 18 gauge spinal needle assures the correct location (Fig. 2.3b, c), which is followed by the "nick and spread" method to avoid injuring the saphenous nerve and long saphenous vein [7]. McGinnis et al. found that the soft spots on the posteromedial aspect of the knee and 1 cm superior to this location were safe portals, but 1 cm inferior was always directly in the path of the saphenous nerve [8]. This portal provides access to posteromedial structures such as the posterior horn of the medial meniscus and the posterior cruciate ligament (PCL) [9].

Posterolateral Portal

As a general rule of thumb, this portal is located just anterior to the biceps tendon (thus anterior to the common peroneal nerve) and just posterior to the iliotibial (IT) band. As described above, the Gillquist maneuver with a spinal needle allows for accurate localization of this portal with the knee in flexion [7] (Fig. 2.3d). In 90° of flexion in a cadaveric model, the common peroneal nerve was noted to travel approximately 25 mm posterior to the portal location, compared to 20 mm with the knee in extension [10].

Superomedial Portal

This portal is located 2–3 cm proximal to the superior pole of the patella just medial to the quadriceps tendon and is made in extension after being localized with a spinal needle. It is commonly used for arthroscopic fluid inflow and outflow, although more advanced arthroscopic tubing and instrumentation have minimized the necessity of an extra portal solely for this use.

Superolateral Portal

This portal is essentially a mirror image of the superomedial portal. It can also be used for arthroscopic fluid inflow and outflow and to observe patellar tracking and to perform an arthroscopic lateral retinacular release.

Transpatellar Portal

For this portal, a vertical incision is made 1 cm distal to the inferior pole of the patella in the middle third of the tendon. This is a less commonly used portal but can be very useful for viewing or grasping loose bodies or meniscal fragments. Avoid this portal if a bone-patellar tendon-bone ACL autograft is planned as some minor damage to the patellar tendon is unavoidable.

Proximal Superomedial Portal

Located 4 cm proximal to the medial pole of the patella, this portal allows for assessment of patellar tracking as well as visualization of the anterior horns of both menisci and the tibial attachment of the ACL [11].

Far Lateral/Medial Portal

Additional accessory portals may be created as needed as long as careful attention is paid to surrounding neurovascular structures. These portals can be utilized to access areas of the knee not well visualized by the other portals mentioned above.

Diagnostic Knee Arthroscopy

In the following paragraphs, the basics of the diagnostic knee arthroscopy are described. During the procedure, it is imperative that the surgeon be thorough and inspects the knee in a methodical and systematic way. Directing all attention at the pathology seen on preoperative magnetic resonance imaging (MRI) and not conducting an exhaustive diagnostic arthroscopy may result in residual pathology causing a clinical failure of the surgery. During the initial diagnostic arthroscopy, the surgeon may choose to treat the pathology as it is encountered versus returning to the involved compartment after completing the complete diagnostic arthroscopy. While either approach is correct, the knee must be wholly investigated by the completion of the procedure.

With the knee flexed and landmarks drawn, the anterolateral portal is created with a #11 blade inserted to a depth sufficient to incise the joint capsule. The blade should be directed toward the intercondylar notch as to not damage the lateral femoral articular cartilage. As with any portals around the joint line, it is wise to insert the knife with the blade facing superior and to extend the portal incision proximally as to not blindly cut down onto the meniscus. Following the scalpel, the trocar and sheath are introduced into the joint and slid into the suprapatellar pouch as the knee is brought into extension. Forcing the trocar into the joint should be avoided, as the articular cartilage can be easily damaged by plunging.

Once the sheath is nestled in the suprapatellar pouch, the trocar is removed, the 30° white-balanced arthroscopic camera with the fiber-optic light source is inserted, and the appropriate tubing (arthroscopic fluid inflow and outflow) is attached. Depending on the expected pathology and surgeon preference, arthroscopic fluid can be pressurized by gravity alone or by an inflow pump set usually to 60 mm of mercury. Once the setup is completed, the patellofemoral articular surfaces and joint tracking are inspected, and any chondromalacia is noted (Fig. 2.4a, b). Loose bodies or synovitis can be found here, and then the inspection should proceed into the lateral gutter or recess. Loss bodies tend to collect here, and gentle palpation over the skin can dislodge them into the camera's view. The camera is then brought up and over the lateral femoral condyle, across the trochlear groove into the medial gutter or recess, and then the knee is slowly flexed while observing for femoral condylar articular cartilage damage or a plica.

With the knee slightly flexed, the arthroscope can be directed into the medial compartment. A valgus stress is applied with assistance of a post, well leg holder, or assistant in order to open up this compartment and allow evaluation of its posterior aspect (Fig. 2.5). Additionally, flexing and extending the knee bring different sections of the medial femoral condyle into view, and knee extension followed by knee flexion can assist in gaining access to the posterior horn of the meniscus. Prior to inspection of this compartment, most surgeons create the anteromedial portal which is used to insert instruments to better evaluate any intra-articular pathology. Through this portal, an arthroscopic probe is inserted and used to define the characteristics of meniscal

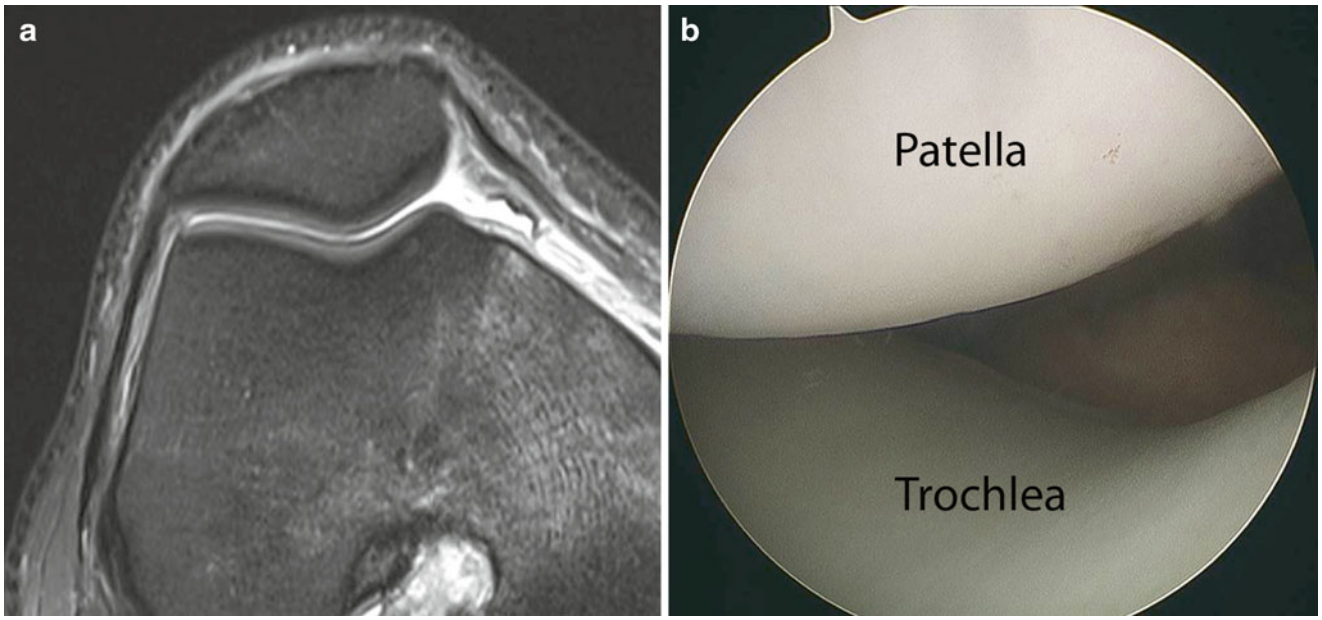

Fig. 2.4 (**a**) An axial T2-weighted MRI image shows healthy cartilage of the patella and femoral trochlea as well as the congruence of the two. (**b**) Viewed from the anterolateral portal, the patellofemoral articulation is well visualized

Fig. 2.5 To perform an arthroscopic evaluation of the medial compartment, a valgus stress is applied across the knee by using the leg holder or post and the hip of the surgeon. Alternatively, an assistant can apply this force

tears and cartilage damage (Fig. 2.6a–c). A normal meniscus should have a smooth articular margin although some undulation at the inner edge is not unexpected. The probe characterizes a meniscal tear by noting meniscal displacement, depth of the tear, or the presence of fragments flipped above or below the joint line. Additionally, the probe should be slid along the articular cartilage to delineate any areas of softening or fissuring. If any pathology is identified, then an arthroscopic shaver, curette, awl, or other instruments may be used through this anterolateral portal.

After the medial compartment is inspected, the arthroscope and probe are swung into the intercondylar notch which is best evaluated with the knee in flexion. The tension on the ACL and PCL can be estimated by tugging on them with the probe (Fig. 2.7a–d). By extending the knee, ACL notch impingement can be assessed.

After the notch is inspected, the arthroscopic instrumentation needs to be carried up and over the ligamentum mucosum. Note that some surgeons will perform a limited debridement of the ligamentum mucosum and of the fat pad, whereas others will work around it secondary to concerns of postoperative pain and hemarthrosis. With the knee flexed to 90°, the instruments should be placed just lateral to the ACL in preparation for the "figure of four" position, at which point they will slide nicely into the lateral compartment as the varus stress is applied (Fig. 2.8). The varus force can be increased by applying an inferiorly

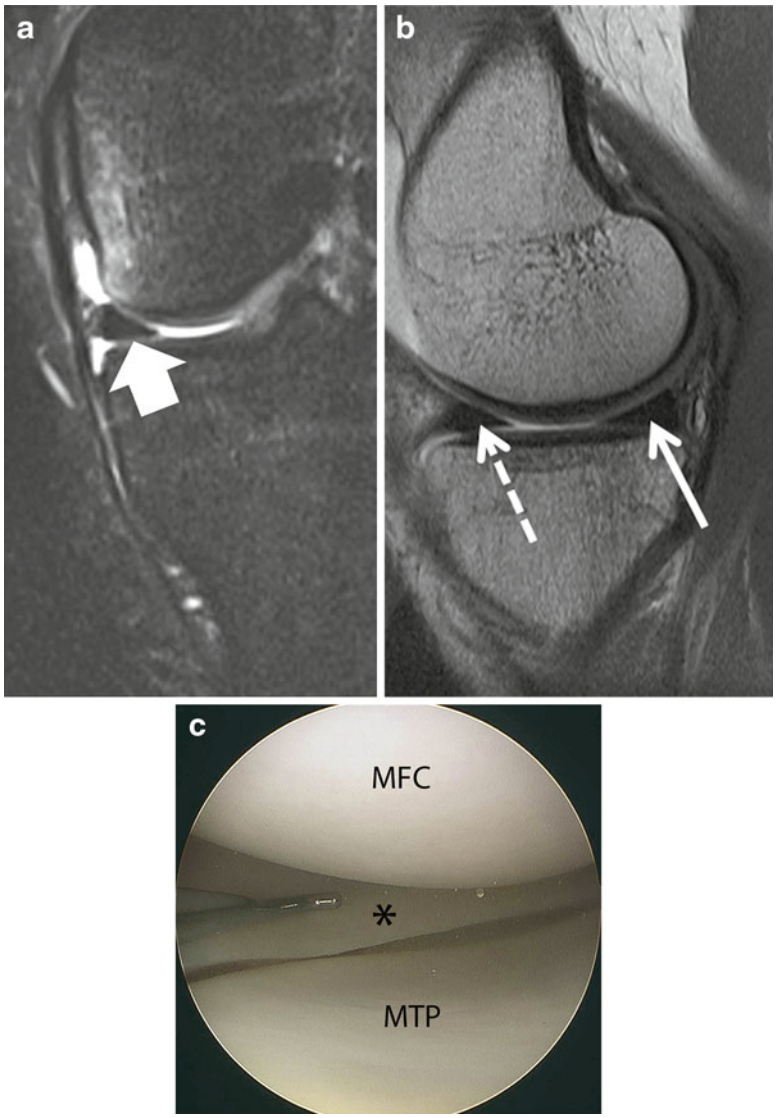

Fig. 2.6 (**a**, **b**) Coronal and sagittal T1-weighted MRI imaging allows for evaluation of the medial compartment articular surfaces and the meniscus. Note that the meniscus appears *triangular-shaped* when the imaging cut is orthogonal to the meniscus. In other words, the body appears *triangular* on coronal imaging, and the anterior and posterior horns appear *triangular* on sagittal imaging. (**c**) Viewed from the anterolateral portal while a valgus forced is applied across the knee, the medial compartment including the meniscus and articular cartilage can be inspected with the arthroscope. *Block arrow* body of medial meniscus, *dashed arrow* anterior horn of the medial meniscus, *solid arrow* posterior horn of the medial meniscus, *MFC* medial femoral condyle, *MTP* medial tibial plateau, *Asterisk* medial meniscus

directed force over the distal femur while lifting the foot superiorly. This portion of the procedure can be quite cumbersome for surgeons unfamiliar with knee arthroscopy, as the plane of hand movements is perpendicular to the plane viewed on the monitor. In addition to meniscal tears and cartilage damage, diagnostic arthroscopy in the lateral compartment includes evaluation of the popliteus tendon and hiatus (Fig. 2.9a, b).

It should be noted that although the anterolateral portal is most commonly the viewing portal, the surgeon should not hesitate to view through the anteromedial portal and place instruments through the anterolateral portal. Examples of when this would be appropriate:

- When performing an ACL reconstruction with an accessory anteromedial portal, viewing through the anteromedial portal allows the surgeon to correctly place the femoral tunnel starting point.
- When debriding a tear of the anterior horn of the medial meniscus, working through the anterolateral portal provides arthroscopic biters with an improved angle to the meniscus.
- For high-grade chondromalacia of the lateral femoral condyle, placing the microfracture awl through the anterolateral portal facilitates orthogonal perforation of the subchondral bone relative to the articular surface.

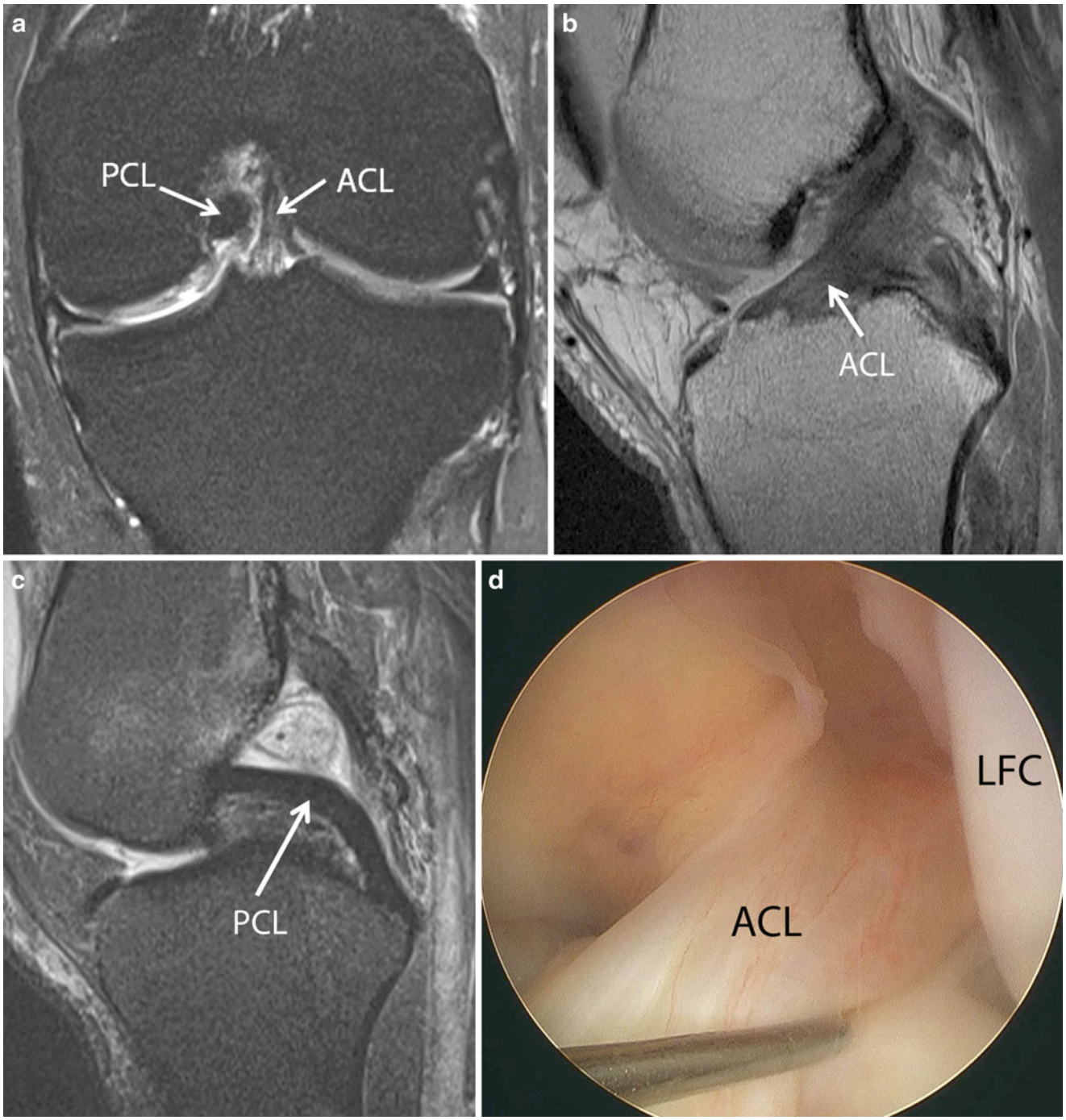

Fig. 2.7 (**a**) Coronal T2-weighted MRI image showing the intercondylar notch with the ACL and PCL. (**b**) Sagittal T1-weighted image of the ACL with its normal striated appearance. (**c**) Sagittal T2-weighted image showing the more well-defined PCL. (**d**) Arthroscopic image of the notch with the probe around the ACL. *ACL* anterior cruciate ligament, *PCL* posterior cruciate ligament, *LFC* lateral femoral condyle

Fig. 2.8 To perform an arthroscopic evaluation of the lateral compartment, a varus force is applied by placing the leg in the "figure of four" position. Note that the camera must be turned 90° relative to the floor in order to provide the appropriate horizontal images on the monitor

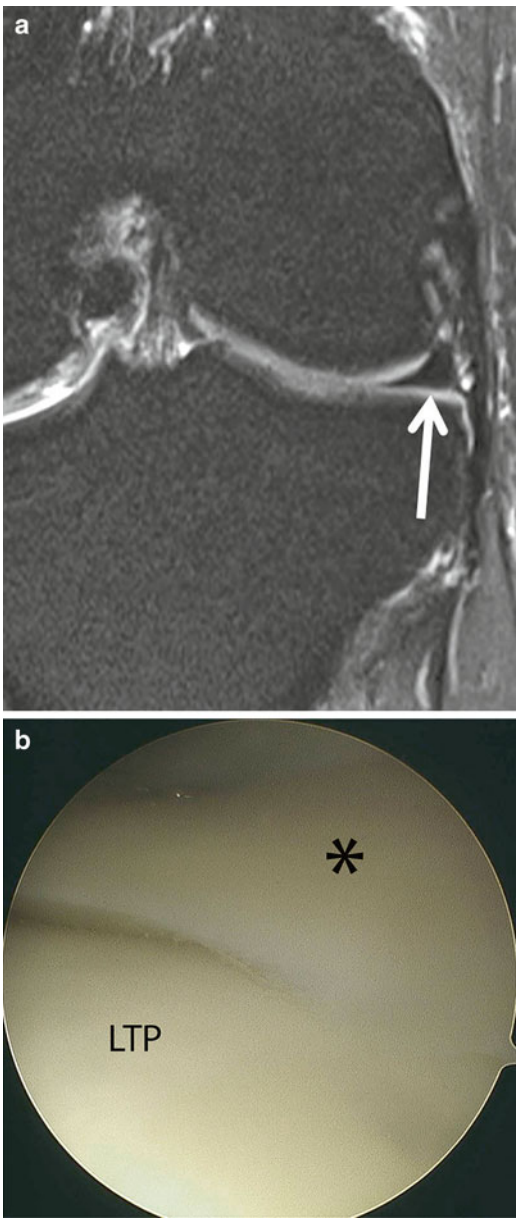

Fig. 2.9 (**a**) Coronal T2-weighted MRI imaging showing the body of the lateral meniscus. (**b**) Arthroscopy allows for evaluation of the lateral compartment articular surfaces and the meniscus

Summary

Due to its expanding indications and continued evolution, today's orthopedic surgeon must possess the ability to perform a basic knee arthroscopy. For a variety of intra-articular knee processes, arthroscopic treatment has become the gold standard when compared to its antiquated open counterpart. However, the surgeon must have a strong understanding of knee anatomy relative to arthroscopic portal locations to minimize iatrogenic neurovascular injuries. With appropriate patient selection and proper surgical technique, knee arthroscopy can provide patients with substantial pain relief and a meaningful return of their knee function.

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