US of the Knee: Scanning Techniques, Pitfalls, and Pathologic Conditions[1]

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Abbreviations: LCL = lateral collateral ligament, MCL = medial collateral ligament

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SA-CME LEARNING OBJECTIVES

After completing this journal-based SA-CME activity, participants will be able to:

- Describe the normal US anatomy of the knee.
- Describe the US technique for comprehensive evaluation of the knee.
- Recognize the US appearances of common pathologic conditions of the knee, as well as common pitfalls/mimics of disease.

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Pain and other disorders of the knee are a common presenting complaint in the ambulatory setting. Although the cornerstones of imaging evaluation of the knee are radiographs and magnetic resonance (MR) imaging, ultrasonography (US) is less expensive than MR imaging, easily available, and of comparable accuracy in the evaluation of certain pathologic conditions of the knee. The benefits of US include portability, low cost, high spatial resolution, dynamic imaging, and ability to guide percutaneous interventions when indicated. US also allows direct patient contact, facilitating immediate clinical correlation and the ability to compare with the contralateral knee. US evaluation of the knee can be targeted to a specific region on the basis of the complaint or be a comprehensive review. For comprehensive evaluation, the knee is divided into anterior, medial, lateral, and posterior compartments for structured evaluation of the tendons, ligaments, joint space, osseous structures, as well as peripheral nerves and vasculature. US is particularly well suited for evaluating injuries of the quadriceps and patellar tendons, injuries of the medial and lateral collateral ligaments, joint effusions, and fluid collections around the knee. There is additional utility in evaluation of the distal hamstrings tendons, the iliotibial tract, the superficial patellar cortex, the common peroneal nerve, the popliteal vessels, and juxta-articular cystic collections including Baker cyst. In-depth appreciation of relevant sonographic anatomy, common pathologic conditions, knowledge of important pitfalls, and mastery of US technique will allow one to effectively use this powerful bedside tool for the evaluation of a wide variety of knee disorders.

Introduction

Knee pain is a common presenting complaint, accounting for greater than 18 million physician visits in 2010 (1). The current primary imaging modality for evaluation of the soft-tissue structures of the knee is magnetic resonance (MR) imaging. Ultrasonography (US) offers several unique strengths over MR imaging, which will be reviewed, that make it a promising technique for the evaluation of certain disorders of the knee. First, US has higher spatial resolution than MR imaging, which may be helpful in evaluating the superficial structures of the knee in detail. Second, US allows for dynamic assessment, which can be particularly helpful in differentiating partial from complete tears involving the quadriceps and patellar tendons. Third, the ability to interact with patients during US evaluation allows one to obtain a relevant history and guide the US examination to identify the cause of specific patient complaints. US also allows easy comparison with the contralateral knee, which can be very helpful for problem solving. Fourth, US may be the modality of choice in evaluating patients with contraindications to MR

TEACHING POINTS

- Ultrasonography (US) offers several unique strengths over MR imaging, which will be reviewed, that make it a promising technique for the evaluation of certain disorders of the knee. First, US has higher spatial resolution than MR imaging, which may be helpful in evaluating the superficial structures of the knee in detail. Second, US allows for dynamic assessment, which can be particularly helpful in differentiating partial from complete tears involving the quadriceps and patellar tendons. Third, the ability to interact with patients during US evaluation allows one to obtain a relevant history and guide the US examination to identify the cause of specific patient complaints. US also allows easy comparison with the contralateral knee, which can be very helpful for problem solving. Fourth, US may be the modality of choice in evaluating patients with contraindications to MR imaging and claustrophobia. Finally, US is lower cost than MR imaging and has the added advantage of portability.
- Scanning is performed with a high-frequency (ideally, 12 MHz) linear transducer, although a lower-frequency (7–9 MHz) transducer is sometimes better suited for evaluating the deep posterior structures.
- Dynamic US is useful in the evaluation of partial tears of the quadriceps tendon, which can sometimes present as a clinical dilemma at physical examination. Partial tears will appear as focal hypoechoic disruptions of the fibrillary and laminar architecture of the tendon. US is also highly sensitive and specific for diagnosing high-grade partial and complete tears, both of which may require surgical management.
- Joint effusions may be simple or complex. One should be careful to distinguish a complex joint effusion from synovitis, which can both appear heterogeneously hypoechoic. Here, color Doppler US is useful, as it can demonstrate increased vascularity within the thickened synovium. Joint effusions may also be identified in the lateral and medial recesses. A small joint effusion may be found only in the lateral and medial recesses in a supine extended knee. Compressibility, redistribution of contents or swirling of the contents with compression or joint movement, and lack of internal flow at Doppler imaging suggest a complex effusion rather than synovitis.
- A Baker cyst (also known as popliteal cyst and semimembranosus–medial gastrocnemius bursa) is a posterior knee cyst that communicates with the knee joint space via a thin neck, located between the semimembranosus and the medial head of the gastrocnemius tendons. Fluid within a Baker cyst may be simple or complex. The cyst may demonstrate partial or complete rupture, becoming irregular appearing or difficult to visualize. Free fluid may be seen tracking inferiorly in the superficial calf, superficial to the medial head of the gastrocnemius muscle.

imaging and claustrophobia. Finally, US is lower cost than MR imaging and has the added advantage of portability. The primary limitation of US of the knee is that it is operator dependent and requires proper training and experience for accurate image acquisition and interpretation. Further, limitations of US include incomplete evaluation of the deep structures of the knee, particularly the cruciate ligaments, the menisci, and the majority of the articular cartilage. Especially for detection of abnormalities of cruciate ligaments, MR imaging remains the investigation of choice. US, unlike MR imaging, cannot evaluate bone marrow edema or intramedullary bone lesions. Table 1 lists the primary indications for which US may be used as the sole or primary modality for evaluation.

US of the knee is diagnostic for the assessment of joint effusions and synovitis. US can also be the primary modality for examining and identifying normal and pathologic fluid collections around the knee, including prepatellar and pes anserine bursae, parameniscal cysts, and Baker cysts. US is useful for evaluation of tendons, particularly the quadriceps and patellar tendons, but also the pes anserine and hamstring tendons. The menisci are incompletely evaluated at US, although some pathologic conditions may be visualized. The medial collateral ligament (MCL) and lateral collateral ligament (LCL) can be evaluated at US, as can the cruciate ligaments to a limited extent. US also allows for evaluation of the common peroneal nerve and the popliteal neurovascular bundle. In this article, we will review US scanning technique with relevant sonographic anatomy, US appearances of common pathologic conditions, and key pitfalls to avoid while evaluating the knee.

General US Technique

US evaluation of the knee is primarily performed with the patient in the supine position, with the obvious notable exception of evaluation of the posterior structures, for which the patient lies prone. Scanning is performed with a high-frequency (ideally, 12 MHz) linear transducer, although a lower-frequency (7–9 MHz) transducer is sometimes better suited for evaluating the deep posterior structures. Although a focused or targeted US evaluation may be completed, a comprehensive evaluation, as described in this article, ensures a complete evaluation. Other benefits of a comprehensive evaluation include identification of pathologic conditions with referred symptoms, development of efficient US technique, high awareness of normal variants and subtle disease, as well as not having to rely on potentially inaccurate or nonspecific patient history.

Comprehensive US Evaluation of the Knee

Multiple protocols for US scanning of the knee have been described in the literature. Described below is the protocol that is followed at our institution (2).

Anterior Knee

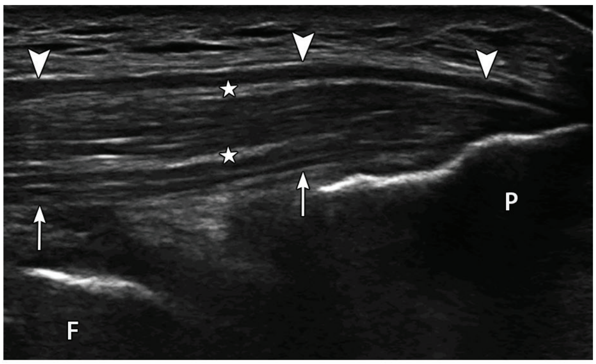
The key structures to be evaluated in the anterior knee are the extensor mechanism (quadriceps tendon, patella, and patellar tendon), patellar retinaculum, suprapatellar joint recess, medial and lateral joint recesses, anterior knee bursae, and femoral articular cartilage. For evaluation of the anterior knee structures at US, the patient is

Table 1: Primary Indication Criteria for US as Sole Modality for Knee Evaluation

Region/Setting	Criteria
MR imaging indicated	
Anterior	Quadriceps tendon disease
	Patellar tendon disease
	Prepatellar bursitis
	Joint effusion
Medial	Medial collateral ligament injury
Lateral	Lateral collateral ligament injury
	Biceps femoris injury
	Posterolateral corner injury
Posterior	Baker cyst
	Deep vein thrombosis
Juxta-articular soft-tissue lesions and fluid collections	Generally indicated
Below-the-knee amputation	Stump neuroma
	Abscess
	Adventitious bursa
MR imaging contraindicated	
Interventions	Aspirations, injections, biopsies

Figure 1. **(a)** US probe placement and positioning of the knee for evaluation of the anterior structures; the knee should be flexed 20°–30°. A rolled towel may be placed under the knee for support. **(b)** Normal longitudinal sonographic appearance of the quadriceps tendon (between the arrowheads and arrows). There is a thin layer of fat and fascia (★) between the muscle slips (muscular bundles) of the rectus femoris anteriorly, the vastus medialis posteriorly, and the vastus medialis and lateralis in the middle. The rectus femoris portion (arrowheads) and the vastus intermedius portion (arrows) of the quadriceps tendon are indicated. *F* = femur, *P* = patella. **(c)** Transverse view of the quadriceps tendon and femoral trochlear cartilage. Note the uniform thickness and hypoechogenicity of the normal trochlear cartilage. *C* = femoral trochlear cartilage, *F* = femur, *QT* = quadriceps tendon, *VM* = vastus medialis.

a.



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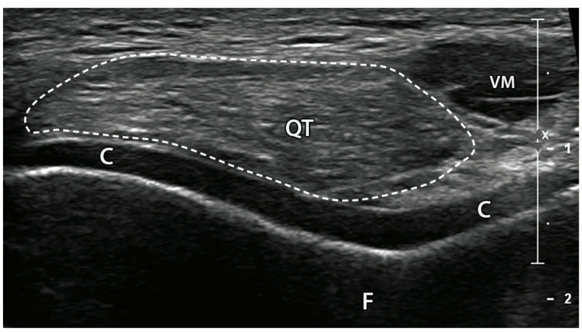


c.

placed in the supine position with the knee slightly flexed (20°–30°) (Fig 1a). It is helpful to place a rolled towel behind the knee for support.

Evaluation begins with placement of the transducer in the sagittal plane just proximal to the patella, along the long axis of the quadriceps tendon. It is important to evaluate the complete quadriceps tendon, medial to lateral, in the long axis as well as in the short axis (Fig 1b and 1c). The tendon should have a typical hyperechoic fibrillary appearance at US. The quadriceps tendon is formed by components from the rectus femoris, vastus medialis, vastus lateralis, and deeper vastus intermedius muscles (Fig 2). The vastus medialis obliquus muscle continues medially to the patella. Again in the sagittal plane, proximal to the patella, the suprapatellar recess is identified deep to the quadriceps tendon,

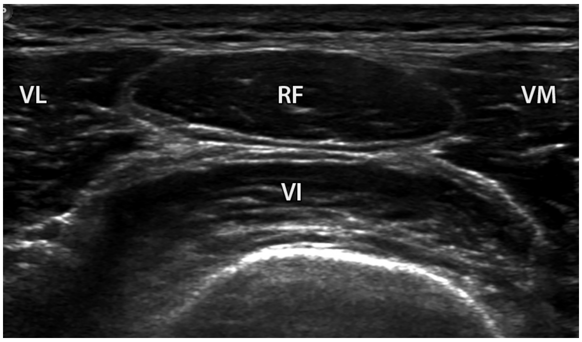
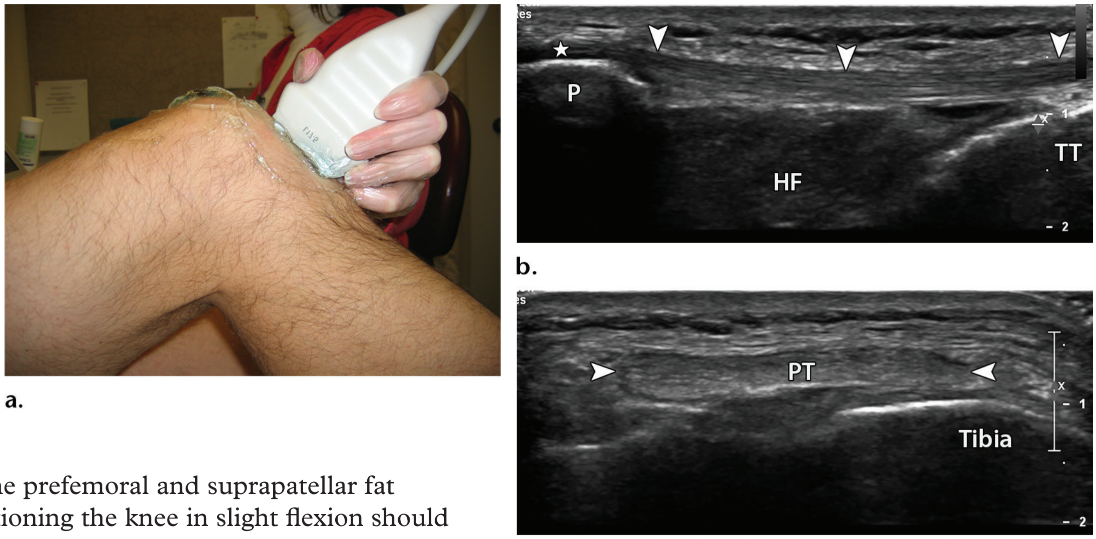


Figure 2. Transverse US view of the distal quadriceps musculature at the level of the distal thigh. *RF* = rectus femoris, *VI* = vastus intermedius, *VL* = vastus lateralis, *VM* = vastus medialis.

Figure 3. US evaluation of the patellar tendon. The patellar tendon is identified as the large fibrillar structure extending from the inferior patella to the tibial tuberosity. **(a)** Probe position for longitudinal evaluation of the patellar tendon. **(b)** Longitudinal view of the patellar tendon (arrowheads). Note the thick, fibrillar architecture, as well as the trace-free fluid in the deep infrapatellar bursa just proximal to the tibial tuberosity. Also note the fibers (★) continuing from the quadriceps tendon to the patellar tendon (the patella being a sesamoid bone). *HF* = Hoffa fat pad, *P* = patella, *TT* = tibial tuberosity. **(c)** Transverse view of the distal patellar tendon *(PT;* arrowheads*)*. Note its broad, flat structure.



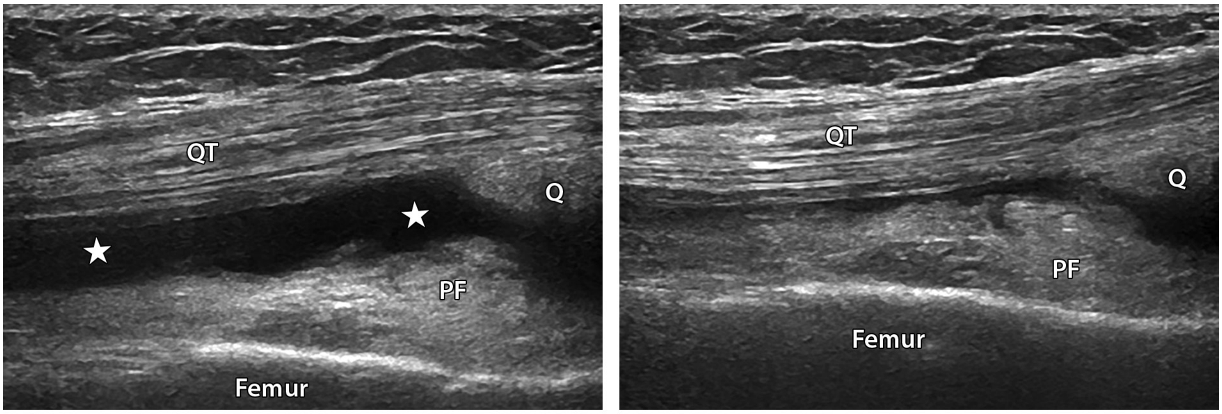
a. b. c.

between the prefemoral and suprapatellar fat pads. Positioning the knee in slight flexion should preferentially drive joint fluid into the suprapatellar bursa, making this a sensitive area for the evaluation of joint fluid. Next, the transducer is moved inferiorly in the sagittal plane just distal to the patella, and the patellar tendon is identified. As with the quadriceps tendon, the entire patellar tendon should be evaluated both in the long and short axes and should have an echogenic, fibrillar appearance (Fig 3). This region is also evaluated for bursal fluid superficial to the patella and the patellar tendon. It is important to not place too much pressure on the transducer, thereby causing displacement of the subcutaneous fluid, an important potential technical pitfall (Fig 4). Next, the medial and lateral patellar retinacula are evaluated in the transverse plane by placing the transducer along the medial and lateral aspects of the patella. This view is also useful for assessing the presence of joint fluid in the medial and lateral recesses, which occur deep to the retinacula and superficially to the underlying femoral condyles. Finally, the knee is placed in a 90° flexed position with the patient's foot on the table, and the femoral trochlear cartilage is evaluated in the transverse plane superior to the level of the patella. The cartilage should appear hypoechoic and of uniform thickness (Fig 1c).

Medial Knee

The key structures to be evaluated in the medial knee are the MCL, the body and anterior horn of the medial meniscus, and the pes anserine tendons (sartorius, gracilis, and semitendinosus). For evaluation of the medial knee, the patient remains in the supine position but rotates the hip externally (Fig 5a).

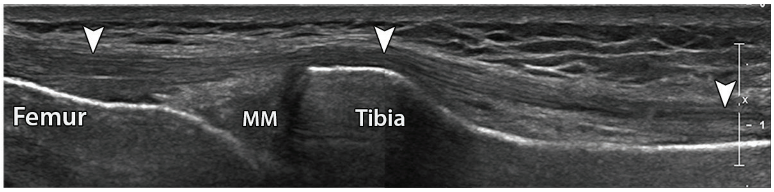
Evaluation is begun in the coronal plane by finding the MCL along the medial aspect of the joint line. This is typically accomplished by placing the transducer along the knee in the true coronal plane and toggling the transducer anteriorly and medially until the bulky fibrillar tissue of the MCL is identified. The entire extent of the MCL should be evaluated in the long and short axes. Note is made of the normally thickened



a. **b.**

Figure 4. Effect of transducer pressure on evaluation of small joint effusions. *PF* = prefemoral fat pad, *Q* = quadriceps fat pad, *QT* = quadriceps tendon. **(a)** Simple joint effusion (★) during normal transducer pressure. **(b)** With increased transducer pressure, the effusion redistributes, differentiating it from synovial hypertrophy (which would persist in shape).

a.



b.

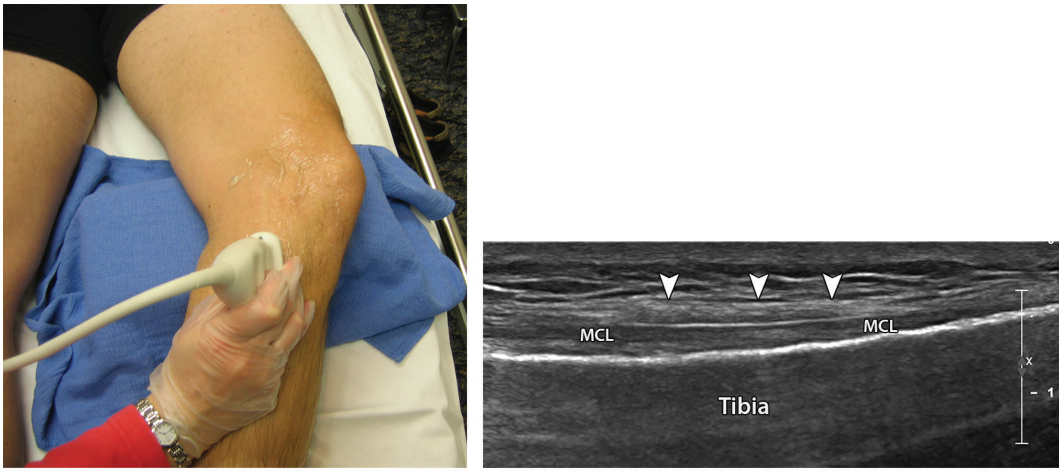
Figure 5. US evaluation of the MCL. **(a)** Probe placement. Note that the hip is externally rotated to allow easier scanning of the medial knee. The MCL can typically be identified by placing the transducer in the true coronal plane along the medial knee and moving the transducer anteriorly and posteriorly to find the nearby bulky hypoechoic fibrillar tissue representing the MCL. **(b)** Longitudinal view of the MCL (arrowheads). Note the normal slight thickening proximally. *MM* = medial meniscus.

proximal MCL (Fig 5b). In the coronal plane along the joint line, the body of the medial meniscus is identified between the femur and tibia, deep to the MCL (Fig 5b). The transducer can be moved anteriorly to the oblique sagittal plane to evaluate the anterior horn of the meniscus. The visualized portions of the meniscus should appear triangular and hyperechoic. Returning to the coronal view of the MCL, the transducer can then be moved posteriorly and the semimembranosus muscle identified in the short axis, which can then be traced proximally and distally in the long and short axes. To evaluate the pes anserine tendons, the transducer is returned to the coronal view of the MCL, then moved distally along the MCL to about 4–5 cm beyond the joint line and slightly anteriorly. Here the insertions of the pes anserine tendons (sartorius, gracilis, and semitendinosus) can be evaluated, as can the presence of bursal fluid located deep to the tendons. The pes anserinus can also be located by identifying in the short axis the three tendons superficial to the MCL (Fig 6), and following them to their distal attachments anteromedially. The sartorius is the most anterior tendon and the semitendinosus is the most posterior tendon, with the gracilis between the two.

Lateral Knee

The key structures to be evaluated in the lateral knee are the iliotibial band (or iliotibial tract), LCL, biceps femoris, common peroneal nerve, popliteus, and body and anterior horn of the lateral meniscus. US can also evaluate the anterolateral ligament (ALL). For evaluation of the lateral knee, maintain the patient in the supine position but internally rotate the hip and slightly flex the knee (Fig 7a). If needed, the patient can turn up slightly onto his or her side.

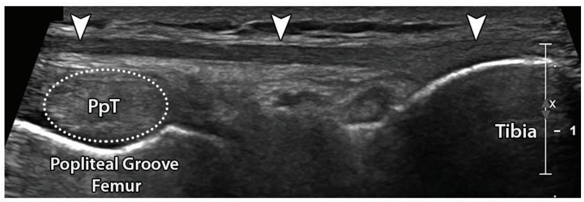
To find the iliotibial band, the patellar tendon is viewed in the plane of the long axis, and then the transducer is moved laterally, over the tibial plateau. The first identifiable longitudinal structure extending proximally from the lateral condyle of



a. b.

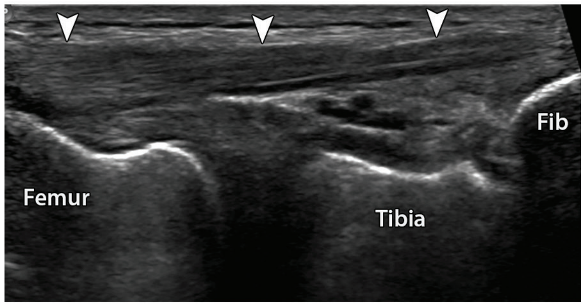
Figure 6. US evaluation of the pes anserine tendons. **(a)** Probe position for short-axis evaluation. Typically, the pes anserine tendons are found by following the MCL to its distal end in the longitudinal plane, then gliding the transducer anteriorly until the conjoined tendon is identified. **(b)** Short-axis (coronal oblique to patient) view of the pes anserine tendons (arrowheads) superficial to the distal MCL. The pes anserine tendons often appear as a single entity at this level, but clear demarcation of the tendons can be seen if they are followed proximally.

Figure 7. US evaluation of the iliotibial band. **(a)** Probe placement. Note the internal rotation of the hip. In evaluating the lateral knee, the iliotibial band is the first large fibrillar structure identified after sweeping the transducer laterally from the patellar tendon. **(b)** Longitudinal view of the iliotibial band (arrowheads). *PpT* = popliteus.



a. b.

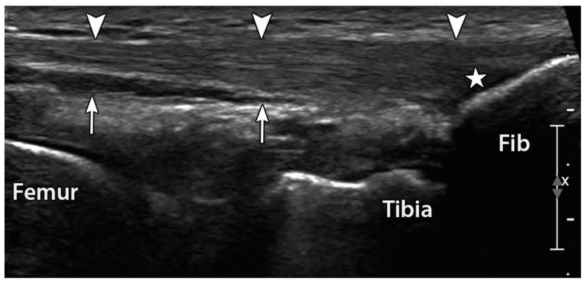
the tibial tubercle (the Gerdy tubercle) will be the iliotibial band (Fig 7b). The iliotibial band should be uniformly thin and flat. Focal thickening or surrounding fluid at the distal femur can indicate iliotibial band friction syndrome. After evaluation of the iliotibial band, the transducer is moved further laterally in the coronal plane until the groove for the popliteal tendon is identified in the lateral femoral condyle. Using this groove as a landmark, the proximal end of the transducer is stabilized on the femur, and the distal aspect of the transducer is then rotated posteriorly to visualize the fibular head. The LCL is identified in this plane (Fig 8). One important pitfall here is that any valgus angulation of the knee can create a wavy appearance of the LCL and cause anisotropy. Next, to evaluate the biceps femoris, the LCL is identified in the long axis (coronal oblique view). The distal end of the transducer is anchored to the fibular attachment of the LCL and the proximal end is rotated posteriorly in the coronal plane, bringing the biceps femoris tendon into view (Fig 9). A potential pitfall here is that the distal tendon may appear heterogeneous, as the fibers bifurcate (to travel superficially and deep to the LCL), which should not be mistaken for tendinosis (3, Fig 9b). Moving the transducer posteriorly from the coronal plane view of the biceps femoris, the common peroneal nerve may be identified (Fig 10). At this point, attention is returned to the popliteal groove, and the distal course of the popliteal tendon is followed as it curves posteriorly around the joint. Finally, in



a. b.

Figure 8. US evaluation of the LCL. **(a)** Probe placement. To find the LCL, begin in the coronal plane, where the popliteal groove is identified. The proximal end of the transducer is fixed at this location, and the distal end is rotated posteriorly to the fibular head. In this oblique plane, the hypoechoic fibrillar LCL can be identified extending from the lateral femoral condyle to the lateral fibular head. **(b)** Longitudinal view of the LCL (arrowheads). *Fib* = fibula. Note that the course of the LCL is slightly oblique relative to the extremity.

Figure 9. US evaluation of the biceps femoris. **(a)** Probe position for longitudinal evaluation. Note the internal rotation of the hip, used to expose the lateral knee for scanning. **(b)** Longitudinal view of the biceps femoris (arrowheads) and its myotendinous junction (arrows). Note also a region (★) that can look thickened and hypoechoic, but is normal. *Fib* = fibula.



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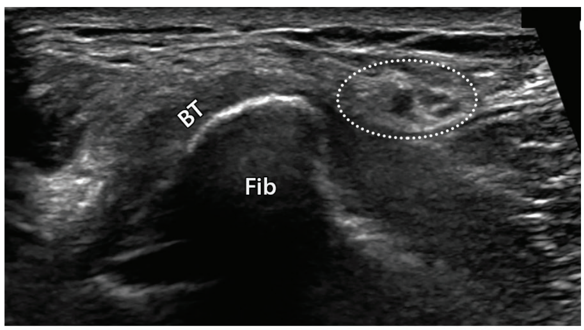


a. b.

Figure 10. US evaluation of the peroneal nerve. **(a)** Probe position for transverse evaluation, just posterior to the fibula. **(b)** Transverse view of the peroneal nerve (oval) coursing posteriorly to the fibula *(Fib)*. The peroneal nerve should be hypoechoic; a fascicular appearance can often be identified. *BT* = distal attachment of the biceps femoris tendon.

RadioGraphics

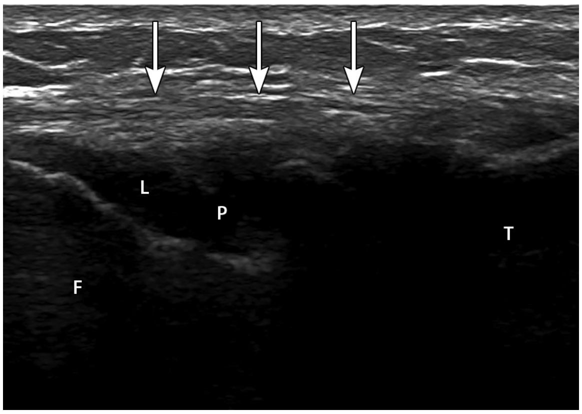
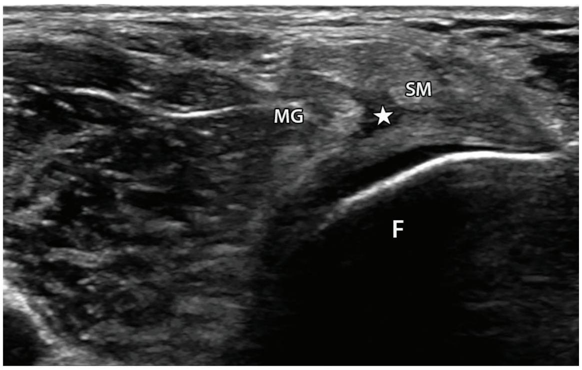


Figure 11. US of the normal ALL (arrows) of the knee, with the knee in flexion. The distal tibial insertion can be identified; it is about halfway between the fibular head and the Gerdy tubercle. The ALL can then be followed proximally over its entire distance to its femoral insertion. *F* = femur, *L* = LCL (hypoechoic from anisotropy), *P* = popliteal tendon (hypoechoic from anisotropy), *T* = tibia.

a.



b.

Figure 12. US evaluation for Baker cyst. **(a)** Probe position for evaluation. The patient is prone, with the knee extended. **(b)** Expected location for Baker cyst. The neck (★) of a Baker cyst will be located between the medial head of the gastrocnemius and the semimembranosus tendon. *F* = medial femoral condyle, *MG* = medial head of the gastrocnemius, *SM* = semimembranosus tendon.

the coronal plane along the joint line, the body of the lateral meniscus is identified. The transducer is then moved anteriorly to evaluate the anterior horn of the meniscus. As with the medial meniscus, the visualized portions of the lateral meniscus should appear triangular and hyperechoic.

A recent study of 18 cadaveric knees demonstrated that US helped to identify the anterolateral ligament (ALL) of the knee in all 18 knees (4). After placing the knee in flexion and internal rotation (to place the ALL under tension), the distal tibial insertion was then identified about halfway between the fibular head and the Gerdy tubercle (Fig 11). The ALL could then be followed proximally over its entire distance to the femoral insertion. More work needs to be done to determine whether US is useful for the evaluation of ALL injury.

Posterior Knee

The key structures to be evaluated in the posterior knee are the presence of a Baker cyst, the posterior horns of the menisci, the posterior cruciate ligament, and the popliteal neurovascular bundle. For evaluation of the posterior knee, the patient is placed prone with the knee extended.

First, the transducer is placed in the transverse plane of the midcalf and the deep soleus and superficial medial and lateral heads of the gastrocnemius muscles are identified. The medial head of the gastrocnemius is then traced proximally until the semimembranosus tendon is identified medially. The Baker cyst, if present, will be located between these two structures at the level of the knee joint medially (Fig 12). The neck of the Baker cyst, located between the medial head of the gastrocnemius and the semimembranosus tendon, can be identified extending deep toward the joint line. One potential pitfall at US is misinterpreting anisotropy of the semimembranosus or the medial head of the gastrocnemius tendons as a small Baker cyst (Fig 13). The semitendinosus tendon can also be identified superficial to the semimembranosus tendon and also evaluated at this point.

Next, where a lower-frequency transducer may be needed, the transducer is oriented sagittally and placed over the posterior medial knee, where the posterior horn of the medial meniscus may be evaluated. Another potential pitfall at this point is

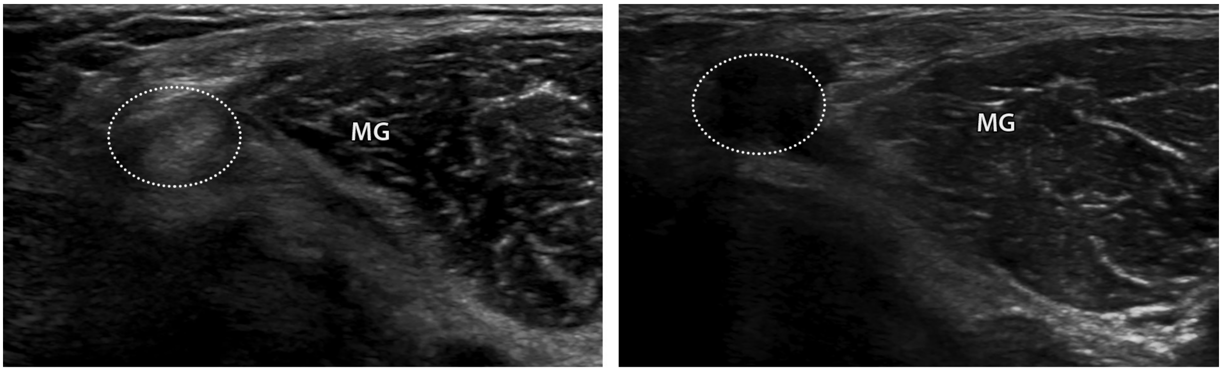


Figure 13. Anisotropy at US of the semimembranosus tendon simulating a Baker cyst. **(a)** Transverse view in the expected location of a Baker cyst demonstrates the medial head of the gastrocnemius (*MG*) and semimembranosus tendon (oval). **(b)** Anisotropy of the semimembranosus tendon (oval) simulating a Baker cyst. Anisotropy is a perceived loss of signal, related to probe positioning, and hence artifactual. *MG* = medial head of the gastrocnemius.

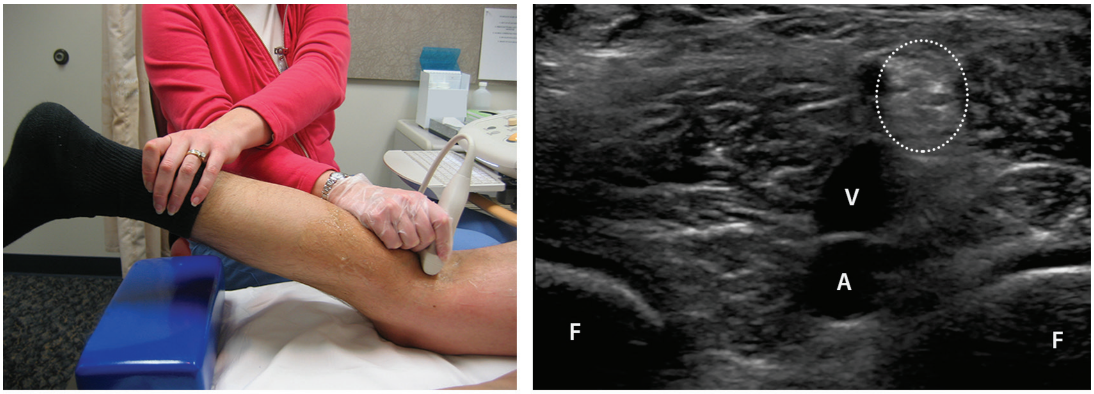


Figure 14. US evaluation of the popliteal vessels. **(a)** Probe and patient position for evaluation of the popliteal vessels. Note the slightly flexed knee. **(b)** Transverse view of the popliteal artery and vein. *A* = popliteal artery, *F* = femoral condyles, oval = tibial nerve, *V* = popliteal vein.

anisotropy within the semimembranosus tendon simulating a parameniscal cyst. Moving to the true sagittal plane in the midline posterior knee, the posterior cruciate ligament and its tibial attachment are identified. Continuing laterally, the posterior horn of the lateral meniscus may be identified. Evaluation of the anterior cruciate ligament is suboptimal and not diagnostic at US. The transducer is oriented transversely and placed over the intercondylar notch of the femur. The femoral attachment of the anterior cruciate ligament can be seen laterally. Posteriorly, evaluation is completed by examining the popliteal vessels and tibial nerve (Fig 14).

Pathologic Conditions

For discussion of pathologic conditions, we have again divided the knee into anterior, medial, lateral, and posterior compartments. Locations of interest and common pathologic conditions for each of the four compartments are summarized in Table 2.

Anterior

Quadriceps Tendon.—Pathologic conditions of the quadriceps tendon can range from simple tendinosis to partial or complete tears (Table 2). With tendinosis, the tendon will appear focally thickened and hypoechoic distally, close to the proximal pole of the patella. Dynamic US is useful in the evaluation of partial tears of the quadriceps tendon, which can sometimes present as a clinical dilemma at physical examination (5). Partial tears will appear as focal hypoechoic disruptions of the fibrillary and laminar architecture of the tendon. US is also highly sensitive and specific for diagnosing high-grade partial and complete tears, both of which may require surgical management (6). Rupture of a healthy tendon is relatively rare, so quadriceps tendon rupture is usually the end result of a chronic process, with risk factors including age, repetitive microtrauma, genetics, systemic diseases, and medications (7). Complete tears will appear as a complete disruption of the tendon with

Table 2: Locations of Interest and Common Conditions by Compartment

Compartment	Locations of Interest	Common Pathologic Condition
Anterior	Quadriceps tendon	Quadriceps tear
	Patella	Patellar tendon tear
	Patellar tendon	Jumper's knee
	Patellar retinaculum	Joint effusion
	Suprapatellar recess	Prepatellar bursitis
	Medial and lateral recesses	
	Anterior knee bursa	
	Femoral articular cartilage	
Medial	MCL	MCL sprain/tear
	Medial meniscus: body and anterior horn	Medial meniscal tear and cyst
	Pes anserinus	Pes anserinus bursitis
Lateral	Iliotibial band	Iliotibial band syndrome
	LCL	LCL sprain/tear
	Biceps femoris	Biceps femoris tendinosis
	Common peroneal nerve	Common peroneal nerve entrapment, gout
	Popliteal	Lateral meniscal tear
	Lateral meniscus (body and anterior horn)	
Posterior	Baker cyst	Baker cyst
	Menisci (posterior horns)	Meniscal tears
	Posterior cruciate ligament	Popliteal artery aneurysms and pseudoaneurysms
	Anterior cruciate ligament	
	Neurovascular structures	
	Lymph nodes	

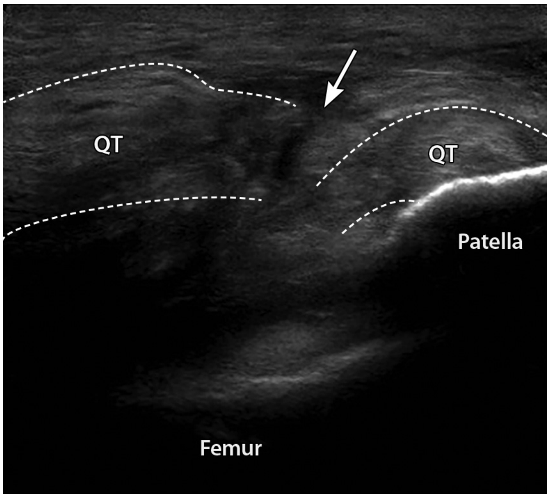


Figure 15. Complete quadriceps tendon tear. Longitudinal US view shows a hypoechoic defect (arrow) between the outlined proximal and distal stumps of the quadriceps tendon (*QT*).

separated ends (8) (Fig 15). A potential pitfall in the evaluation of chronic quadriceps tears at US is that interposed scar tissue can give a complete tear the appearance of a partial tear.

Joint Effusion.—With the knee slightly flexed, a joint effusion will appear as fluid distention of the suprapatellar recess deep to the quadriceps tendon, with fluid separating the prefemoral and suprapatellar fat pads (Fig 16a). Joint effusions may be simple or complex. One should be careful to distinguish a complex joint effusion from synovitis, which can both appear heterogeneously hypoechoic. Here, color Doppler US is useful, as it can demonstrate increased vascularity within the thickened synovium. Joint effusions may also be identified in the lateral and medial recesses (Fig 16c and 16d). A small joint effusion may be found only in the lateral and medial recesses in a supine extended knee. Compressibility, redistribution of contents or swirling of the contents with compression or joint movement, and lack of internal flow at Doppler imaging suggest a complex effusion rather than synovitis (9). Conversely, lack of compressibility with or without internal flow can indicate synovitis (Fig 17). US cannot distinguish between aseptic and septic effusions, but can be used to guide knee joint aspiration.

Hemarthrosis and Lipohemarthrosis.—One potential indication for US of the knee may be for the indirect evaluation of occult intra-articular knee fracture, as US has been shown to be significantly more sensitive for the evaluation of lipohemarthrosis in the suprapatellar bursa than radiographs,

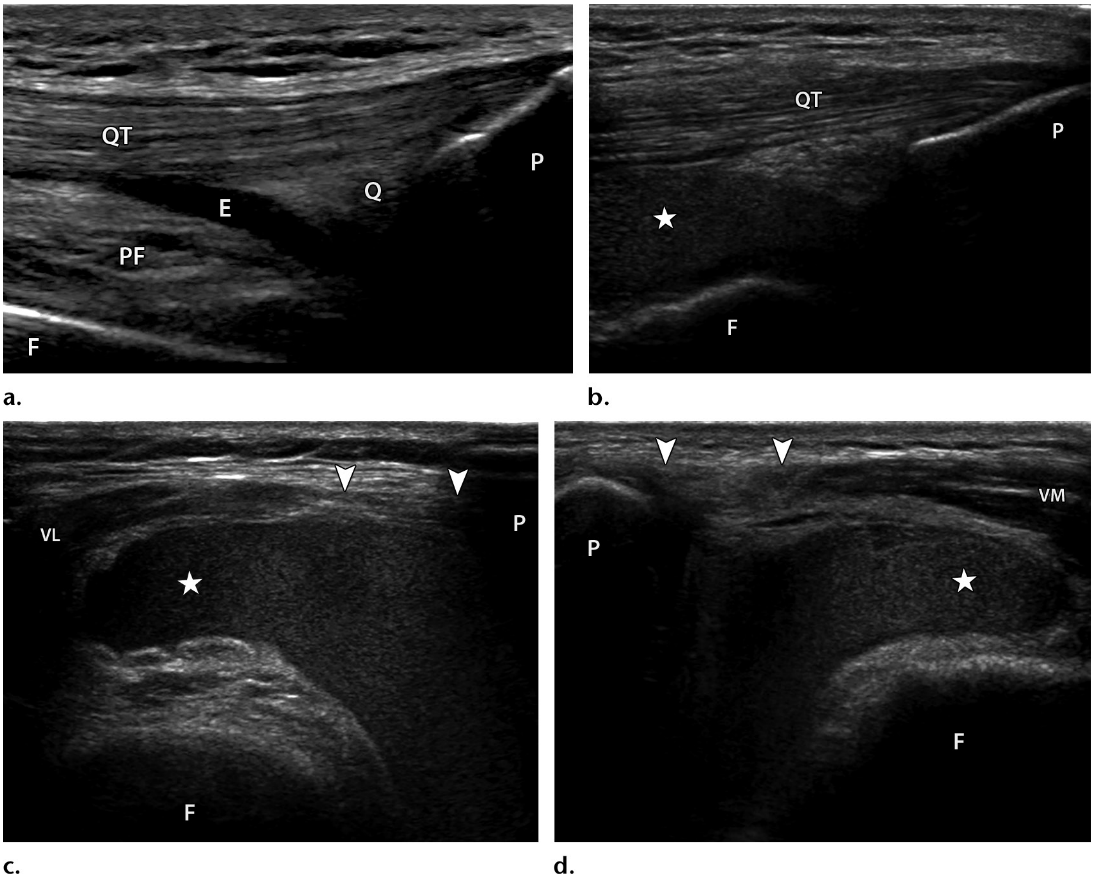


Figure 16. Simple and complex joint effusions at US. Arrowheads = patellar retinacula, *F* = femur, *P* = patella, *PF* = prefemoral fat pad, *Q* = quadriceps fat pad, *QT* = quadriceps tendon, *VL* = vastus lateralis, *VM* = vastus medialis. **(a)** US image along the long axis of the quadriceps tendon demonstrates a simple (anechoic) tiny joint effusion *(E)*. **(b)** Complex joint effusion (★) with diffuse internal echoes representing hemarthrosis. **(c, d)** Transverse views of the lateral **(c)** and medial **(d)** joint spaces demonstrate a complex effusion (★) with diffuse internal echoes.

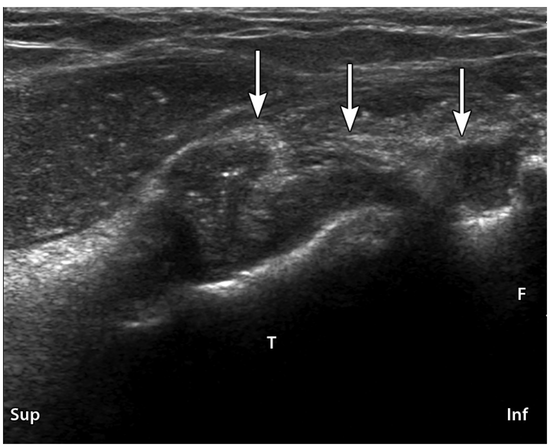


Figure 17. Coronal view at US of the lateral knee demonstrates findings consistent with inflammatory arthritis. There was extensive soft-tissue proliferation about the knee consistent with synovitis, as shown here along the lateral aspect (arrows) of the knee. *F* = fibula, *Inf* = inferior, *Sup* = superior, *T* = tibia.

97% versus 55%, respectively (10). As with other imaging modalities, the US appearance of a lipohemarthrosis will be a fat-fluid level in the suprapatellar recess (Fig 18). Pure hemarthrosis will appear as a complex joint effusion with internal echoes.

Patella.—Fractures of the superficial cortex of the patella may be identified as cortical discontinuity or step-off deformity (Fig 19). A bipartite patella, in which the superolateral ossification center is unfused, must not be confused with a fracture. Bipartite patella occurs at the superolateral patella, and has characteristic radiographic appearances, so radiographs can be obtained if there is uncertainty at US.

The prepatellar bursa may be identified immediately superficial to the patella when abnormal (thickened or fluid-containing). Bursitis, which can be suggested when there is bursal fluid (simple or complex) or thickening with hyperemia, is ultimately a clinical diagnosis.

Patellar Tendon.—As with quadriceps tendon tears, complete tears of the patellar tendon are usually readily apparent clinically, but US can be

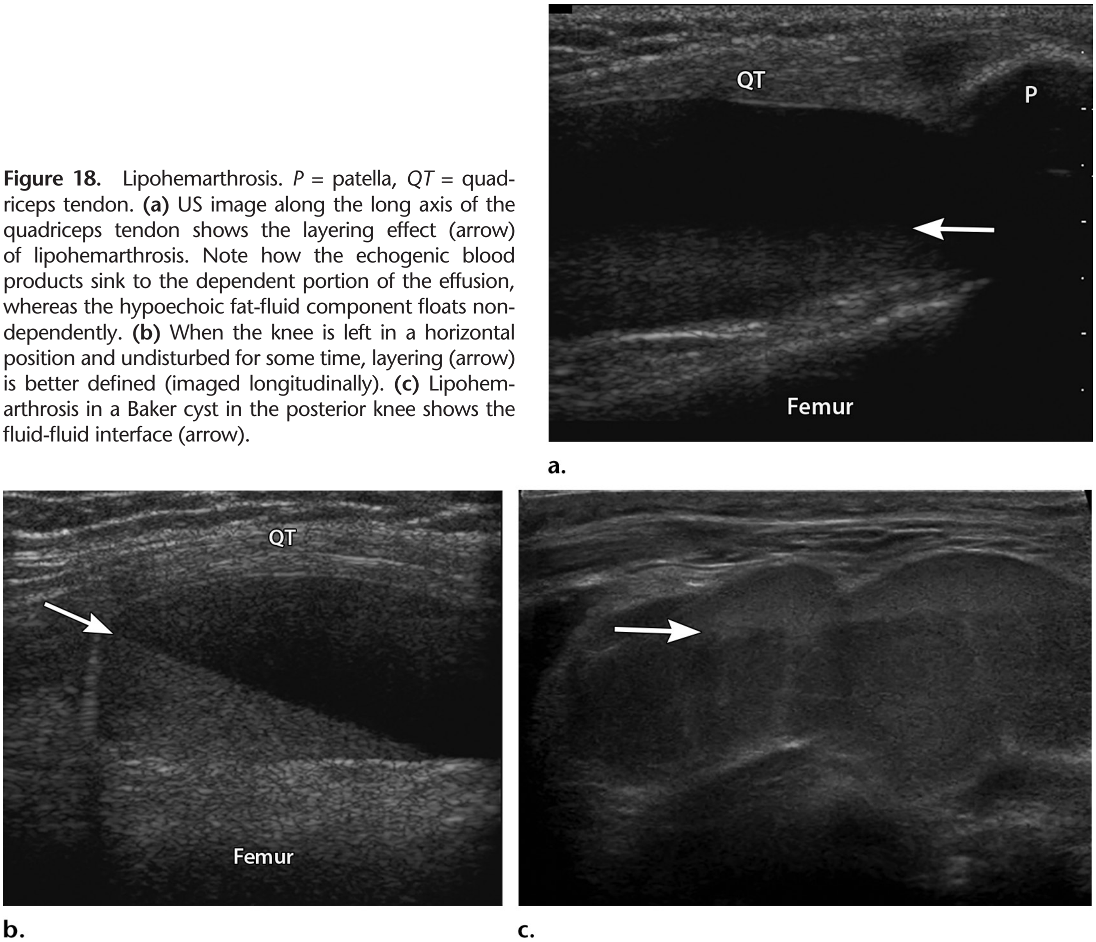


Figure 18. Lipohemarthrosis. *P* = patella, *QT* = quadriceps tendon. **(a)** US image along the long axis of the quadriceps tendon shows the layering effect (arrow) of lipohemarthrosis. Note how the echogenic blood products sink to the dependent portion of the effusion, whereas the hypoechoic fat-fluid component floats nondependently. **(b)** When the knee is left in a horizontal position and undisturbed for some time, layering (arrow) is better defined (imaged longitudinally). **(c)** Lipohemarthrosis in a Baker cyst in the posterior knee shows the fluid-fluid interface (arrow).

useful in the evaluation of tendinosis and partial tears. Complete patellar tendon tears will demonstrate a full-thickness disruption of the tendon and could lead to proximal retraction of the patella (Fig 20). Refraction shadowing may also be seen deep to the torn end of the tendon.

Patellar tendinosis is common and typically manifests as anterior knee pain (11). Also referred to as jumper's knee, patellar tendinosis commonly affects athletes in sports that require jumping, such as basketball, and involves the proximal aspect of the tendon. Tendinosis will appear as focal or diffuse decreased echogenicity and thickening of the tendon, with possible anechoic interstitial clefts or tears (Fig 21). Hyperemia may also be identified and represents neovascularity, not inflammation (12).

One of the common tendons involved in gout is the patellar tendon, where the monosodium urate deposits (tophi) can vary in size and echogenicity and can infiltrate the tendon, giving a pseudotumor appearance (Fig 22). Tendon involvement by gout may appear as architectural distortion of the normal fibrillar structure, thickening, and typically increased echogenicity. Tophaceous deposits typically appear hyperechoic, often with a hypoechoic rim, can appear nodular or infiltrative, and may cause posterior acoustic shadowing due to associated calcifications (13). Other tendons in the knee favored by gout include the distal quadriceps tendon and proximal intra-articular popliteal tendon in the popliteal groove.

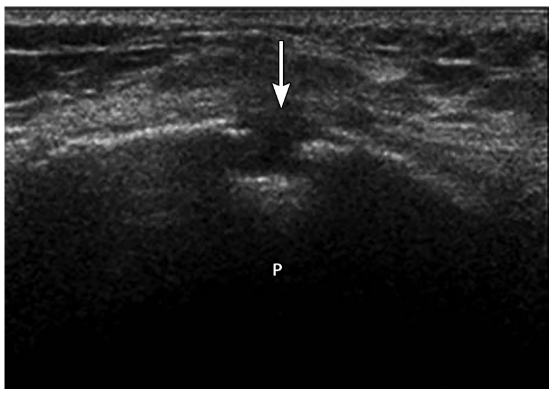


Figure 19. Patellar fracture. Longitudinal US image of the anterior patella *(P)* demonstrates a focal cortical defect (arrow) consistent with fracture.

Bursal fluid may be identified superficial or deep to the patellar tendon in the respective superficial and deep infrapatellar bursae (Fig 23). A small amount of fluid is normal in the deep in-

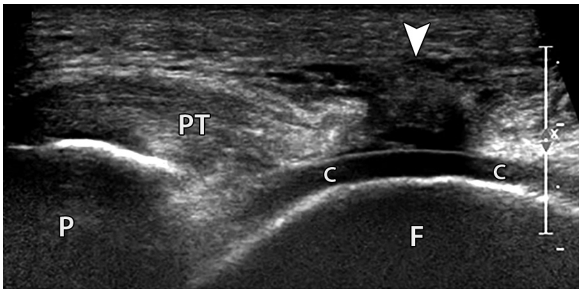


Figure 20. Complete patellar tendon *(PT)* tear with an anechoic fluid-filled cleft (arrowhead). Longitudinal US view shows the patella *(P)* retracted proximally, above the femoral condyle *(F)*, exposing the femoral articular cartilage *(C)* through the defect.

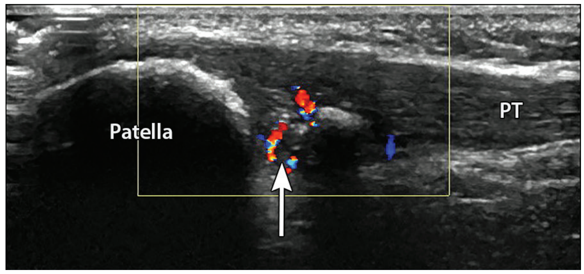
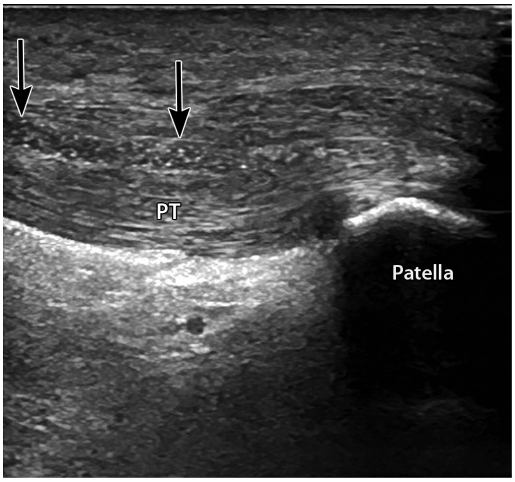


Figure 21. Jumper's knee. Longitudinal color Doppler US view of the patellar tendon shows thickening, heterogeneity, and hyperemia (arrow) of the proximal patellar tendon *(PT)*.



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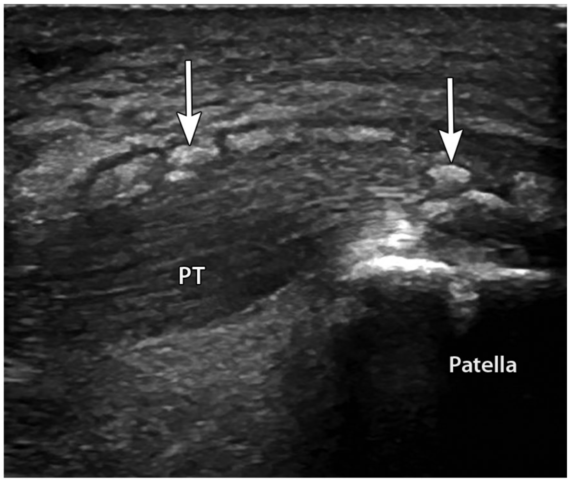

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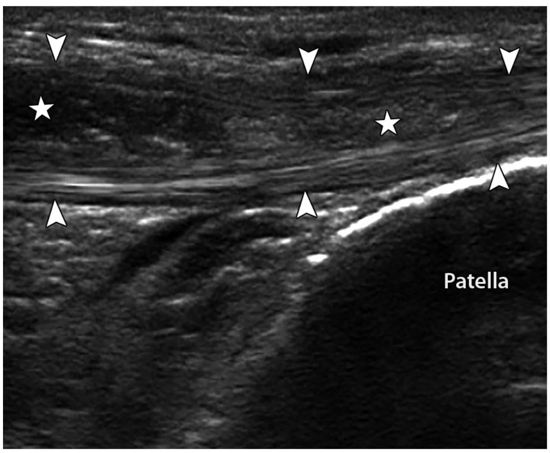


c.

Figure 22. Multiple examples of gouty involvement of the patellar tendon *(PT)* demonstrated in the long axis at US. **(a)** Tiny echogenic foci (arrows) within the midportion of the patellar tendon disrupt the normal fibrillar structure of the patellar tendon. **(b)** Larger echogenic deposits (arrows) in the patellar tendon. **(c)** Ill-defined infiltrative masslike abnormality (★) disrupting the normal fibrillar structure (arrowheads) of the patellar tendon.

frapatellar bursa at the proximal tibia. Again, it is important to scan this area with minimal pressure applied and a light touch of the transducer, so as not to obscure a small fluid collection.

Medial

MCL Injury.—As the major medial stabilizer of the knee joint, the MCL is susceptible to injury during valgus stress and/or twisting injuries. Most injuries of the MCL are to its proximal part (Fig 24). Calcification can be seen in chronic injury (Pellegrini-Stieda disease). US can be used to diagnose injuries of the MCL, with 94% accuracy reported in one small series (14). Typical findings of MCL injury were ligamentous thickening and heterogeneous hypoechogenicity of the ligament. Ligamentous thickening greater than 6 mm at the femoral attachment or greater than 3.6 mm at the tibial attachment implies injury (14). Any loss of the normal taut fibrillar structure of the ligament may imply injury, as can surrounding fluid. Dynamic US imaging of the medial joint space in valgus stress may be useful, as the degree of joint space widening is related to injury grade (14). Joint space widening less than 5 mm indicates grade 1 injury, widening between 5 and 10 mm

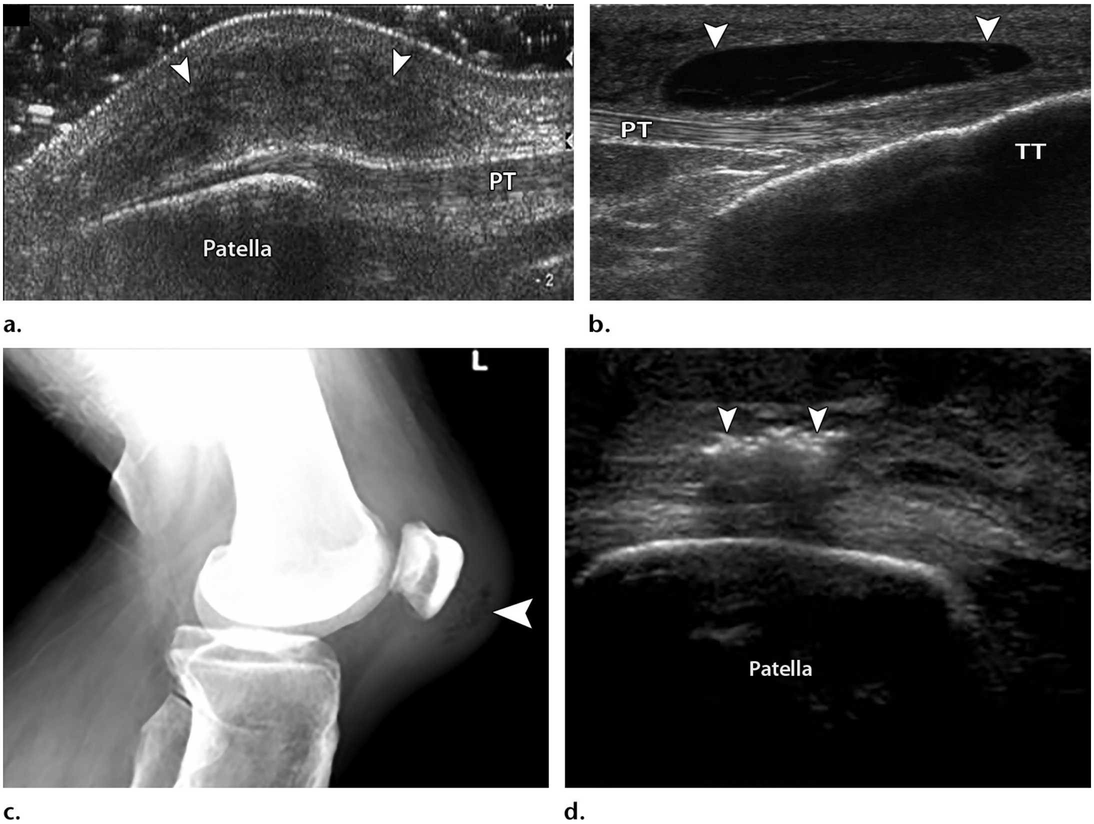


Figure 23. Prepatellar bursitis on US images obtained at the midline, along the long axis of the patella. **(a)** Ill-defined hypoechoic thickening (arrowheads) of the prepatellar bursa, best appreciated when using abundant surrounding gel and minimal transducer pressure. **(b)** Complex fluid (arrowheads) within the superficial infrapatellar bursa. **(c, d)** Radiograph **(c)** and US image **(d)** demonstrate gas (arrowheads) within a thickened prepatellar bursa. The presence of gas may indicate infection. Gas generates hyperechoic foci at US with posterior acoustic shadowing.

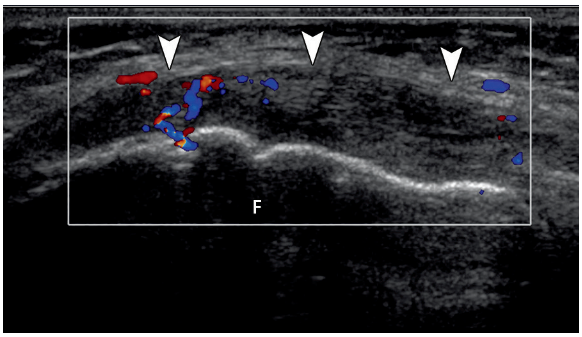


Figure 24. MCL injury. Long-axis color Doppler image demonstrates thickening, vascularity, and hypoechogenicity (arrowheads) of the MCL, consistent with sprain. *F* = femur.

indicates grade 2 injury, and widening greater than 10 mm indicates grade 3 injury (14).

Medial Meniscal Tear.—US is not reliable as a sole modality for evaluating the menisci (15), but may provide useful information when there are positive findings. The sensitivity and specificity of US for the evaluation of meniscal tears have been reported to be 85% and 86%, respectively (16). Tears will typically appear as focal hypoechoic or anechoic linear defects extending to the superior or inferior meniscus surfaces. Meniscal degeneration, often identified at US involving the "body" of the meniscus, will typically appear as meniscal heterogeneity with possible extrusion and fragmentation. US is highly accurate for the evaluation of parameniscal cysts (with a reported accuracy of 88%), which are commonly associated with underlying meniscal tears or degeneration (17). Meniscal extrusion in the setting of osteoarthrosis can also be identified (18).

Pes Anserine Tendon Disease and Bursitis.—The pes anserinus is the conjoining of the sartorius, gracilis, and semitendinosus tendons, which run along the medial knee and insert onto the anteromedial proximal tibia, just anterior to the distal MCL. Risk factors for pes anserine tendon disease and bursitis include valgus knee deformity with or without collateral instability (19), as well as traditional risk factors such as diabetes, osteoarthritis, and obesity. US may also be particularly useful in the evaluation of pes anserine bursitis in patients with osteoarthritis (20). Typical abnormal findings include bursal fluid initially deep to the pes anserine

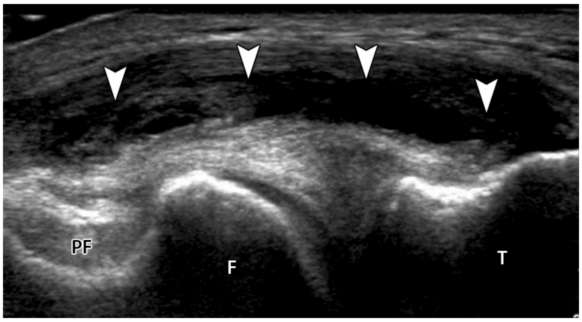
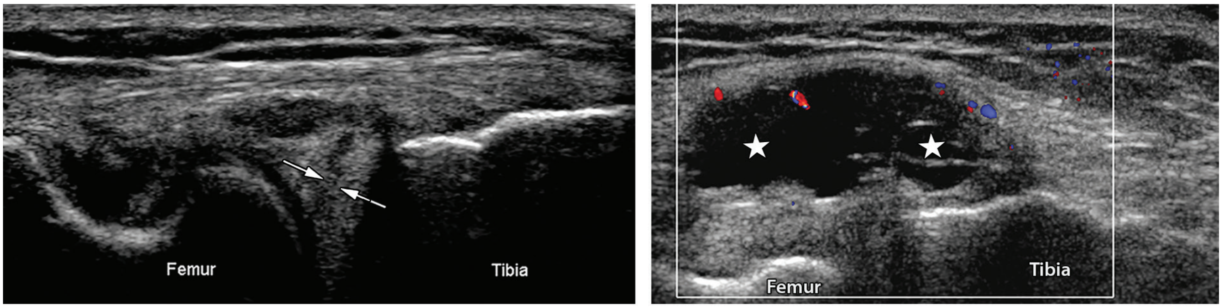


Figure 25. Iliotibial band friction syndrome. Longitudinal view of the lateral knee shows a heterogeneous fluid collection (arrowheads) deep to the iliotibial band, representing an adventitious bursa and consistent with iliotibial band friction syndrome. *F* = femur, *PF* = popliteal fossa, *T* = tibia.



a. b.

Figure 26. Lateral meniscal tear with parameniscal cyst. **(a)** Longitudinal US image obtained along the lateral knee shows a linear hypoechoic defect (arrows) in the lateral meniscus, consistent with a tear. **(b)** Coronal color Doppler US image more posteriorly demonstrates an associated parameniscal cyst (★).

tendons and thickening and decreased echogenicity of the tendons indicating tendinopathy.

Lateral

Iliotibial Band Friction Syndrome.—Iliotibial band friction syndrome is a relatively common overuse injury with several proposed causes, including friction of the iliotibial band against the lateral femoral epicondyle, compression of the fat and connective tissue deep to the iliotibial band, and chronic inflammation of the iliotibial band bursa (21). US evidence of iliotibial band syndrome includes hypoechoic edema of the iliotibial band, fluid superficial or deep to the iliotibial band, and thickening of the band itself by greater than 2–3 mm (22) (Fig 25). Sometimes cortical irregularity of the adjacent femoral condyle is also noted.

LCL Injury.—The LCL is part of a larger complex of lateral knee stabilizers and is seldom injured in isolation. An important pitfall in the evaluation of the LCL is that any valgus angulation of the knee can cause anisotropy and a wavy appearance of the tendon, simulating injury. As with the MCL, indicators of disease include ligamentous thickening, heterogeneity, a wavy appearance, frank disruption, and surrounding fluid. Avulsions of the LCL from the fibula can also be identified.

Lateral Meniscal Tear.—As mentioned previously here, US is not reliable as a sole modality for evaluating the menisci (14), but may provide useful information when there are positive findings (Fig 26). As with the medial meniscus, the lateral meniscus should appear as a hyperechoic triangular structure. Degeneration and tears will appear similar to that described for the medial meniscus previously here.

Biceps Femoris Injury.—Biceps femoris tendinosis will appear as thickening and hypoechogenicity at its conjoined attachment with the LCL. Tears are more common at the distal myotendinous junction.

Common Peroneal Nerve.—The common peroneal nerve can be affected by multiple pathologic conditions including direct injury, entrapment, and neoplasms. The peroneal nerve branches close to the neck of the fibula where it is prone to injury, given its proximity to bone. Intraneural ganglion cyst arising from the proximal tibia-fibula joint can sometimes extend into the peroneal nerve or its branches (23). Nerve entrapment will appear as hypoechoic swelling of the involved nerve at, and just proximal to, the level of entrapment (2). The common peroneal nerve or branches thereof can be affected by stump neuromas in amputees, which appear as small hypoechoic masses associated with the nerve (Fig 27).

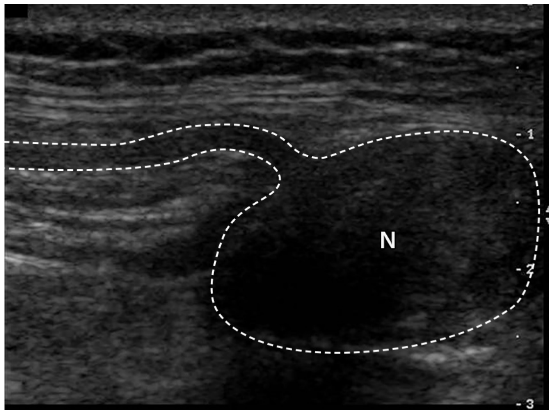
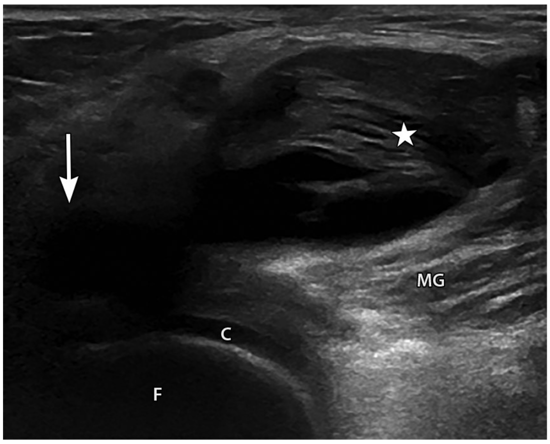


Figure 27. Stump neuroma at US. Round hypoechoic mass represents a stump neuroma *(N)*. Also note the peroneal nerve entering the mass. Outline = peroneal nerve and neuroma.

Figure 28. Complex Baker cysts. *MG* = medial head of the gastrocnemius, *SM* = semimembranosus tendon. **(a)** Transverse US view shows complex septa and echogenic material (★) within a Baker cyst. Arrow = anisotropy of the semimembranosus tendon, not to be mistaken for an enlarging Baker cyst. **(b)** Transverse view shows complex hemorrhagic echogenic fluid (★) within a Baker cyst. **(c)** Long-axis view demonstrates a partially distended Baker cyst (arrowheads) with distal fluid dissecting along tissue planes (★), indicating extravasation.



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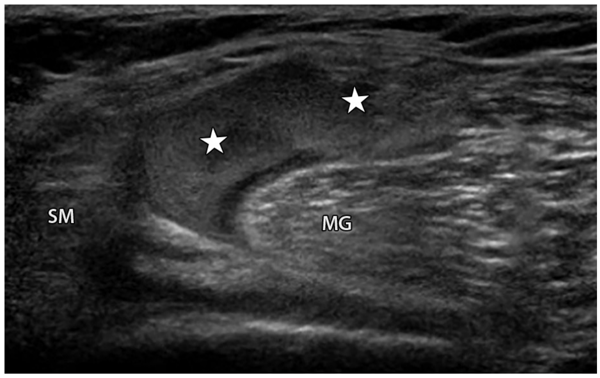

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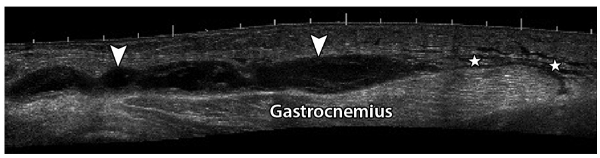

c.

Posterior

Baker Cyst.—Evaluation of a popliteal fossa cyst is the one of the most common indications for US of the knee. A Baker cyst (also known as popliteal cyst and semimembranosus–medial gastrocnemius bursa) is a posterior knee cyst that communicates with the knee joint space via a thin neck, located between the semimembranosus and the medial head of the gastrocnemius tendons. Fluid within a Baker cyst may be simple or complex (Fig 28). The cyst may demonstrate partial or complete rupture, becoming irregular appearing or difficult to visualize. Free fluid may be seen tracking inferiorly in the superficial calf, superficial to the medial head of the gastrocnemius muscle. Baker cysts may be aspirated or injected with steroids under US guidance.

Cruciate Ligaments.—The posterior cruciate ligament (PCL), as with the anterior cruciate ligament (ACL), can be only partially visualized at US, so MR imaging remains the primary imaging method for complete evaluation. With this in mind, abnormalities of the visualized portions of the cruciate ligaments that indicate injury may be identified and prompt further evaluation with MR imaging. Thickening of the PCL to greater than 1 cm or hypoechogenicity of the ligament indicate injury (24). Tears may appear as focal disruptions or diffuse thickening (25). An abnormal hypoechoic or anechoic appearance of the partially visualized ACL along the lateral intercondylar notch is suggestive of a ligament tear (26).

Popliteal Arterial Aneurysms and Pseudoaneurysms.—Popliteal arterial aneurysms and pseudoaneurysms must also be considered in the differential diagnosis of cystic masses in the posterior knee. Fortunately, these are easily recognized at

US by their association with the popliteal artery and internal vascular flow at color Doppler US.

Popliteal Vein Deep Venous Thrombosis.—Posterior knee pain may be occasionally due to deep venous thrombosis (DVT), so comprehensive evaluation of the knee requires evaluation of the popliteal vein. The vein should be anechoic and easily compressible. Lack of compressibility or presence of internal echogenic material may indicate thrombosis and necessitate a full lower extremity DVT scan.

Conclusion

US of the knee is a portable and relatively low-cost modality that is well-suited for evaluation of disease of the knee, particularly in evaluation of injuries of the quadriceps and patellar tendons, injuries of the MCL and LCL, joint effusions and fluid collections around the knee, and guiding percutaneous interventions. Understanding US technique for complete evaluation of the knee and relevant sonographic anatomy, US appearance of common pathologic conditions, and knowledge of important pitfalls provides another tool for the evaluation of knee pathologic conditions.

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