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REVIEW ARTICLE

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Ultrasound of the knee

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Abstract Ultrasound is emerging as a viable imaging modality in the diagnosis and assessment of the musculoskeletal system. Advantages of ultrasound include its easy availability and multiplanar capability, as well as economic advantages. Unlike magnetic resonance imaging, ultrasound demonstrates the fibrillar microanatomy of tendons, ligaments and muscles, enhancing its diagnostic capability. The ability to compress, dynamically assess structures and compare easily with the contralateral side is advantageous. The patient's exact point of clinical tenderness can be correlated with underlying anatomical structures and associated pathology. The main strength of knee ultrasound is the assessment of para-articular disease. The specific structures best suited for ultrasound assessment include tendons, muscles and ligaments, as well as periarticular soft tissue masses. Joint effusions, synovial thickening, bursal fluid collections, intra-articular loose bodies, ganglion cysts, ligament and tendons tears, tendonitis and occult fractures can be diagnosed. With experience, ultrasound is a time-efficient, economical imaging tool for assessment of the knee.

Keywords Ultrasound · Knee · Ligaments · Tendons · Injuries

Introduction

The knee is a common joint affected by arthritis. Injuries are also frequent and often sports-related. While radiographs of the affected joint are often obtained first, these provide little information regarding soft tissue structures. Magnetic resonance imaging (MRI) is the current imaging procedure of choice for assessment of internal derangement of the knee joint, particularly for evaluation of menisci, cruciate ligaments, bone marrow and cartilage [1].

It is important to recognize the limitations of ultrasound for assessing the status of menisci, cartilage and bone [1, 5]. Ultrasound, however, is increasingly being advocated as a valuable additional diagnostic modality for the evaluation of the knee joint, with recognition of its strengths and weaknesses [2, 3, 4].

There are many advantages of this imaging tool, including cost, portability, dynamic real-time assessment, and easy side-to-side comparison. Ultrasound's major disadvantage is its operator dependence, as well as a long learning curve. It requires trained experienced hands, with appropriate high-resolution equipment, for ultrasound to succeed as an effective diagnostic tool.

Until recently, musculoskeletal ultrasound has been limited by a small field of view. This often prevents documentation of a finding on a single image. The use of split-screen imaging has aided the imaging of larger masses or findings, as well as comparison between two sides. The development of extended field of view imaging has further facilitated this process [2, 5, 6]. The relationship of a finding to recognizable and important surrounding anatomy or anatomic landmarks can be demonstrated. It also has the potential for more accurate measurement and follow-up comparison. Although this technology does not necessarily improve diagnosis, it does aid in visually demonstrating the finding, particularly for clinical colleagues.

The purpose of this article is to outline the scanning technique for the evaluation of the knee joint and surrounding anatomy. The normal ultrasound appearance of the knee is described, as well as common pitfalls. Common disorders involving the knee and regional structures are presented, with emphasis on their sonographic appearance.

Technique

Ultrasound of the knee should be performed with high-resolution, multi-frequency linear transducers (7–10 MHz). Curved transducers in the 5–7 MHz range can also be utilized, particularly for assessment of the posterior knee.

The patient is initially positioned in a supine, sitting or semi-reclined position. The knee should be comfortably flexed. It is often helpful to place a pillow under the knee for support. The transducer is swept in a longitudinal plane, from medial to lateral or lateral to medial, commencing in the suprapatellar region (Figs. 1, 2, 3). Longitudinal and transverse images are obtained of the quadriceps tendon. This structure demonstrates the typical echogenic fibrillar echotexture of tendons. The suprapatellar recess is evaluated, from side to side, assess-

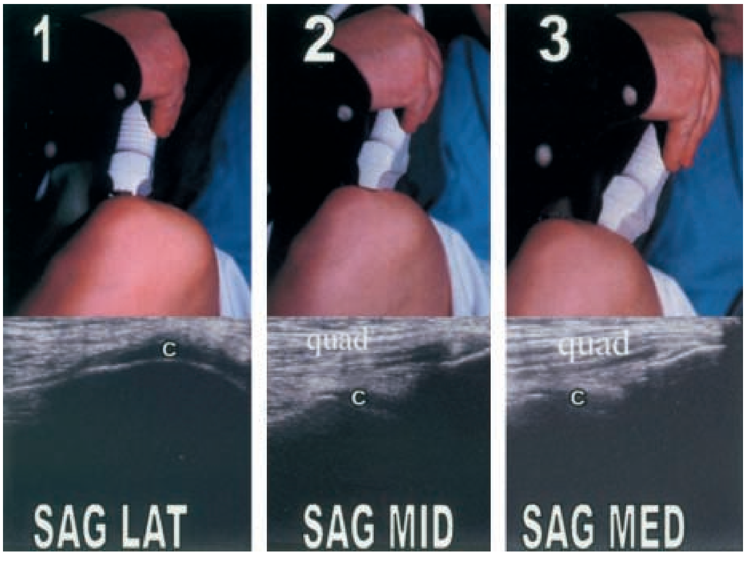


Fig. 1 Sagittal transducer position for assessment of the lateral suprapatellar region, demonstrating hypoechoic femoral cartilage (*c*)

Fig. 2 Midline sagittal position and corresponding image of the quadriceps tendon

Fig. 3 Sagittal position and image of the medial suprapatellar region

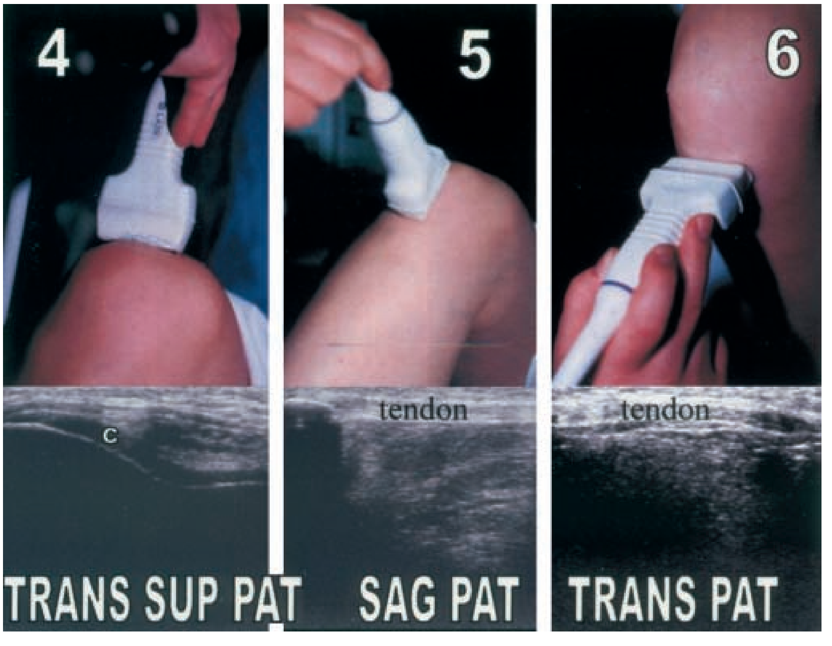


Fig. 4 Transducer position and image of the distal femoral cartilage (*c*)

Fig. 5 Sagittal transducer position and corresponding image of the patellar tendon

Fig. 6 Transverse transducer position and appearance of the patellar tendon

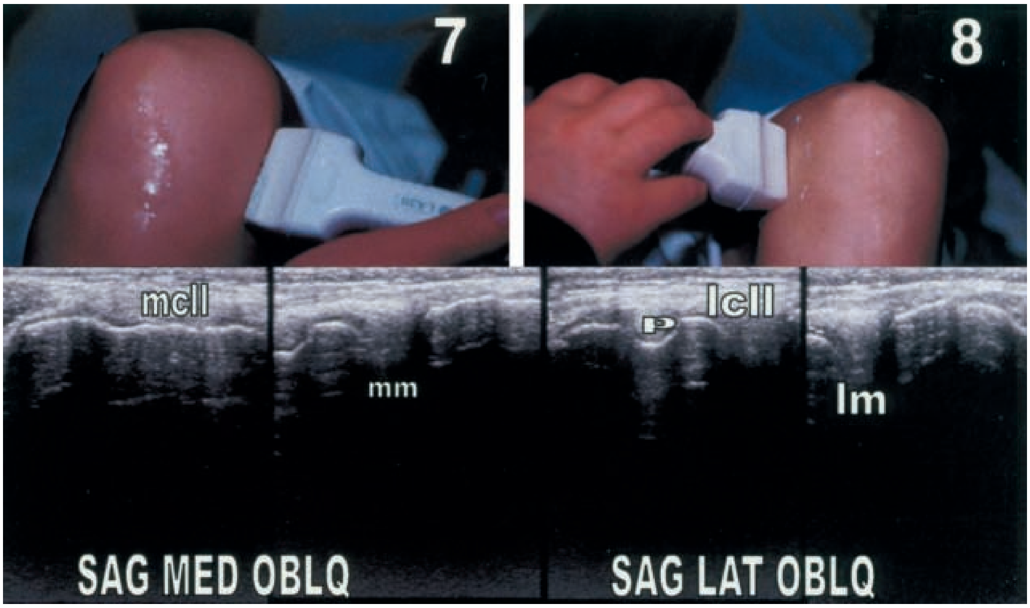


Fig. 7 Sagittal oblique transducer position and image of the medial collateral ligament (*mcl*) and anterior horn of the medial meniscus (*mm*)

Fig. 8 Sagittal oblique transducer position and image of the lateral collateral ligament (*lcl*). Proximally this traverses over the popliteus tendon (*p*). The anterior horn of the lateral meniscus (*lm*) is assessed in the same position

ing for fluid, intra-articular bodies and synovial thickening. The bursa extends at least 5–6 cm above the superior margin of the patella. It often contains a small amount of physiologic fluid, usually no more than 2 mm thick [5]. Joint fluid is often best identified with the knee in 30° to 45° of flexion [5, 7]. It is important to position the knee in various degrees of flexion, as well as to evaluate the medial and lateral patellar recesses, in order to assess for a joint effusion [5].

With the transducer in the transverse plane, the distal femoral cartilage thickness is assessed (Fig. 4). The cartilage appears as a thin hypoechoic band, paralleling the echogenic interface of the distal femoral articular surface. In order to visualize the articular cartilage optimally, this assessment is performed in the 90°flexion position. Transverse and longitudinal images of the patellar tendon are then obtained, best imaged in 30°–45° of flexion [5] (Figs. 5, 6). The medial and lateral patellar retinaculum are examined, appearing as thin hyperechoic bands extending from the respective margins of the patella. They may appear hypoechoic, due to their oblique course, and resultant anisotropy [2]. The retinaculum is thickest at the patellar margin [8].

For assessment of the medial knee, the patient remains supine, with the knee slightly flexed. The hip should be mildly flexed and externally rotated. Alternatively, this assessment can be performed with the patient in the lateral decubitus position. Sagittal views of the medial collateral ligament (MCL) are obtained. If this structure appears thickened, it can be useful to obtain transverse images, particularly with comparison imaging of the asymptomatic knee [9]. The three tendons of the pes anserinus insert slightly inferiorly and anteriorly, onto the tibia. These tendons consist of the sartorius, gracilis and semitendinosus. The medial knee evaluation may also include assessment of the medial femorotibial joint space, as well as the anterior horn of the meniscus. This latter structure may require dynamic assessment with valgus stress, in order to improve visualization [5]. For assessment of the lateral aspect of the knee joint, the leg may be internally rotated, with the patient remaining supine, or the lateral decubitus position may be employed. The lateral collateral ligament (LCL) and biceps femoris tendon can be identified and imaged. The iliotibial band is positioned slightly anterior, and can be followed throughout its length, with insertion identified onto the tibia, at Gerdy's tubercle. The anterior horn of the lateral meniscus is examined (Figs. 7, 8), as well as the lateral joint space.

The patient is then turned prone. The posterior horns of the medial and lateral menisci are interrogated (Figs. 9, 10), as well as the popliteal fossa. The curved or linear transducers in the lower frequency range are often useful for assessment in this region, particularly in more obese patients. The popliteal vessels as well as medial gastrocnemius-semimembranosis bursae are evaluated. The lateral collateral ligament is often better assessed in this prone position, with the leg extended.

The examination is concluded with assessment of the intercondylar region (Fig. 11) and posterior cruciate ligament (PCL) (Fig. 12), with the knee in full extension. For evaluation of the PCL, the transducer should be placed in a sagit-

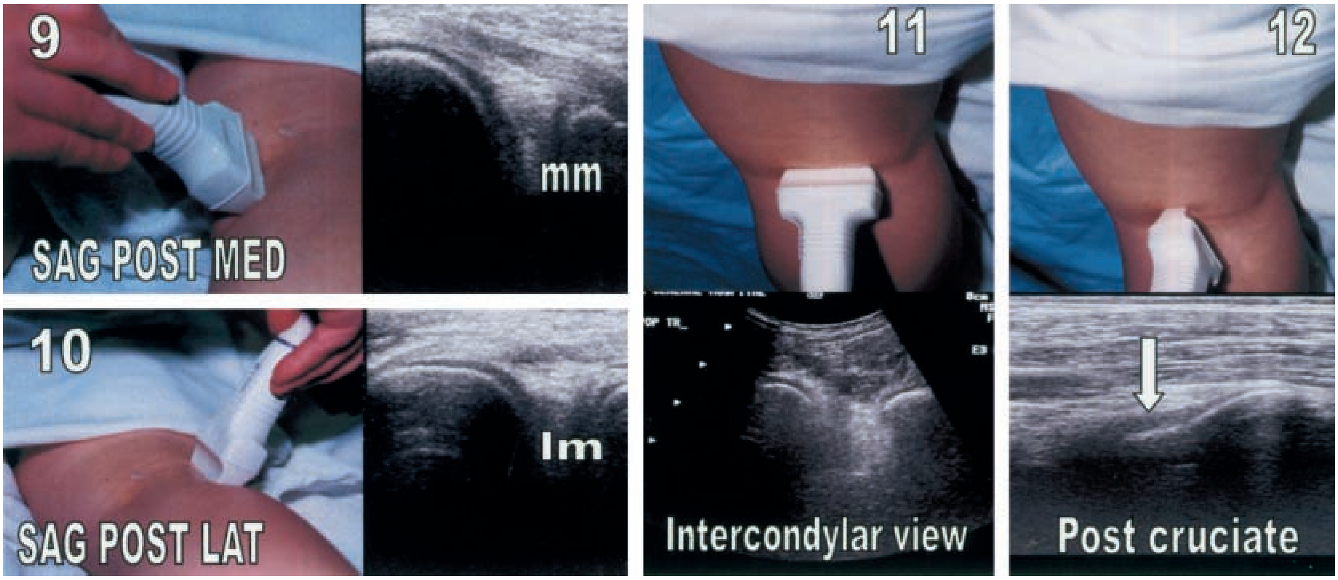


Fig. 9 Sagittal posterior transducer position and image of the medial meniscus (*mm*)

Fig. 10 Sagittal posterior transducer position and image of the lateral meniscus (*lm*)

Fig. 11 Transverse assessment of the intercondylar region of the posterior distal femur. This region may be amenable to evaluation with a linear probe (positioning image); however curved transducers may be required, particularly for larger patients (sonographic image)

Fig. 12 Sagittal oblique position and image of the distal posterior cruciate ligament (*white arrow*)

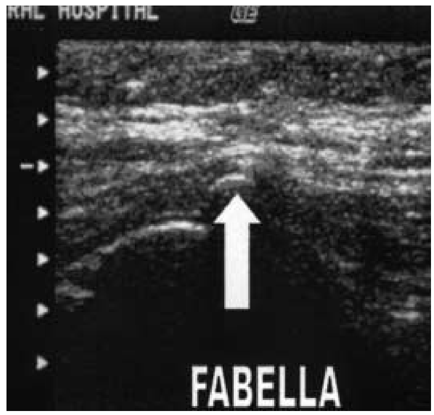


Fig. 13 Ultrasound appearance of the normal fabella (*arrow*)

tal oblique orientation, with the proximal end of the transducer oriented medially (approximately 30° rotation) [10].

Color Doppler is useful for confirming vascular pathology, such as deep vein thrombosis and popliteal artery aneurysm, as well as for demonstrating the relationship of joint disorders or masses to adjacent arteries and veins. This can be particularly useful when planning the route of aspiration or biopsy. Power Doppler is more sensitive to slow flow and regional perfusion patterns. This can aid in assessing soft tissue hyperemia [11]. For ultrasound assessment of the knee, this has great potential for the evaluation of inflammatory disorders of joints, bursae and tendons. The current disadvantages include the lack of quantification and reproducibility of measurement [12].

Pitfalls

The general principles of ultrasound artifacts apply to musculoskeletal imaging, with some having particular relevance. Recognizing normal appearances of structures and common pitfalls is essential, in order to avoid misdiagnosing findings.

Anisotropy is one of the most important imaging pitfalls in musculoskeletal imaging [1, 2, 5]. Care must be taken to orient the ultrasound transducer parallel to tendons and ligaments, in order to avoid the creation of false hypoechoic areas. These can mimic tears, tendinosis or fluid.

Age-related changes must be recognized, for instance the presence of cartilaginous epiphyses and growth plates in children. The prominent hypoechoic cartilage in children should not be mistaken for a joint effusion.

Patient positioning can influence image interpretation. An important example of this is the degree of knee flexion during assessment of the anterior knee. With the knee positioned in 90° of flexion, the cartilage is optimally visualized; however, joint fluid may not be apparent. The patient must be positioned in 30°–40° of flexion to optimally evaluate for the presence of a joint effusion. It is also important to remember not to compress too hard, as this can displace important fluid collections or compress bursae, which are then easily overlooked.

Other pitfalls include normal structures, such as vessels, mimicking regional pathology. Doppler is an impor-

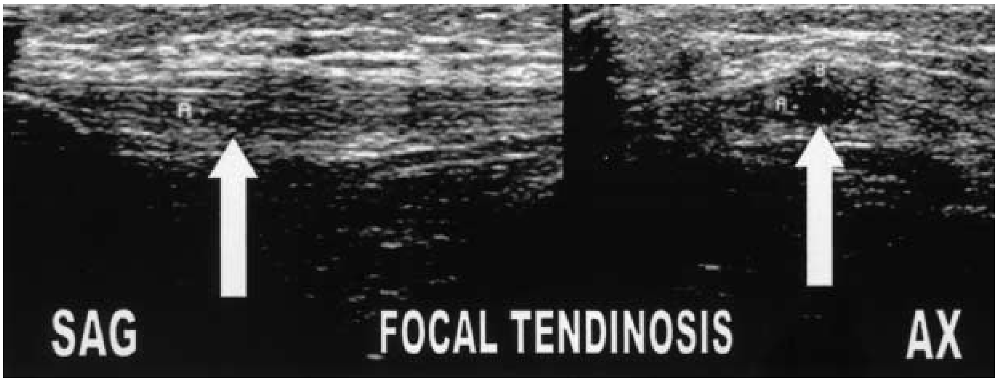


Fig. 14 Sagittal image (left) of the proximal patellar tendon demonstrating the linear hypoechoic space (*arrow*) within the mid-substance of the tendon. This is also identified on transverse imaging (*right, arrow*)

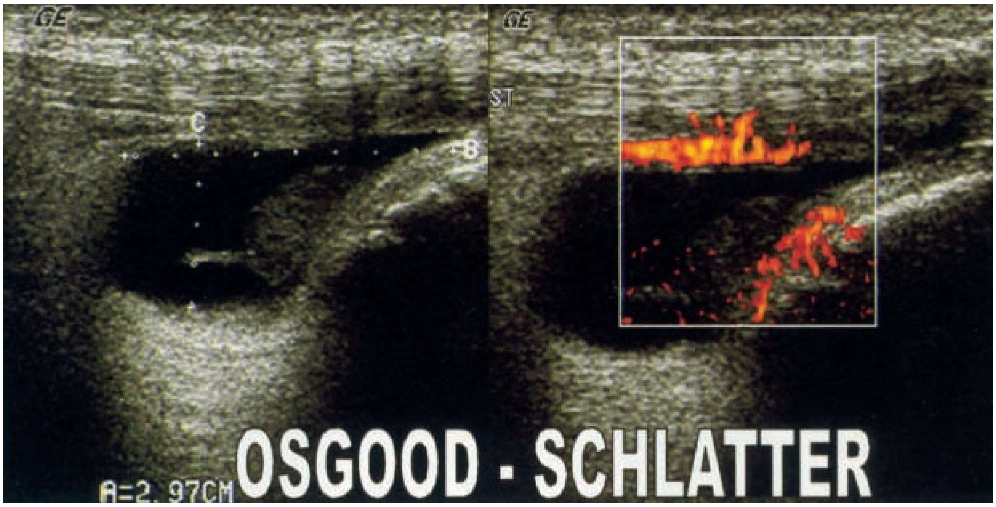


Fig. 15 Osgood-Schlatter disease. Ultrasound documents abnormal distension of the deep infrapatellar bursa (*left*) as well as abnormal power Doppler flow (*right*)

tant tool to confirm whether an observed abnormality is related to vessels or to other pathology. In addition, normal structures such as the fabella must be recognized, and not mistaken for an abnormal soft tissue calcification or loose body (Fig. 13).

Tendons

The ability to assess tendons is a particular strength of ultrasound, as it is able to clearly visualize and evaluate the fibrillar echotexture of normal tendons. The typical appearance consists of a series of parallel hyperechoic structures [13]. An exception to this is at the site of insertion, which often has a hypoechoic appearance, not to be mistaken for a tear. This is due to anisotropy. Comparison with the asymptomatic side is important, and easy to perform. Both transverse and longitudinal images are easily obtained. Subluxation and function can be dynamically assessed.

In tendons without a synovial sheath, such as the quadriceps and patellar tendons, tendonitis may appear as increased tendon size, and decreased echogenicity, either focal or generalized. Hypoechoic spaces may appear between the normal echogenic fibrils (Fig. 14). Peritendinous fluid may also be present. This condition and appearance may more correctly represent tendinosis, a histopathologic term referring to intrasubstance mucoid degeneration, with absence of inflammatory cells when histologically evaluated. In the chronic stage, calcifications, nodularity and heterogeneous echotexture can be seen [1, 2, 5, 13]. This appearance is frequently thought to represent a precursor to tendon tear.

An example of a common abnormality involving the knee is Osgood-Schlatter disease. This is an entity involving the tibial tuberosity, which occurs typically in the 10- to 15-year-old age group. Males are affected more than females, and there is often a history of involvement with sports. The process is likely related to repeated microinjury to the patellar tendon, at its site of insertion onto the tibial tuberosity. Tenderness over the region is often appreciated clinically, coupled with soft tissue swelling. With ultrasound, the tendon may initially demonstrate distal thickening and swelling [14]. The cartilage appears to swell and there may be fluid in the superficial and deep infrapatellar bursa [2, 4] (Fig. 15). At

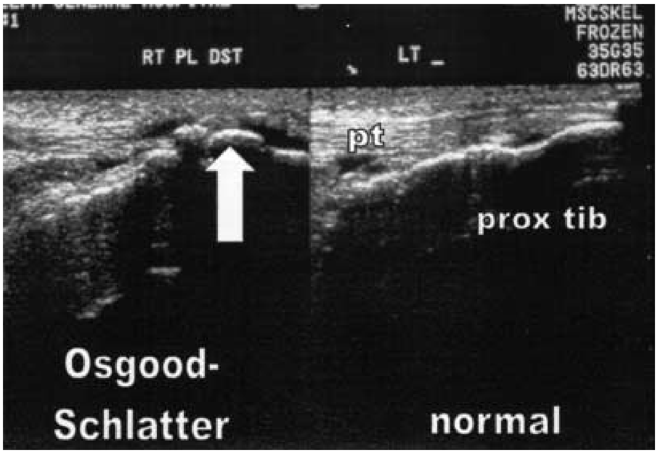


Fig. 16 Osgood-Schlatter disease. At the late stage, ultrasound can document bony fragmentation (*left*). Compare with the normal appearance (*right*)

Fig. 18 Jumper's knee. Ultrasound demonstrates abnormal proximal tendon thickening, the hypoechoic appearance and increased power Doppler flow

Fig. 17 Sagittal midline image of a patient with a suspected quadriceps tendon tear (*left*). The image demonstrates complete disruption of the normal tendon, with a short distal tendon stump (*arrow*). The normal tendon position is filled with hypoechoic fluid. Compare with the normal distal quadriceps appearance (*right*)

later stages, bony fragmentation at the hyperechoic ossification center may be seen [15] (Fig. 16). The same appearance can be observed at the distal patella and proximal patellar tendon, known as Sinding-Larsen-Johansson syndrome.

Tendon tears are well suited to ultrasound evaluation. Partial tears present as confluent anechoic areas or clefts in the tendon, with disruption of a portion of the normal fibrillar echotexture. Complete tears appear as separated ends of the tendon, tendon retraction, thickened tendon ends and interruption of the regional tendon fibers. Fluid or hematoma may fill the site of tear [5] (Fig. 17). Conditions predisposing to patellar tendon tears include those with local trauma or steroid injections, systemic disorders, including rheumatoid arthritis, systemic lupus erythematosus and chronic renal failure, as well as following joint replacement [1]. Similar conditions predispose to quadriceps tendon tears. Spontaneous rupture of this tendon rarely occurs. It is important to recognize quadriceps tendon injury, as surgical intervention must occur early in full-thickness tears. Ultrasound can aid in prompt diagnosis [16]. Dynamic assessment, with flexion and extension, can aid in the diagnosis of patellar and quadriceps tendon tears. A common pitfall is to mistake hypoechoic change near the tendon insertion onto the patella for a tear.

Jumper's knee is a condition thought to represent a non-healed partial tear of the patellar tendon. This typically involves the central and proximal insertion site of the patellar tendon into the lower pole of the patella. It is often seen in athletes, particularly those who participate in sports requiring repetitive extensor mechanism activity, and can lead to significant continuing disability. It is often clinically confused with bursitis or chondromalacia. Jumper's knee commences as a repeated acute injury, but often presents in the chronic stage, at which point it is referred for evaluation. On ultrasound, it appears as a focal hypoechoic area within the tendon [17]. In the chronic stage, calcifications may be identified within the tendon, usually close to the cartilaginous insertion [2, 4]. Bony spurs may be present at the inferior pole of the pa-

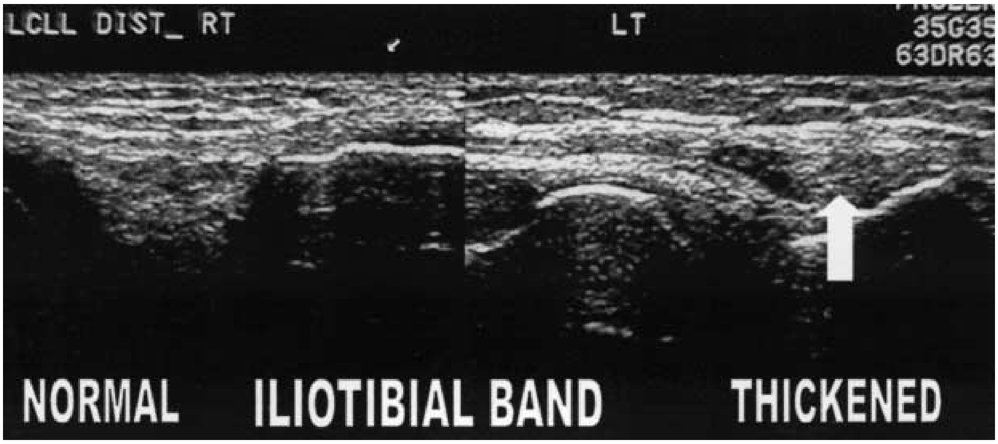


Fig. 19 Iliotibial band syndrome. Sagittal ultrasound image demonstrates abnormal thickening of the distal iliotibial band (*right*) compared with the normal side (*left*)

tella. Color Doppler may aid in imaging and diagnosis of this disorder [18] (Fig. 18).

Other tendinopathies include distal biceps femoris and pes anserinus tendinitis, most often seen in athletes and obese patients. The iliotibial band syndrome, also known as runner's knee, is a fasciitis rather than a true tendinitis, and is due to repetitive rubbing of the iliotibial band against the lateral femoral condyle [1] (Fig. 19). Ultrasound may demonstrate thickening, surrounding edema and focal tenderness, along with possible distention of the adjacent bursa [2, 3, 19].

Muscles

The normal muscle bundles are hypoechoic in appearance, with hyperechoic lines throughout, representing fibroadipose septa. The outer margin of the muscle is hyperechoic in appearance. This is thought to be due to surrounding connective tissue fascia [5].

Ultrasound can evaluate muscle injuries, and can demonstrate partial or complete tears of the involved muscle or tendon. Appearances can be assessed during contraction and relaxation. Comparison can be made with the asymptomatic side, looking for altered configuration and asymmetry. As a general principle that applies to tears of other structures, care must be taken to evaluate for disruption of the normal muscle architecture. Partial tears appear as anechoic clefts or hypoechoic collections within the muscle belly (Fig. 20). Partial tears have been graded from I to III, an evaluation helpful in the assessment of healing. Grade I may be normal or contain small hematomas, less than 1 cm, and usually heals in 2–3 weeks. Grade II involves less than one third of the muscle, with hematomas less than 3 cm, and often heals in 3–6 weeks. Grade III involves more than one third of the muscle, contains hematomas larger than 3 cm, and usually takes months to heal. In complete tears, the ends of the ruptured muscle are separated, with rounded margins and loss of regional fiber continuity [20]. It can be difficult to differentiate a high-grade partial tear from a complete tear. Complete tears often present with a palpable gap in the region of involvement. The appearance can be mistaken for a soft tissue mass or tumour (Fig. 21).

Quadriceps muscle and tendon tears are a relatively common injury in young athletes [2, 5]. These occur during forced muscle contraction, or direct trauma. Ruptures are often traumatic, but can be idiopathic, or due to a variety of systemic diseases. The clinical presentation includes pain and swelling proximal to the patella, with limited extension of the knee. Extended field of view imaging can be particularly useful for documenting these tears [2]. It is important to attempt differentiation between partial and full-thickness tears, as the latter require prompt surgical intervention.

Ligaments

The important ligamentous structures at the knee include the collateral and cruciate ligaments. The extra-articular collateral ligaments usually appear hyperechoic on ultrasound; intra-articular ligaments, such as the cruciate ligaments, appear hypoechoic, and are less optimally visualized.

The medial collateral ligament (MCL) is 8–10 cm in length, and extends from the medial femoral epicondyle to its tibial attachment. It has a broad and flat morphology, and is composed of a superficial and a deep component. The superficial portion is identified as a broad, long, dense fibrillar connective tissue structure, with a hyperechoic appearance (Fig. 22). The deep component consists of the hyperechoic meniscofemoral and meniscotibial ligaments. A hypoechoic layer of connective tissue separates these layers [5]. The deep component is more commonly torn than the superficial one [21]. If the tear is isolated to the deep layer, hematoma and/or fluid can displace the superficial layer laterally (Fig. 23). A triad of injury is often present, consisting of a torn medi-

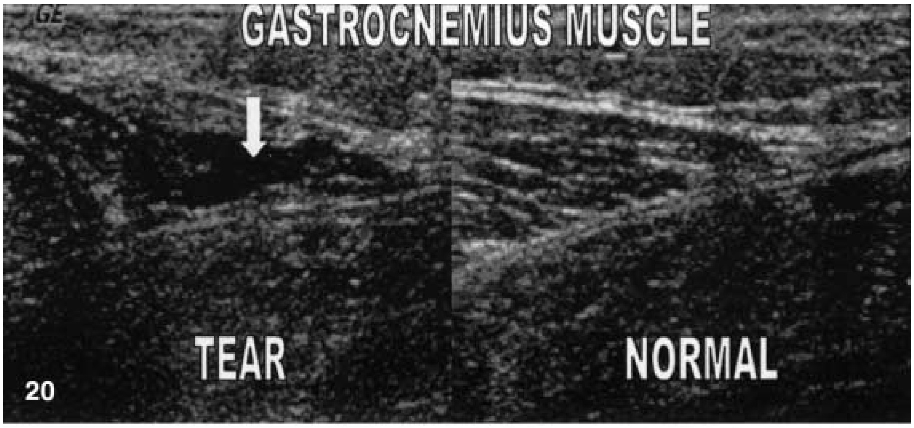


Fig. 20 Partial tear of the gastrocnemius muscle. Sagittal ultrasound image clearly demarcates disruption of normal muscle fibers, with rounded proximal muscle (*right*). Fluid fills the site of the tear (*arrow*). Compare with the normal contralateral side (*left*)

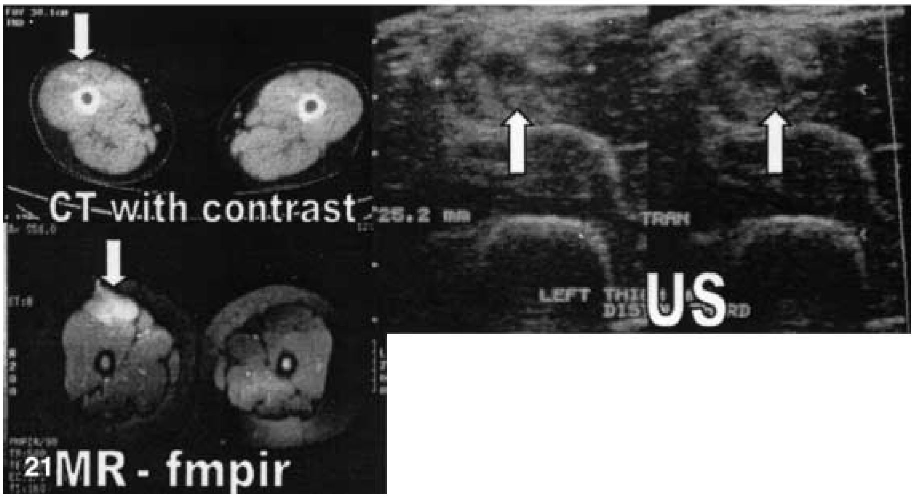


Fig. 21 Rectus femoris tear in a young patient with a palpable thigh mass. Transverse CT images (*upper left*) demonstrate an abnormal area of contrast enhancement. Transverse FMPIR MRI image of same location (*lower left*) identifies extensive abnormal high signal within the rectus femoris, raising the question of a possible neoplasm. Subsequent ultrasound image (*right*) demonstrates a process isolated to the rectus femoris muscle, with an appearance consistent with a tear

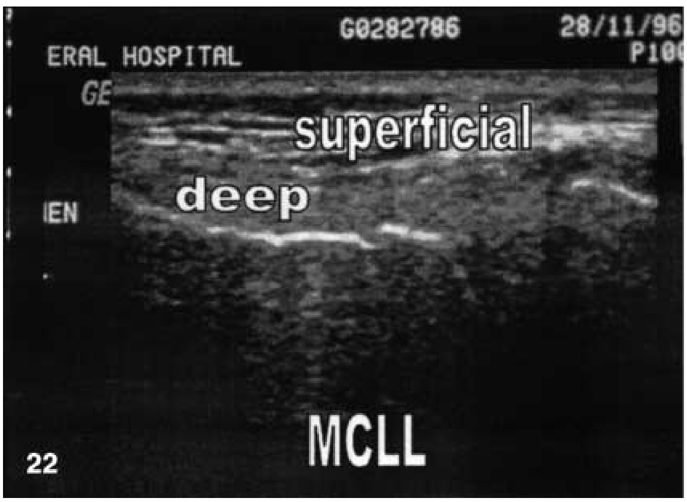
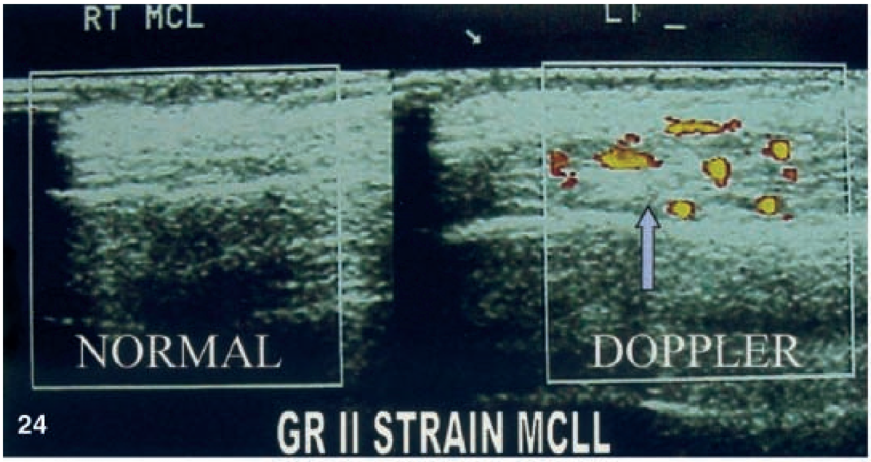
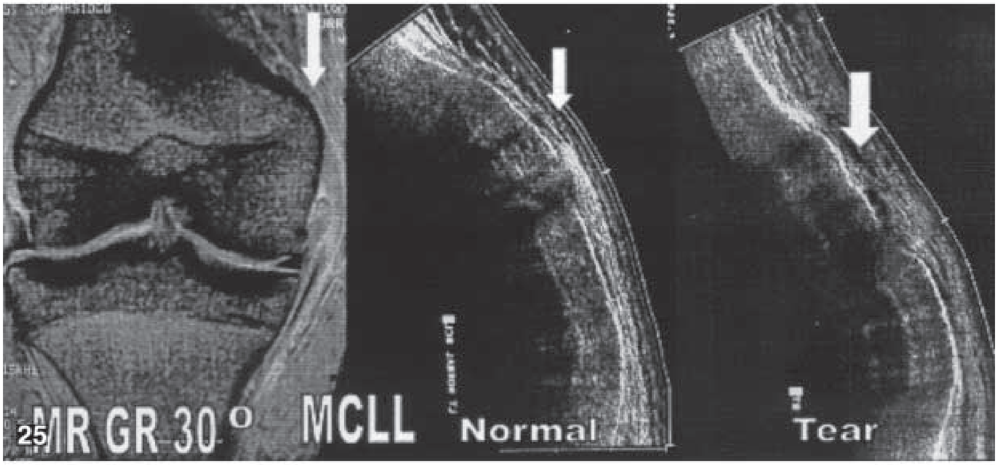


Fig. 22 Sagittal image of the medial collateral ligament demonstrates the superficial echogenic component overlying the deep component

Fig. 23 Sagittal image demonstrates a deep hypoechoic fluid collection displacing an intact superficial medial collateral ligament





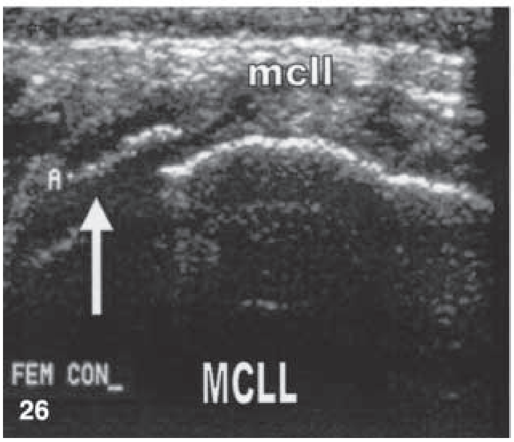


Fig. 24 Sagittal image (*right*) demonstrates an abnormal medial collateral ligament with thickening and increased Doppler flow. Compare with the normal side (*left*)

Fig. 25 Coronal gradient MRI image (*left*) demonstrates complete disruption of the proximal medial collateral ligament (MCL), consistent with a grade III tear. Extended field of view sagittal image of the same knee (*right*) demonstrates absence of normal MCL anatomy, with fluid and edema present. Contrast with the normal contralateral knee (*center*)

Fig. 26 Sagittal image of the proximal medial collateral ligament demonstrates abnormal ligament calcification (*arrow*)

al collateral ligament, medial meniscus tear and anterior cruciate ligament rupture.

Tear of the MCL has a similar appearance on ultrasound as has been described for MRI [22]. The ultrasound appearance follows the same principles as tears of other structures, including discontinuity of normal fibers. It is important to observe tendon thickening and heterogeneity, as well as to compare the appearance with the asymptomatic side [9]. A grade I tear represents a minimal tear or strain injury, without instability clinically. It is thought to represent a predominantly periligamentous injury, with microfiber tearing. The ultrasound appearance is that of hypoechoic fluid, due to edema and hemorrhage, parallel to the MCL. A grade II injury represents intrasubstance rupture, with increased instability. Hypoechoic fluid can be identified as well has ligament thickening (Fig. 24). Grade III injury represents complete rupture, with gross instability and fiber discontinu-

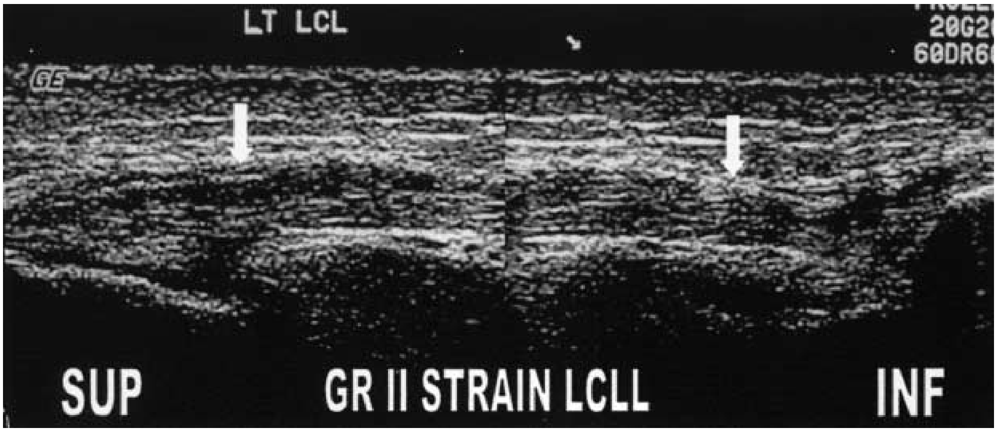


Fig. 27 Lateral collateral ligament tear. Sagittal image demonstrating abnormal tendon thickening and hypoechogenicity

ity. On ultrasound, hypoechoic fluid or hematoma is identified filling the site of the tear, with disruption of both superficial and deep components (Fig. 25). A thick well-defined or calcified ligament can indicate old injury [21] (Fig. 26).

The lateral collateral ligament (LCL) is approximately 5–7 cm in length, and is extracapsular in location. It is a thin band-like structure and may have a slightly hypoechoic appearance, secondary to its oblique orientation and resultant anisotropy [21]. It courses from the lateral femoral epicondyle to the fibular head, where it has a conjoined insertion with the biceps femoris tendon. The intracapsular popliteus tendon is positioned deep to the proximal aspect of the LCL. The iliotibial band is a thin hyperechoic structure identified anterior to the LCL, inserting on to Gerdy's tubercle on the tibia.

Injury to the LCL is less common than to the MCL. With complete tear, the ligamentous fibers are disrupted, with hypoechoic focal hematoma present. A partial tear is suggested by the presence of tendon thickening, poor definition, surrounding fluid and a more hypoechoic appearance [1] (Fig. 27).

While MRI is the primary imaging modality of choice for assessment and evaluation of the cruciate ligaments, some information can be obtained by ultrasound. The anterior cruciate ligament (ACL) is a difficult structure to visualize and evaluate. The posterior intercondylar view can assess the site of tendon attachment. The normal appearance is that of a small oval-shaped hypoechoic structure. A tear presents as a hypoechoic collection along the lateral wall of the femoral intercondylar notch, representing a hematoma at the proximal attachment site of the ACL [23]. Anterior imaging approaches have also been investigated and described [5, 10].

Posterior cruciate ligament (PCL) ruptures are less common than ruptures of the ACL. The distal insertion site onto the tibia appears as a hypoechoic, curved, triangular-shaped band, identified posteriorly with a sagittal oblique orientation [10]. The hypoechoic appearance is thought to represent anisotropy [24]. Partial or complete

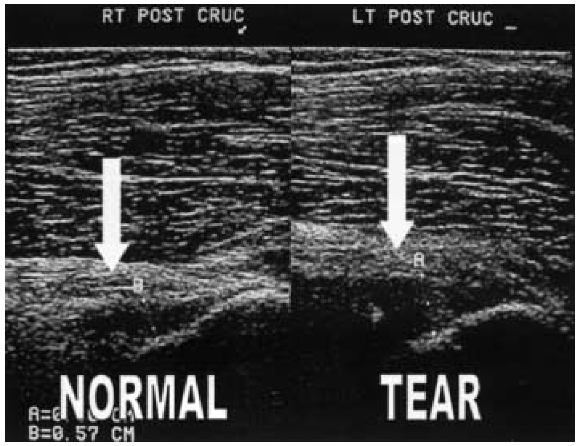


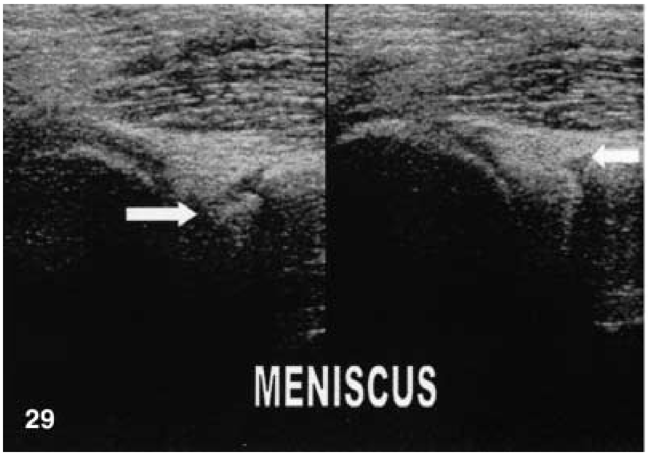
Fig. 28 Posterior cruciate ligament tear. Ultrasound demonstrates abnormal thickening of the visualized posterior cruciate ligament compared with the normal contralateral side

tears may appear as a mass effect or thickening of the ligament (Fig. 28), or possibly as a visible tear or disruption.

Menisci

Although MRI is still the favored imaging modality for meniscal assessment, ultrasound can demonstrate some pathology. This requires thorough technique, and can be more difficult in obese patients.

The normal ultrasound appearance of the menisci is of a triangular-shaped hyperechoic structure positioned at the joint space. Imaging on ultrasound can be problematic, due to artifacts and limited visualization. Tears appear as anechoic or hypoechoic linear clefts within the meniscus (Figs. 29, 30); however, hyperechoic tears have also been described [5]. Posterior and peripheral tears are easiest to visualize. Small internal or medial tears can easily be missed, which is part of the limitation



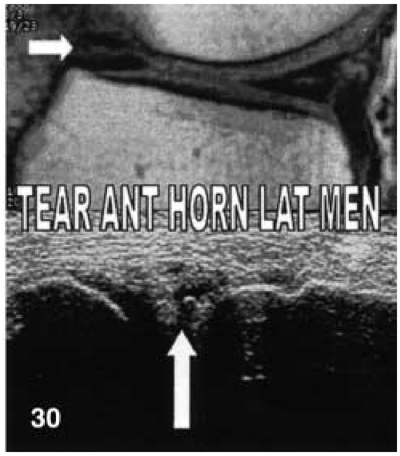
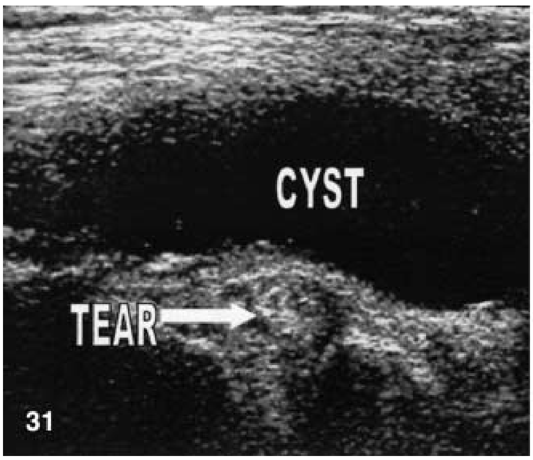


Fig. 29 Posterior meniscal tear. Sagittal images of the posterior meniscus demonstrate an oblique linear hypoechoic cleft through the meniscus

Fig. 30 Anterior meniscal tear. Sagittal MRI image (*above*) documenting a meniscal tear (*horizontal arrow*) which is also demonstrated on ultrasound (*below*) as a hypoechoic cleft through the meniscus (*vertical arrow*)



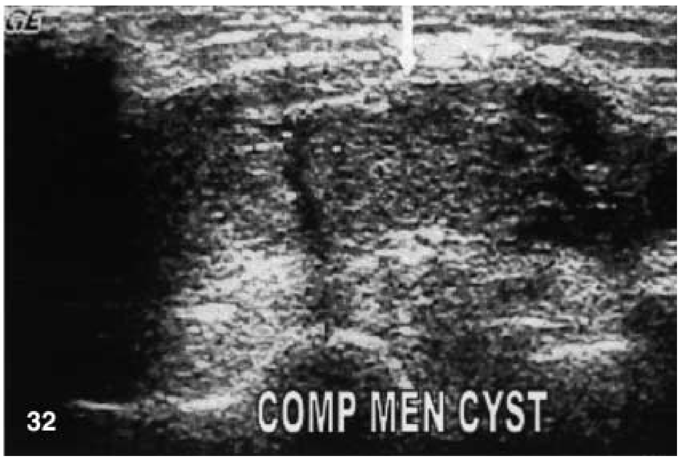


Fig. 31 Meniscal cyst. Sagittal ultrasound image demonstrates a large meniscal cyst. An associated tear of the meniscus is also demonstrated (*arrow*)

Fig. 32 Complex meniscal cyst. Sagittal ultrasound demonstrates a meniscal cyst containing echogenic material, mimicking a solid lesion

of ultrasound in assessing internal derangement. With degeneration, the menisci appear swollen, with decreased echogenicity. Cystic areas can become visible [2]. The meniscus often extrudes out of the joint space, and may contain small cysts within. Meniscal chondrocalcinosis can result in a linear hyperechoic appearance [2, 3].

Meniscal cysts are encapsulated mass lesions, containing synovial-like fluid. They can present clinically as a palpable mass or incidentally on imaging. These cysts appear as hypoechoic or partially anechoic structures, adjacent to the meniscus (Fig. 31), and often contain septa or debris [25]. With time, the ultrasound appearance can become complex, and they may mimic a solid lesion [26] (Fig. 32). These cysts can be, but are not always, associated with horizontal meniscal tears. The cyst can be a result of primary myxoid degeneration of the meniscus. When meniscal cysts are large, the pressure effect can result in bony erosion [25].

Cysts and fluid collections

Joint effusions

The presence of joint fluid is easily recognized by ultrasound, but requires optimal patient positioning, as has been previously emphasized. It is important not to compress too hard while scanning, in order to avoid dissipating small amounts of joint fluid. A joint effusion can present as anechoic fluid, often suggesting a more acute

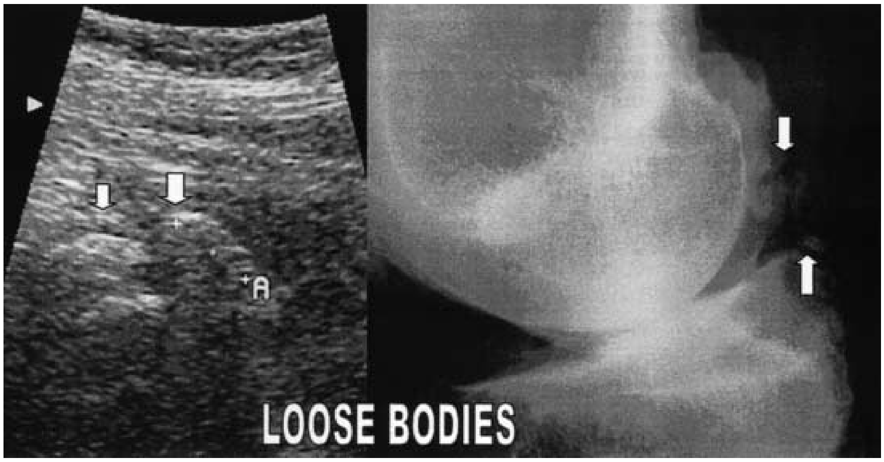


Fig. 33 Intra-articular bodies demonstrated by ultrasound (*left*), correlating with the plain film findings (*right*)

process, or as hypoechoic, possibly containing some debris. The internal echoes or debris are often related to small loose bodies (Fig. 33), inflammatory or hemorrhagic material or fat globules [5]. Ultrasound is a useful modality for the detection of loose bodies, typically found in the suprapatellar pouch or in a Baker's cyst [27]. Recognition or confirmation of loose body may require dynamic assessment [28, 29]. Details regarding characteristics of the synovium can be assessed in the suprapatellar bursa and joint space [12]. It is important to evaluate for synovial thickening and nodularity, which can be highlighted with the aid of compression [1]. Pannus or thickened synovium appears more hypoechoic than the adjacent soft tissues. Power Doppler can demonstrate hyperemia in acutely inflamed synovium, assisting in distinguishing acute from chronic presentations [2]. Ultrasound also has added value in guidance for joint aspiration and synovial biopsy [30].

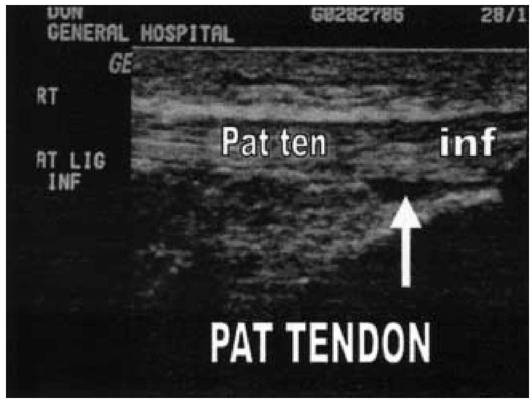


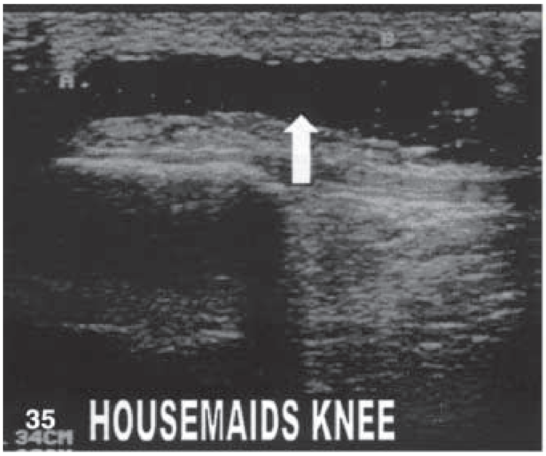
Fig. 34 Normal small triangular collection of fluid behind the distal patellar tendon, representing a tiny amount of fluid in the deep infrapatellar bursa

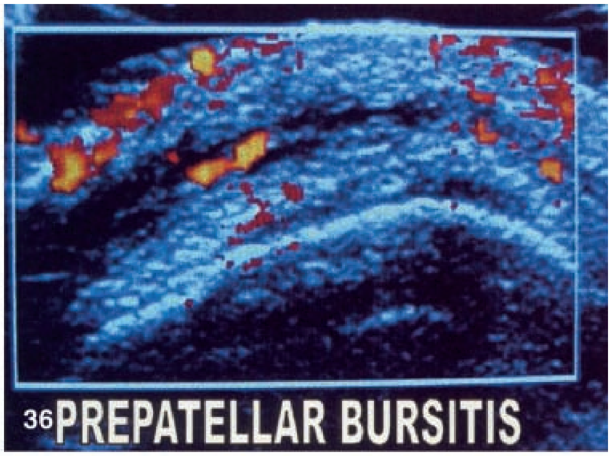
Bursae

The lining of normal bursa appears hyperechoic on ultrasound, with a slit-like hypoechoic appearance centrally. The central hypoechoic cleft is usually less than 2 mm [5, 21]. The normal suprapatellar bursa can contain a small amount of physiologic fluid, comparison with the other side often proving useful in recognizing abnormally increased amounts. In addition, there is often a small physiologic amount of fluid posterior to the distal patellar tendon insertion, representing a tiny amount of fluid within the deep infrapatellar bursa (Fig. 34). The small superficial infrapatellar bursa is usually not visualized on ultrasound [2].

Synovial proliferation and thickening within a bursa can be observed, particularly in rheumatoid arthritis and other inflammatory conditions. Echogenic material within may indicate hemorrhagic, inflammatory or infectious etiologies. Fibrous adhesions may be seen with long-standing effusions. Ultrasound can help to differentiate between bursitis and tendon problems, whereas clinical differentiation can often prove difficult.

Superficial bursae do not communicate with a joint space. A common example of pathology involving a superficial bursa is prepatellar bursitis, commonly known as “house-maid's knee”. This affects individuals who spend extended periods of time on their knees. On ultrasound, hypoechoic bursal fluid is recognized (Fig. 35). Often there is thickening or inflammation of the synovium, which can be assessed with Doppler (Fig. 36). Pes anserine bursitis is also commonly observed and can be seen in athletes, obese patients, secondary to arthritis or idiopathically [3]. Ultrasound demonstrates a cystic mass adjacent and deep to the pes anserine tendon (Fig. 37). Less commonly, ultrasound can identify inflammation of the bursa surrounding the semimembranosis tendon (Fig. 38).





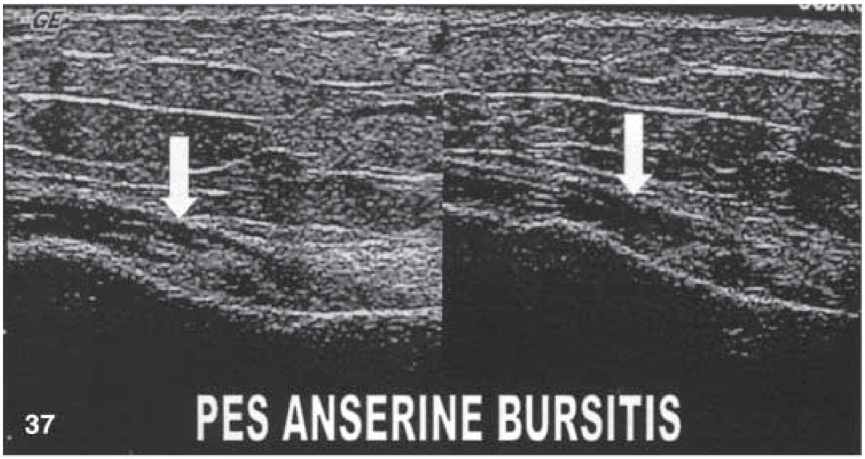


Fig. 35 Sagittal image over the lower pole of the patella and proximal patellar tendon, documenting abnormal fluid within the prepatellar bursa

Fig. 36 Transverse image demonstrating increased power Doppler flow within the tissues surrounding an enlarged prepatellar bursa

Fig. 37 Sagittal images demonstrate abnormal fluid adjacent to the pes anserine tendons

Fig. 38 Semimembranosis bursitis. Transverse image (*left*) demonstrates abnormal fluid within the semimembranosis bursa. Compare with normal (*right*)

Baker's cyst

Baker's cyst represents enlargement of the gastrocnemius-semimembranous bursa. To correctly diagnose this entity it is important to look for the neck of fluid extending between the medial gastrocnemius muscle and semimembranosis tendon (Fig. 39). This represents the channel of communication with the joint space, and the route for potential decompression of large intra-articular fluid collections, of any etiology. Baker's cysts typically present at the medial aspect of the popliteal fossa, but can cross the midline, with enlargement. The shape can be

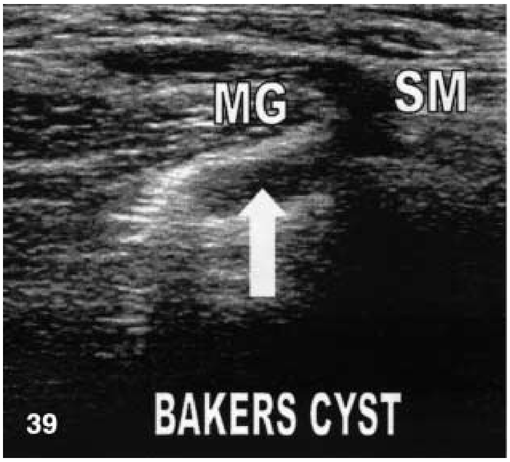


Fig. 39 Transverse image of the medial popliteal fossa demonstrates the typical appearance of a Baker's cyst, with a neck of fluid (*arrow*) identified between the medial gastrocnemius muscle (*MG*) and semimembranosis tendon (*SM*)

Fig. 40 Transverse image of a Baker's cyst demonstrates hyperechoic material within, consistent with hemorrhagic material

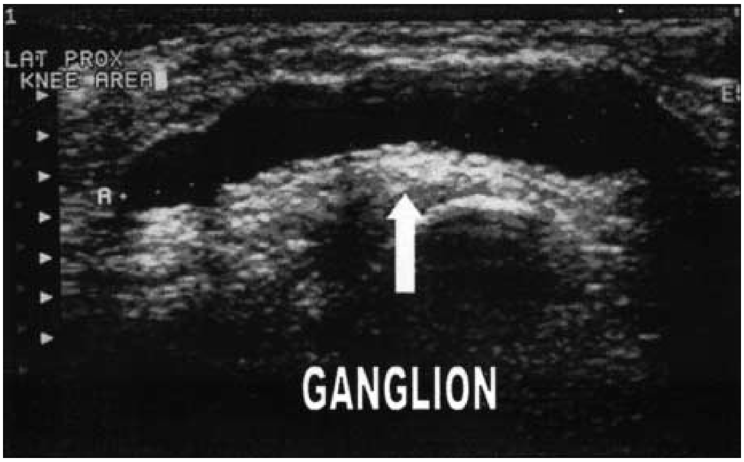


Fig. 41 Ganglion cyst. Sagittal image at the lateral aspect of the knee demonstrates a large, anechoic, unilocular collection

variable [31]. Loose bodies may be present within, as well as hemorrhagic material (Fig. 40). The inferior aspect of this bursa typically has a rounded configuration, with pointed or angulated appearances raising suspicion of rupture [2, 3, 5]. Doppler can play an important role in differentiating small cysts from popliteal aneurysms.

A Baker's cyst is frequently associated with meniscal tears, medial more commonly than lateral. It can also occur with degenerative and inflammatory arthropathy. The synovial thickening and internal debris, often associated with these conditions, is easily documented with ultrasound.

Ganglion and synovial cysts

Ganglia contain a connective tissue lining. The internal contents consist of viscous, mucinous-like material. They may be the result of mucoid degeneration of connective tissue and rarely communicate with a joint [3]. Synovial cysts are synovial-lined structures, originating from a joint capsule, tendon sheath or adjacent bursa. Clinically and often on ultrasound imaging, these lesions cannot be distinguished. On imaging, they are typically anechoic, and may be unilocular or multilocular (Fig. 41). At the knee, these commonly arise from the proximal tibiofibular joint [3].

Cartilage

Normal hyaline cartilage has a homogeneous hypoechoic appearance on ultrasound, with a smooth contour, paralleling the echogenic interface with bone. There is a gradual tapering at the articular margins. When the ultrasound beam falls perpendicular to the cartilage surface, a

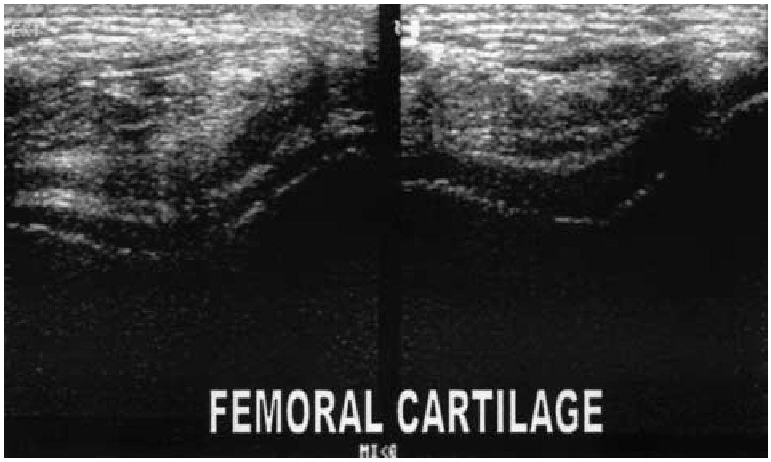
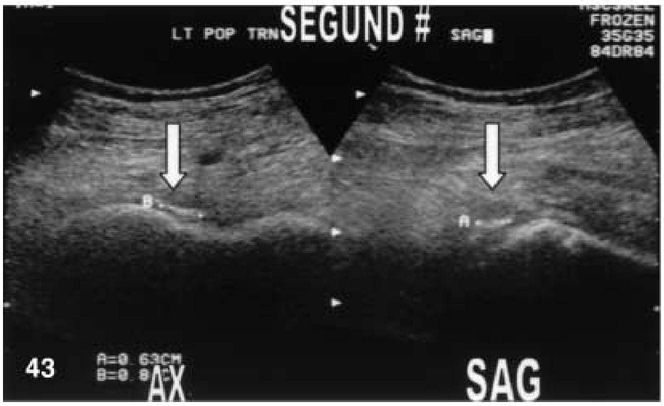
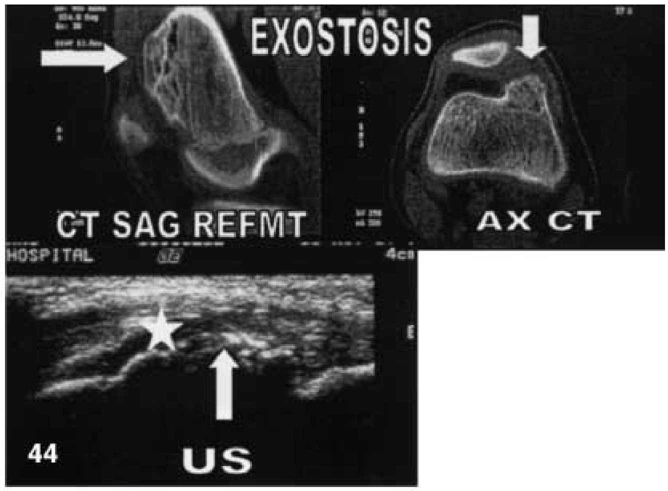


Fig. 42 Cartilage is demonstrated as thinner on the *left* image, compared with *right*





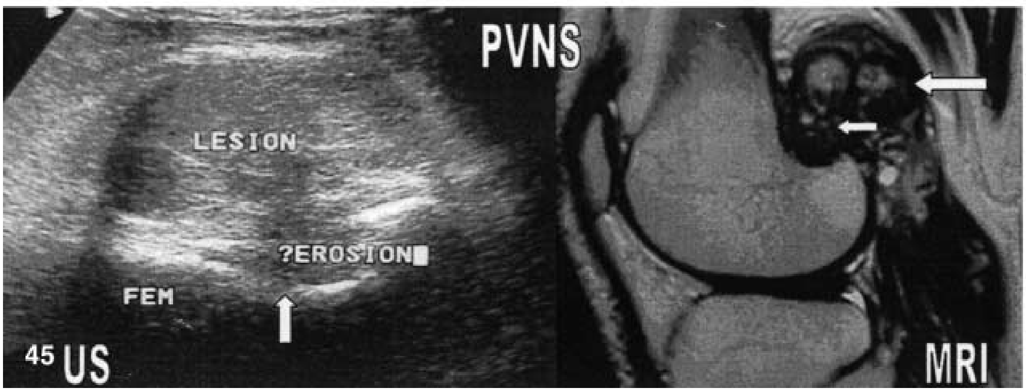


Fig. 43 Second fracture identified at the time of ultrasound. Axial (*left*) and sagittal (*right*) images at the level of the tibial plateau demonstrate this subtle fracture

Fig. 44 Exostosis. Ultrasound demonstrates an exophytic growth contiguous with the femoral condyle (*below*), confirmed by CT imaging (*above*)

Fig. 45 Ultrasound of the posterior femoral region (*left*) identifies an unusual solid soft tissue lesion, with possible underlying bone surface erosion. MRI (*right*) confirmed features consistent with PVNS

thin hyperechoic line is observed. Ultrasound has the potential to recognize cartilage thinning (Fig. 42), surface irregularity, and defects, on surfaces accessible to scanning [5, 21]. Unfortunately in knee ultrasound imaging, not all the articular surface can be evaluated, despite a variety of patient positions. Ultrasound does have an advantage in the immature skeleton, in that the relationship between bony and cartilaginous structures can be assessed.

Bone

The strong echogenic surface of bone can be used to advantage in order to detect abnormalities. Ultrasound can assess the circumference of the bone in question, offering an advantage over conventional radiography. For this reason, subtle fractures that may be missed on standard radiographic views, as well as adjacent hematoma, can be detected (Fig. 43). There is easy correlation with the patient's point of maximal tenderness. Incidental bone lesions, such as osteochondromas or bone cysts, can also occasionally be recognized [1, 32] (Figs. 44, 45).

Conclusion

The development of high-resolution technology has led to increasing acceptance of ultrasound as a valuable diagnostic tool in musculoskeletal imaging. The affordability and availability of ultrasound versus other imaging modalities is of great appeal. The prerequisites for excellent results include high-resolution ultrasound equipment, thorough knowledge of the regional anatomy, and recognition of the normal appearances and common pitfalls. Assessment can be rapid and offers the advantage of dynamic testing. It is important to recognize when ultrasound is appropriate or inappropriate for answering the clinical question at hand. With experience at acquiring and interpreting images, ultrasound can play a role in the assessment of pathologic conditions involving the knee joint.

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