7
Imaging of Tendon Ailments

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Introduction

Twenty-five years ago, imaging of tendons was confined to faint soft tissue opacities on conventional radiographs, possibly with the visualization of calcification, and to tenography to show the surface anatomy of tendons and tears. Since then, there has been an enormous leap forward with the development of ultrasound (US) and magnetic resonance imaging (MRI). The fine internal architecture of the tendons can now be visualized by both of these methods, and their development continues apace. This chapter will concentrate on these later two methods. Local availability and experience are other major factors determining the choice of imaging modality. Also, the referring physician's comfort zone with the report of a dynamic study such as ultrasound may be a factor.

Conventional Radiography

Although the presentation of most tendon injuries will be clinically obvious, there will always be the unusual presentation. Because of this, conventional radiography is a good first line investigation since it is widely available, cheap, quick, and well understood by many. It can help to exclude significant other pathology such as a bone tumor presenting as a tendon injury, or show the soft tissue calcification of a variety of other conditions. In the immature skeleton, an apophyseal avulsion will occur rather than a tendon rupture, and conventional radiography will exclude this [1]. It may show direct or indirect signs of tendon pathology and is complimentary to other imaging techniques.

When looking for tendon pathology, it is important to adjust the conventional radiographic technique to enhance soft tissue and radiographic contrast. Patient positioning is important to reduce the amount of non-essential overlying tissue, which would decrease tissue contrast. Radiographic contrast can be enhanced by the use of a low kV. Fine focal spot size and fine grain single emulsion film will enhance detail. Exposure to ionizing radiation is always an issue, and low kV techniques increase the absorbed dose. However, most tendons imaged are in the periphery and through relatively thin areas of the body, where reduced exposures are used and the tissues are less sensitive to radiation. An experienced radiographer will produce reproducible high quality studies with the need for fewer repeat films.

There are essentially only four densities visible on radiographs: air, fat, soft tissue, and calcium. Visualization of a structure therefore depends on the contrast between these. For instance, calcification can be seen in soft tissue. A tendon that is normally clearly seen due to adjacent fat may no longer be visible if the fat becomes edematous and takes on the density of soft tissue. This can be a secondary sign of other pathologies such as scaphoid fracture with the loss of the fat plane between this and abductor pollicis longus and extensor pollicis brevis tendons [2], or indicate primary tendon pathology (Figure 7-1).

Radiographic signs of tendon pathology may be direct or indirect. Direct indicators would include calcification and thickening of the tendon (Figure 7-2). By obtaining both internal and external rotation views of a site such as the greater tuberosity of the humerus, the location of calcific deposits can be accurately assessed.

An indirect indicator of tendon pathology in a location such as the shoulder would be the reduction in the acromiohumeral distance to less than 6 mm. This is a good indication of a long-standing full thickness supraspinatus tendon tear, and, in some clinical settings, this will obviate the need for further imaging. Other indirect signs of tendon pathology would include the bony changes seen at tendon insertions, such as the bony pitting at the greater tuberosity suggesting long standing rotator cuff degenerative pathology. Radiography may show bony changes adjacent to tenosynovitis, such as periosteal new bone or cortical irregularity of the radial styloid in de Quervain's tenosynovitis [3]. Sometimes the presence of

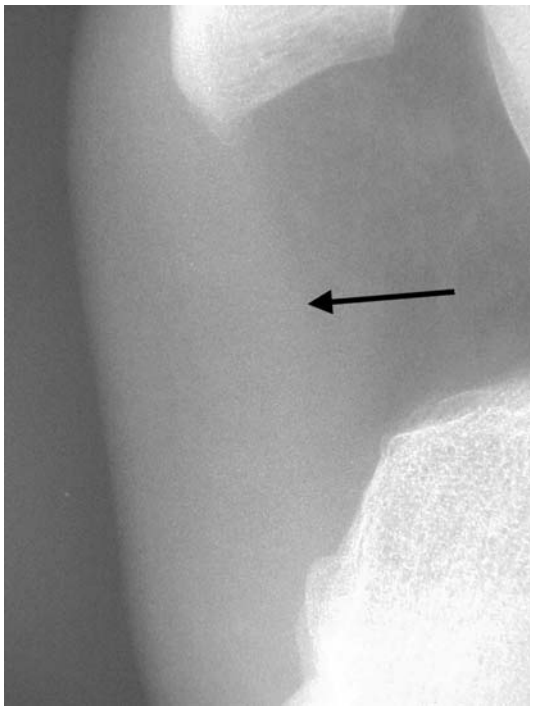

Figure 7-1. Lateral X-ray of the patella tendon. Loss of definition of the fat planes about the tendon due to paratendinosis (arrow).

an accessory ossicle can be an indicator of tendon problems, such as an accessory navicular and insertional tears or peritendinitis of the posterior tibial tendon [4].

Contrast Techniques: Tenography, Conventional Arthrography, and Bursography

The injection of water soluble contrast agents into tendon sheaths, joints and bursae is a relatively quick and safe way to outline these spaces and adjacent structures (Figure 7-3). Ironically, this is often easier under ultrasound control. These structures can then be imaged either statically with conventional radiography, or dynamically with fluoroscopy. Alternatively, the addition of dilute gadolinium can make an MRI-specific contrast agent, which can be very useful to assess structures such as the rotator cuff when injected into the glenohumeral joint (Figure 7-4). Distinction of this fluid from subdeltoid bursal inflammatory fluid that does not contain gadolinium makes it possible to confirm full thickness tears of the rotator cuff and accurately outline their margins. These injection techniques can be combined with therapeutic corticosteroid injections for inflammatory conditions, being particularly appropriate about the ankle [5]. The role of these techniques in isolation has been surpassed by MRI and US when available.

Computed Tomography

Despite huge advances in CT technology in recent years, principally due to computing power, its role in the imaging of tendons is very limited. Even reports 10–12 yeas ago already showed ultrasound to more accurately assess pathology [6,7]. US and MRI have better soft tissue contrast without ionizing radiation, and are preferable. CT may have a role in detecting small areas of calcification deep in soft tissues, such as along the linea aspera at gluteus maximus insertion or in the longus colli muscles and tendon in the cervical spine.

Nuclear Medicine

By the injection of the bone seeking, gamma ray emitting, radiopharmaceutical agent Tc-99 methylene diphosphonate, it is possible to study the entire skeleton with either planar or cross sectional (SPECT) imaging. Resolution is low, but the bone uptake reflects function. Areas of increased bony uptake may be seen adjacent to tendon

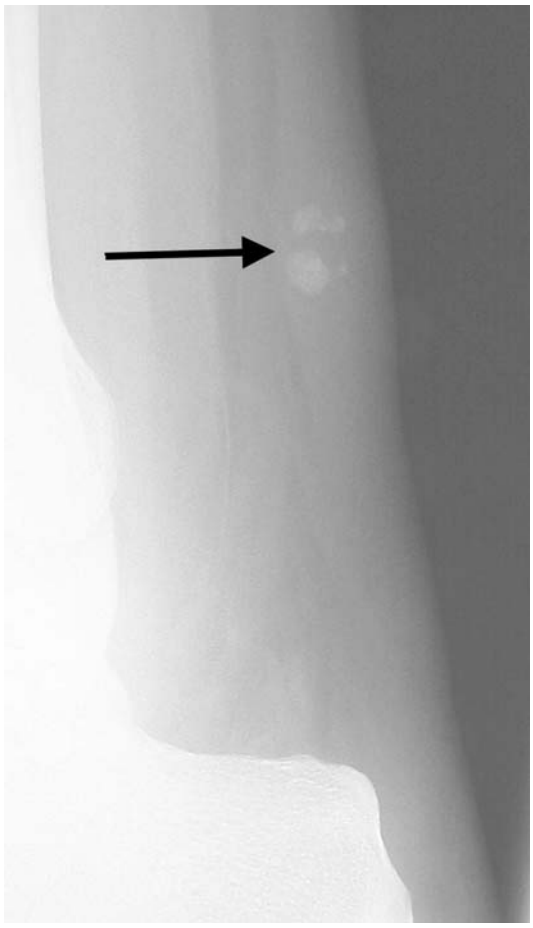

Figure 7-2. Lateral X-ray of the Achilles tendon showing the thickening of chronic tendinopathy and dystrophic calcification (arrow).

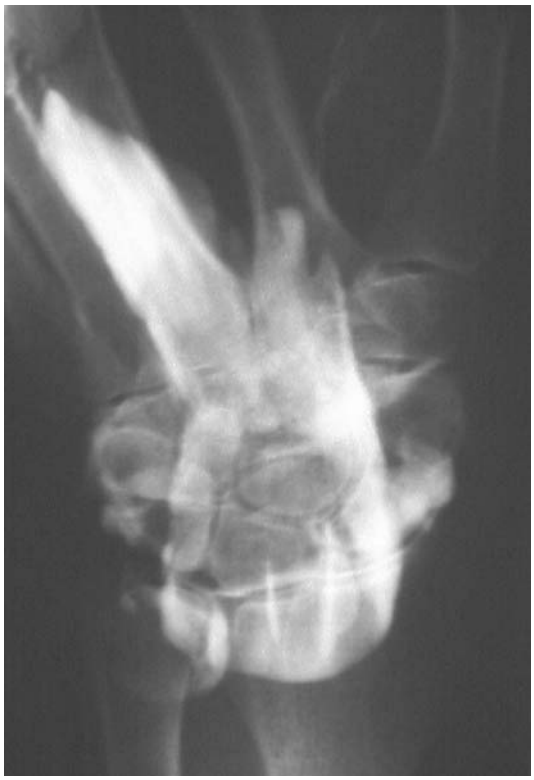

FIGURE 7-3. Iodinated contrast injection outlining the tendons in the common flexor sheath of the hand.

pathology such as the apophyseal insertions. It is also possible to see increased uptake in tendon calcific deposits (Figure 7-5), but, since these can also be seen with non-ionizing techniques, it is not justified.

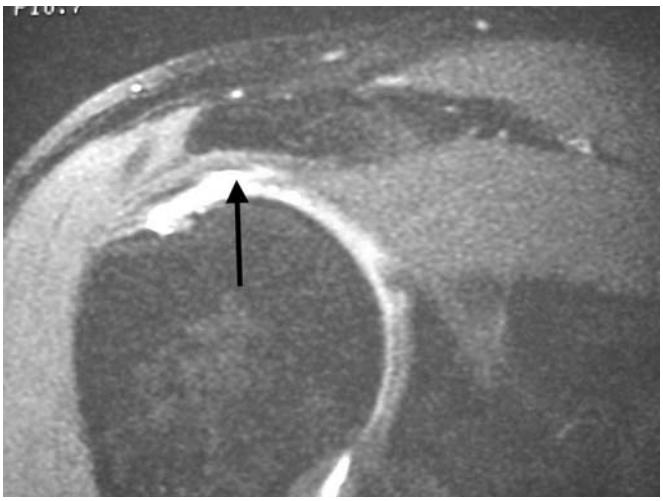

FIGURE 7-4. Coronal T1 fat saturated image of the right shoulder following intraarticular injection of dilute gadolinium. Undersurface partial thickness supraspinatus tendon tear (arrow).

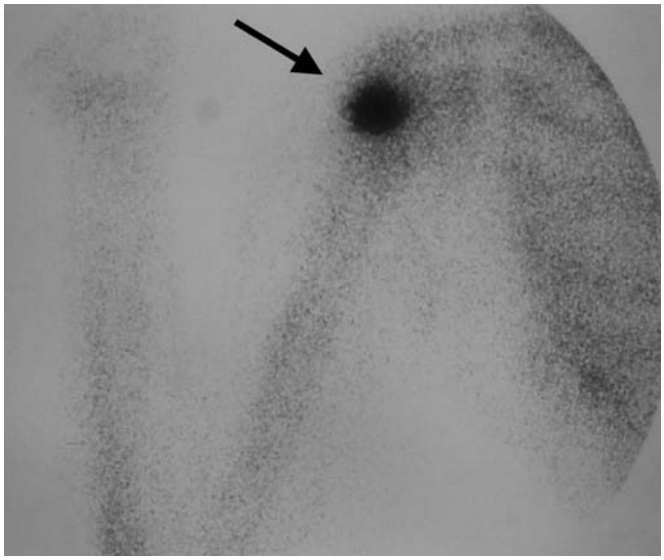

FIGURE 7-5. Methylene diphosphonate delayed phase bone scintigraphy of the right shoulder, showing abnormal uptake due to calcific tendonitis (arrow).

Ultrasound

Ultrasound imaging of tendons has recently become a first line investigation as it is widely available, relatively inexpensive, easy to use, and gives high lesion detection. There have been tremendous advances in ultrasound technology, making many of the older machines and probes inadequate for the imaging of tendons. Recent advances include higher frequency (10 to 15 MHz) broad bandwidth probes, with better near field beam focusing and gray scale processing, giving very high resolution near field imaging. (Ultrasound has better than twice the resolution of MRI [8] in the axial plane.) Doppler shift color imaging and, more recently, power Doppler imaging to detect flow have become essential adjuncts to gray scale imaging in the assessment of vascularity. This is particularly important when assessing inflammation and tumors. More recently, harmonic imaging and contrast agents have been introduced, to produce higher resolution in deeper structures, and increased detection of flow. Compound (Sono CT) (Figure 7-6) imaging has recently been introduced, and, although not essential to reduce artifact of curved anisotropic structures (see below), it makes the process far easier, and likely reduces false positive results. 3D imaging is also now available, but of limited use in tendon imaging. Also, very recently introduced is panoramic imaging, which uses very powerful computing techniques, to seamlessly combine images and produce panoramic views of structures which extend beyond the normal field of view (Figure 7-7). This is very useful for showing the relationship of one structure to another, such as a musculotendinous junction tear of the Achilles to the calcaneus. US does have the advantage of

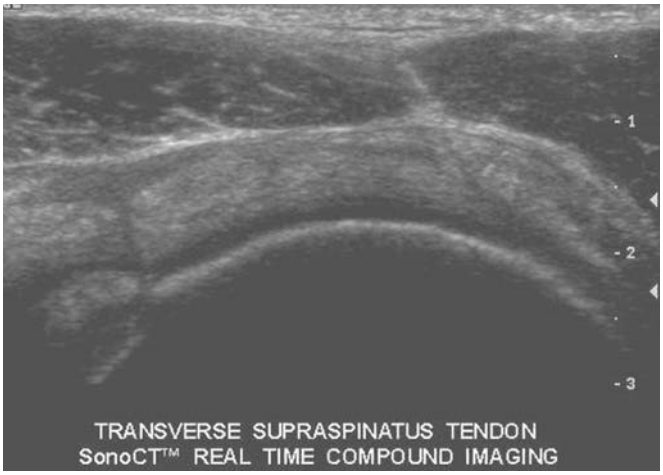

FIGURE 7-6. Transverse compound ultrasound of normal supraspinatus. Anterior is on the left of picture.

rapid comparison with the contralateral corresponding tendon, and of dynamic imaging.

Ultrasound of tendons requires a great deal of experience, and is operator dependent. (Both MRI and US are operator dependent [9].) With experience, there is good interobserver correlation when looking at rotator cuff pathology [10]. One of the key issues of ultrasound is that it is a hands-on procedure with the patient. The area of pain can be interrogated and the relevance of the findings put into clinical perspective. This is particularly important, since US, like all imaging modalities, will find abnormalities that are of no clinical significance.

With regards to lesion detection, there are now numerous studies, which generally show good accuracy for US. Depending on the area of interest, US and MRI usually have similar detection rates for a variety of pathologies. Due to near field resolution, US is often better for superficial structures and MRI better for deeper structures [11].

The appearance of tendons with US is determined by their anatomy. Interfaces that run parallel to the surface (footplate) of the probe (right angles to the line of insonation) produce strong specular echoes. Hence, if a tendon runs parallel to the surface of a linear probe, not only will the epitendineum surrounding the tendon produce a strong bright echo, but so will the internal fibrillar bundles of collagen. As the transducer frequency increases, these internal linear echoes derived from the interfaces of collagen bundles and interleaving loose connective tissue increase in intensity and become thinner, producing a fibrillar pattern. Because of the ordered parallel nature of tendons they are anisotropic (different properties in different directions). Obliquity of the tendon produces areas of reduced echoes. This can occur if the probe used is a curved array rather than linear, or if the tendon is curved, such as the rotator cuff. This also commonly occurs at the bony attachment of a tendon when the fibers curve to enter the bone at an enthesis. This is most apparent at the Achilles and supraspinatus tendon insertions (Figure 7-8). Also occurring normally at these sites is a narrow zone of hyporeflectivity (dark) at the tendon-bone interface. If the tendon is not parallel to the skin, such as the distal insertion of biceps brachii, then a compressible triangular stand off can be useful to help angle the probe for the tendon and maintain contact with the skin. The uniform fibrillar pattern may also be broken when a tendon is derived from two or more muscles, such as the Achilles or quadriceps femoris tendons. This type of normal variant should not be mistaken for a longitudinal tear.

To enable the tendon to move through the surrounding tissues, the tendon either has a synovial sheath containing a thin film of lubricating fluid, or a paratenon composed of loose areolar and adipose connective tissue. A normal synovial sheath is seen at US to be a thin hypoechoic (dark) rim around the tendon, unlike the paratenon, which is an undefined hyperechoic (bright) rim. It is also normal to see an increase in the fluid around tendons that communicate with joints following exercise. Although this could be problematic to differentiate from pathological fluid, clinical and ultrasound correlation with other findings should help.

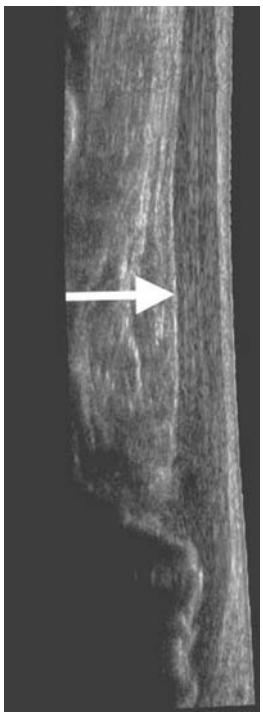

FIGURE 7-7. Sagittal panoramic compound ultrasound of the normal Achilles tendon.

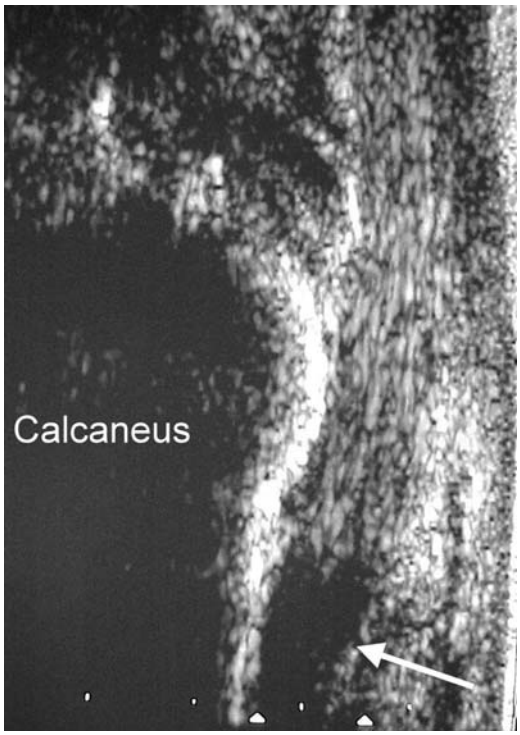

FIGURE 7-8. Non compound sagital ultrasound of Achilles tendon showing anisotropic artifact at the insertion onto the calcaneus (arrow).

The course of the tendon close to a joint is often constrained, by a bony tunnel, a groove, a retinaculum or an annular pulley. The soft tissue constraints may be difficult to see with US due to anisotrophy, but their disruption can be detected by both US and MRI either directly or by tendon displacement [12]. Bursae are often present when a tendon passes over a bony prominence. These can be seen with US and MRI and are usually less than 2 mm thick. As with synovial sheath fluid this can increase following exercise.

Magnetic Resonance Imaging

Some of the recent developments in MRI of tendons involve more dedicated surface coils for the various parts to be imaged, and new sequences to reduce the time, and increase the resolution and contrast. These faster scans reduce the risk of patient movement that would otherwise produce non-diagnostic images, and allow time for additional sequences to improve diagnostic accuracy. The use of fat suppression techniques and MRI-specific contrast agents are now commonly employed. MRI remains an expensive imaging modality.

The one great advantage of MRI over a technique such as US is that it gives a reproducible overview of the area of interest in multiple planes. Other possible non-tendon pathologies are also covered. When combined with Gadolinium arthrography of the shoulder, MRI can give a one step investigation of shoulder pain [13] (Figure 7-4). This is of particular value in the assessment of the long head of biceps anchor and the rotator cuff undersurface.

Some basic principles of the physics of MRI need to be stated. The way the scanner is programmed will determine which characteristics of the tissue are enhanced. A T1 weighted image gives good signal to noise ratio and is good for anatomy. A T2 weighted image has high signal (bright) from fluid, which is the common situation for most pathology. Fat is bright on T1 sequences which is useful to outline structures, and on the newer fast spin echo T2 techniques. This relatively high signal from fat obscures the high signal of pathology. Hence, many of the newer sequences use techniques to suppress the signal from fat.

Generally, normal tendons have a uniform low signal (dark) on both T1 and T2 weighted MRI. An artifact known as the 'magic angle artifact' can occur due to the highly organized longitudinal pattern of tendon [14]. This occurs when the tendon passes through an angle of 55 degrees to the main magnetic field. With T1 imaging the tendon may falsely appear bright. T2 imaging is not affected by this artifact and is used to differentiate the high signal seen on T1 due to magic angle from that seen in pathology (Figure 7-9). Another associated artifact occurs at bony entheses in a similar way to US, where a thin band of higher signal may be observed. In addition to looking for pathology in tendons, MRI can assess function. By a noninvasive method, the degree of myotendinous and tendon stretch can be measured and used as an indirect measurement of force production [15].

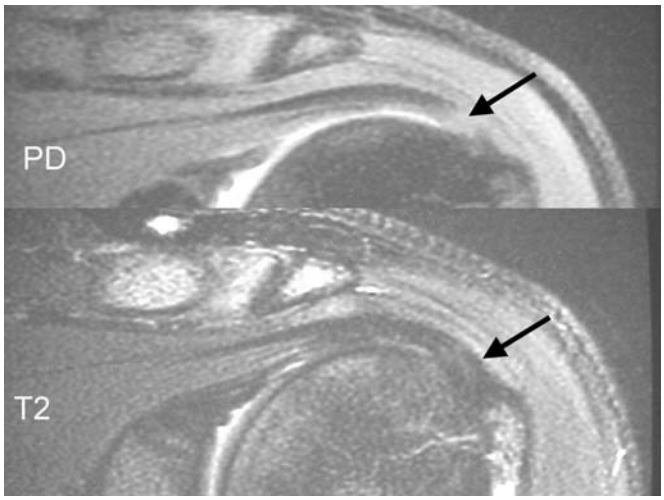

FIGURE 7-9. Coronal proton density (top) and T2 (bottom) MRI of the left shoulder. Magic angle artifact seen on PD is cancelled out on T2 (arrows).

US and MRI of Pathology

The common pathologies of tendons that US is used to image include degeneration and tears, dislocation, inflammatory conditions, and tumors.

Tendon Degeneration

The main difference between degeneration due to aging and chronic overuse degeneration is the presence of pain in the overuse syndrome (tendinopathy), although a small tear may cause pain in an aged degenerative tendon. Tendinopathy may also be due to a direct contusion or recurrent subluxation. The point of injury or the presence of US-detected subluxation are good pointers as to these causes.

Although an otherwise normal tendon may rupture due to a single significant traumatic event (Figure 7-10), many reports now suggest that there is a spectrum of conditions with multiple microtraumas producing degeneration in a tendon that may then progress to rupture with only mild trauma. Indeed, supraspinatus tendon rupture can be asymptomatic with no loss of strength [16]. Ultrasound of contralateral Achilles tendons to those ruptured may show significant thickening, which may indicate that tendinopathy predisposes to tendon rupture [17]. The role of overuse as a precursor to degeneration (tendinosis, tendinopathy) is not well understood. Ultrasound can differentiate the various stages of tendon damage, and may have prognostic significance.

The earliest change of tendinopathy is when the US and MRI show the tendon to be thickened (Figure 7-11). The diameter of ankle tendons does not change with the degree of ankle plantar or dorsi flexion, as shown by MRI [18]. The usually uniform fibrillar pattern may be reduced, more hyporeflective with US and heterogeneous, due to the deposition of glycosaminoglycans in the extracellular matrix, and the breakdown of collagen microfibrils. Internal increased signal on T1 and T2 images with fat suppression is observed (Figure 7-12). The use of contrast medium-enhanced T1 MRI does

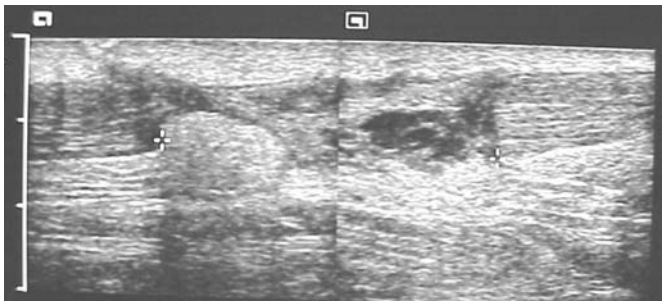

Figure 7-10. Sagital plane ultrasound of the Achilles tendon following a laceration injury with distraction of the tendon ends to the asterisks, in an otherwise normal tendon.

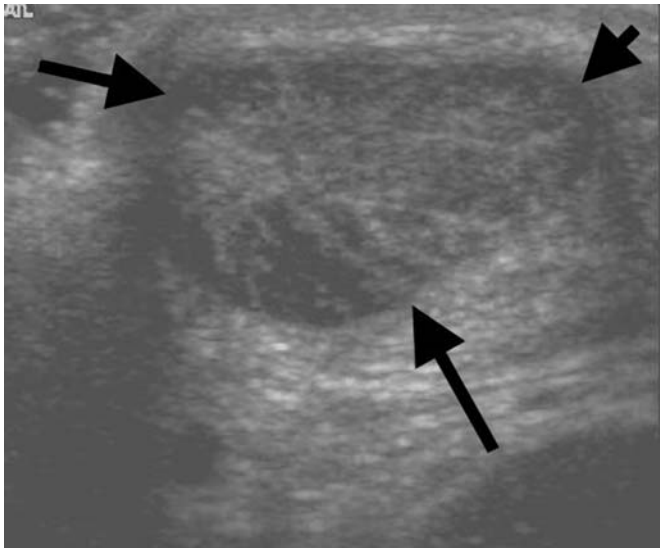

Figure 7-11. Transverse ultrasound of the Achilles tendon showing the marked thickening of tendinopathy (inside arrows).

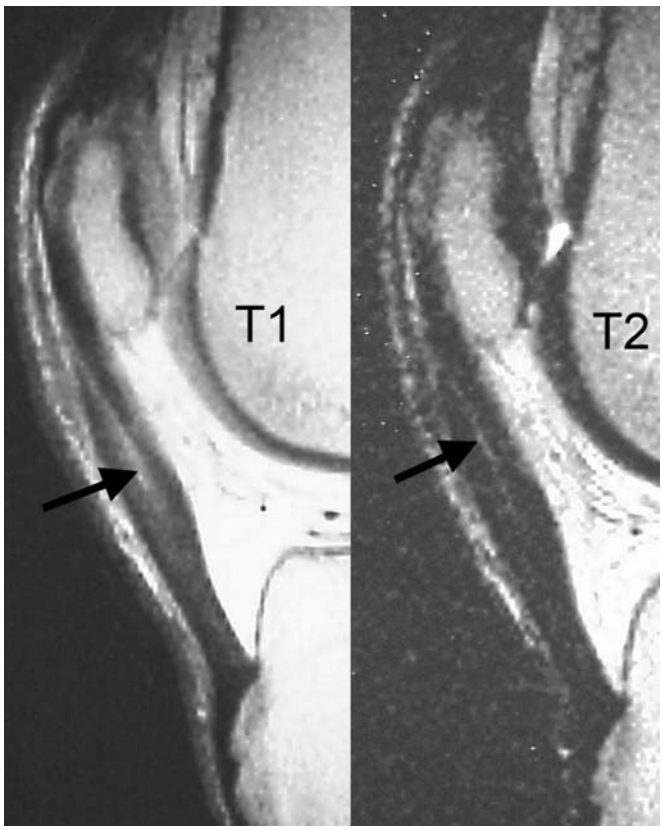

Figure 7-12. Sagital plane T1 (left) and T2 (right) MRI of the patella tendon. High signal in the proximal tendon represents myxoid change of chronic tendinopathy (arrows).

show abnormality in regions of the Achilles tendinopathy beyond that shown by US [19].

As this process continues, small cystic collections develop in the tendon. These are visible as focal hypoechoic regions, or high signal on T2 within the expanded tendon. Fibrocartilaginous metaplasia can occur in these areas of abnormal tissue, producing areas of calcification visible on both plain radiography and ultrasound scans, but often poorly seen with MRI. The abnormal configuration of the tendon can evoke a bursal effusion adjacent to points of constraint. Possible imaging findings that may suggest overuse tendinopathy rather than aging degeneration are the close correlation of imaging abnormalities and tenderness to US probe pressure. Also, there is increased intratendon and peritenon vascularity, which can be observed with color Doppler imaging but is better depicted by power Doppler imaging (Figure 7-13).

Other extratendinous changes, such as an accompanying thickening of the retinaculum, also point to a tendinopathy. The cause of pain with overuse tendinopathy may well come from the peritendinous inflammation since tendons do not possess nociceptive nerve fibers, but only stretch receptors. With overuse tendinopathy, mild bone marrow edema can be observed at the apophyses and in the peritendinous tissues on T2 fat suppressed images. MRI is accurate in the detection of overuse tendinopathy of the Achilles and the associated peritendinous changes that may occur [20].

MRI imaging of Haglunds syndrome not only shows the insertional tendinopathy, and both the retrocalcaneal and retro-Achilles bursitis, but also calcaneal tuberosity edema [21]. However, one group has suggested that both MRI and US do not offer sufficient diagnostic accuracy, when compared with clinical examination in the assessment of chronic injuries of the Achilles tendon [22]. Others have shown good correlation between both US and MRI with histologic changes in the proximal patella tendon of jumper's knee [23] and of Achilles tendinopathy [24,20]. With continuing breakdown of the collagen microfibrils, small tears occur and these can progress to complete rupture.

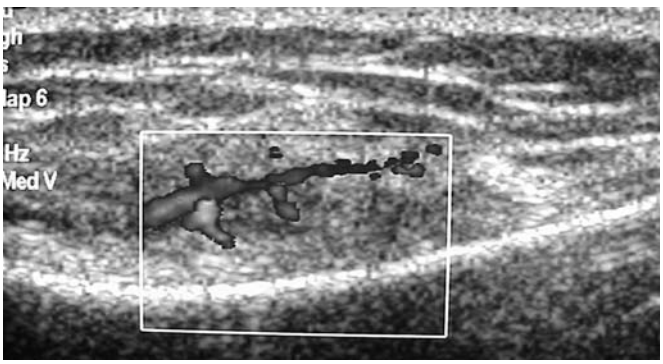

FIGURE 7-13. Coronal plane colour Doppler ultrasound of the pes anserinus tendon insertion. The increased colour flow in and around the tendon indicates a paratendinitis.

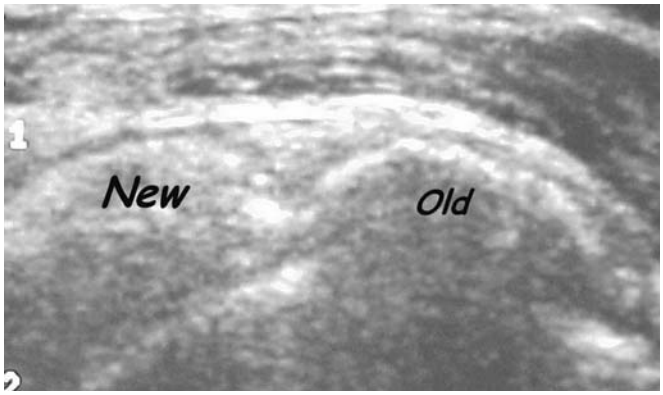

FIGURE 7-14. Transverse ultrasound of the supraspinatus tendon showing the different morphology of calcific tendinitis. The old calcium has a strong superficial spectral echo and deep shadow and is unlikely to drain via needle aspiration.

Crystal deposition disorders are another common association of chronic tendinopathy. In the acute stage of deposition, the crystals may be an amorphous hyperechoic mass without acoustic shadowing. This has fluid consistency and may deform, which suggests needle aspiration is likely to be successful, and could also be directly guided by the US [25]. When chronic, the mass has a strong punctate appearance and superficial spectral echo with deep shadowing, and is unlikely to drain via a needle (Figure 7-14). Crystal deposition can have high signal in the acute phase within the tendon on T2 images. MRI imaging of calcific tendinopathy of the hip shows associated inflammatory change and enhancement of the tendon and edema of the adjacent bone [26]. In the chronic stage, the signal is similar to normal tendon and the crystals can be difficult to see.

Another form of tendinopathy is xanthomatous deposition in states of hypercholesterolemia, particularly the familial forms. In this situation there is tendon heterogeneity, with multiple hypoechoic nodules in a thickened tendon. It is also usually bilateral. Xanthomatous deposits have high signal on T1 due to their fatty (cholesterol) nature.

Tendon Rupture

Nearly all tendon ruptures, either partial or full thickness, may be predisposed to by some form of tendinopathy mentioned above (Figure 15). Partial tears may be either longitudinal or transverse. The cardinal feature of partial or complete tendon rupture is the discontinuity of fibers (Figure 7-16). If retraction of fibers occurs, there will either be absence of the tendon or a contour defect of the surface. Because a variety of substances (fluid, fresh

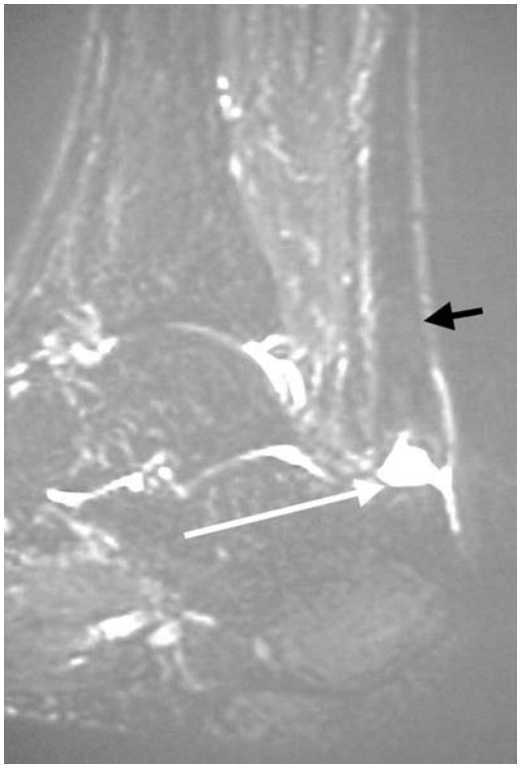

FIGURE 7-15. Sagital fat suppressed (STIR) image of the achilles tendon. The tendon is thickened (black arrow) compatible with chronic tendinopathy, and has an acute distal rupture (white arrow).

blood, organizing hematoma, granulation tissue or pseudotumor) can fill the tendon defects, the imaging appearances are variable. When long standing, the tears may calcify or ossify. It is therefore necessary to rely on the discontinuity of the fibers (excluding artifact as the cause) to make a diagnosis of tear. Tendon ruptures are seen with MRI as discontinuity of the normal tendon low signal, which is replaced by high signal on T2 weighted images (Figure 7-17). An acutely torn tendon is often associated with retraction and a hematoma collecting at the musculotendinous junction, which appears as a heterogeneous hypoechoic mass. MRI and US both have good accuracy for the detection of full thickness rotator cuff tears [27], but are less accurate in the detection of partial thickness tears [9,28]. A prospective study of US and MRI for tendon abnormalities about the ankle showed US to be much more accurate than MRI in the detection of intrasubstance and complete tendon tears [29]. Dynamic ultrasound and MRI show similar accuracy in the detection of longitudinal posterior tibial tendon surgically induced tears in cadavers [29,8]. MRI is also very good for the assessment of distal biceps tendon tears [30]. In addition, with chronic tendon tears MRI can detect the associated atrophy of the muscle with fatty infiltration, which takes on an appearance of marbling, and measure supraspinatus tendon retraction, which extends beneath the acromium (Figure 7-18).

These are two factors that determine surgical management. Ultrasound is not as good as MRI at assessing

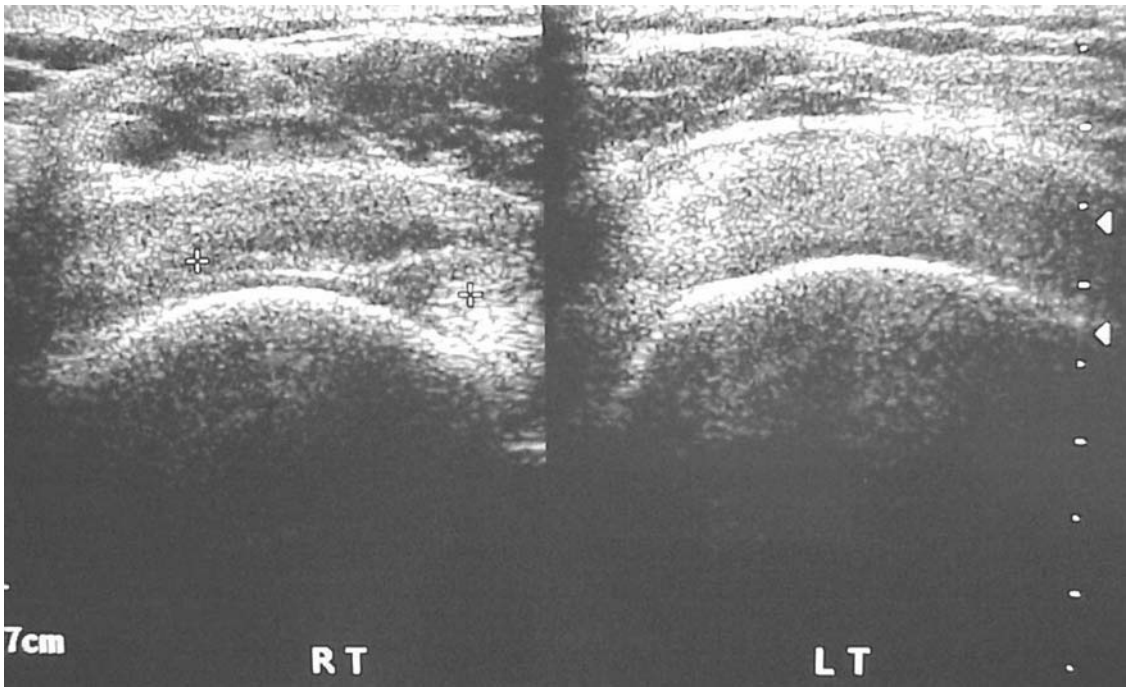

FIGURE 7-16. Transverse ultrasound of the supraspinatus tendon of both shoulders. The left is normal. The right has a full thickness tear between the astericks.

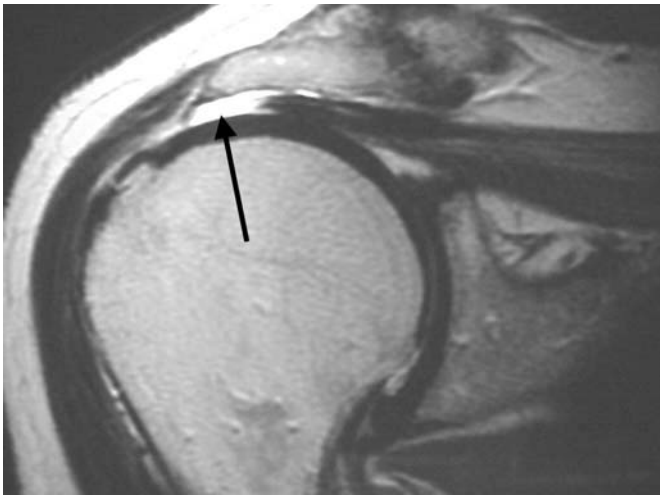

FIGURE 7-17. Coronal T2 MRI of the right shoulder. There is a full thickness tear of the supraspinatus tendon with fluid in the gap (arrow).

muscle changes secondary to chronically torn tendons, particularly muscles that pass deeply away from the probe such as subscapularis. MRI is likely superior to US in the assessment of postoperative repairs of the Achilles and may be prognostic for re-rupture [31]. MRI has limited ability to differentiate focal myxoid degeneration from partial tears of tendons, and US is superior in this matter [10].

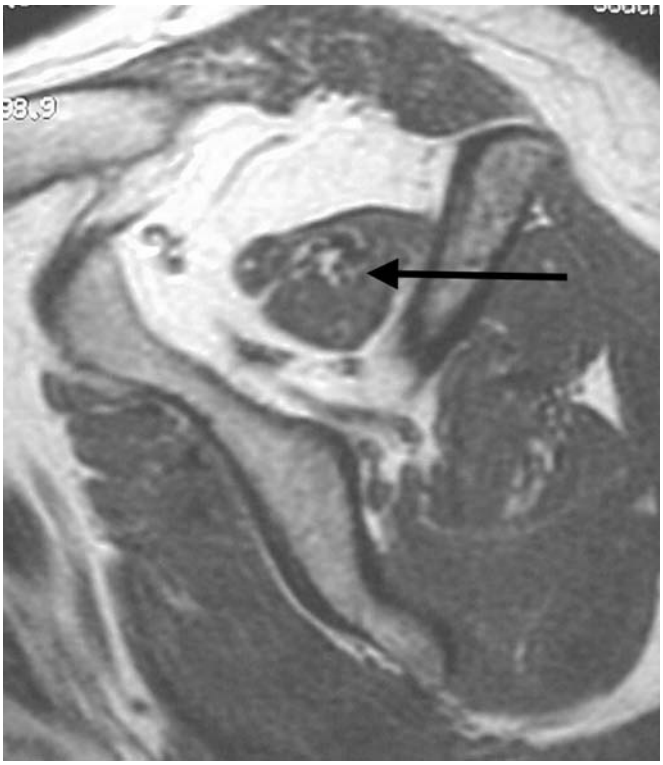

FIGURE 7-18. Sagital T1 MRI of the supraspinatus tendon. The muscle is atrophied and mildly marbled (arrow).

Tendon Dislocation

Dislocation of tendons occurs in tendons with a synovial sheath when there is disruption of the constraints. It is most commonly seen with the peroneal tendons, the long head of biceps brachii, and the flexor tendons of the hand. Disruption of the insertion of subscapularis can allow the long head of biceps brachii to dislocate medially from its groove (Figure 7-19), most commonly deep to subscapularis, but occasionally superficial. Either of these situations is well seen with US and MRI as an empty bicipital groove and displaced tendon. A pseudotendon due to granulation tissue within the groove can be misleading. Since US is a dynamic investigation it is also possible to observe biceps tendon subluxation with external rotation of the arm, which relocates on internal rotation. Dynamic US is also useful for peroneal tendon dislocation following rupture of the superior peroneal retinaculum. This is enhanced by dorsiflexion and foot eversion. As mentioned above a chronically subluxing tendon will show secondary degenerative change. Dynamic scanning with active finger flexion enhances subluxation of finger flexor tendons. All of these dislocations will have accompanying increase in surrounding fluid, either within the sheath, the bursa, or surrounding soft tissues. Tendon dislocation can easily be seen by MRI if the tendon is dislocated at the time of imaging. However, some tendon dislocations are joint position dependent and therefore the only signs may be interruption of pulleys or retinacula, or abnormal signal in the tendon.

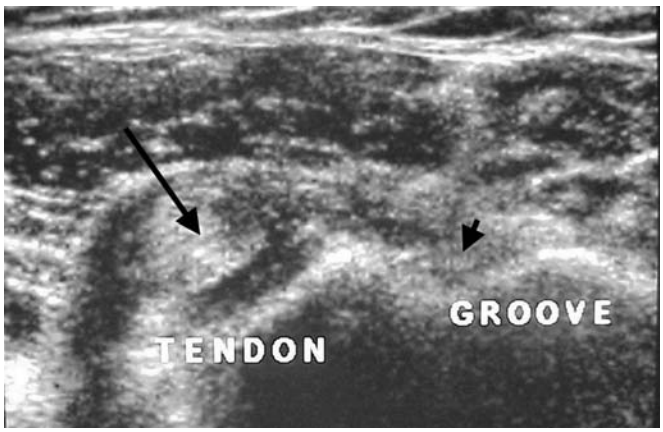

FIGURE 7-19. Transverse ultrasound of the left bicipital groove. The groove is empty (short arrow) and the tendon dislocated medially (long arrow).

Inflammation

The causes of inflammation of tendons include acute overuse syndrome, infection, and the inflammatory arthritides, most notably rheumatoid arthritis. The imaging appearances vary according to whether or not there is a synovial sheath. Usually there is thickening of the tendon that on US can be heterogeneous and hypoechoic.

When there is a synovial sheath, the hallmark finding on both US and MRI is fluid in the tendon's sheath and possibly thickening of the synovium, especially in tuberculous infection. On MRI, the thickened synovium is bright on T2 sequences and enhances post gadolinium on T1 sequences. The fluid varies from anechoic to hyperechoic when purulent. When the fluid appears complex, it is most likely due to pus or to the rice bodies of rheumatoid arthritis. When infectious, the adjacent tissues may show cellulitis and edema on both US and MRI. This is not pathognomonic, and aspiration will be required if infection is suspected. The hyperemia of inflammation can be seen, with both US and MRI, within the tendon, the mesotendon and synovium. Villous projections can be seen extending into the fluid from hypertrophic tenosynovitis such as rheumatoid arthritis and tendon rupture can be associated. US and MRI have good specificity but poor sensitivity for partial thickness finger extensor tendon tears in rheumatoid arthritis [33]. Doppler US will not only show the hyperemia, but can help distinguish hypoechoic hyperemic pannus from hypoechoic fluid, which can be useful to assess disease progression and response to therapy. MRI is useful to assess disease activity in rheumatoid arthritis [34]. Dedicated MRI sequences including MRA and post gadolinium T1 fat saturated images are exquisitely sensitive for early rheumatoid hyperemia (Figure 7-20).

When there is a paratenon rather than a synovial sheath, the peritendinous regions may become irregular and thickened with hyperemia. This is seen on MRI as poorly marginated high signal on T2 weighted images and on US as an irregular compressible fluid filled space. Adhesions of the tendon may also occur. Flow may be seen within the tendon, more so than those with sheaths. A stenosing tenosynovitis such as de Quervain's or trigger finger may occur at sites of tendon constraint. The thickened tendon can be observed with dynamic US passing through the thickened synovium at the points of entrapment

Tendon Tumors

The tumors and tumor-like conditions that can affect the tendon sheath complex include ganglion cysts, giant cell tumor of tendon sheath, fibroma of tendon sheath [35] and synovial sarcoma. They arise from the sheath.

Ganglion cysts are common peritendinous cystic lesions filled with mucoid material. They are common on the dorsum of the hand and foot. On ultrasound, they are hypoechoic or anechoic with through transmission of sound producing posterior acoustic enhancement (Figure 7-21). There should be no internal blood flow in contradistinction to a tumor and therefore Doppler should

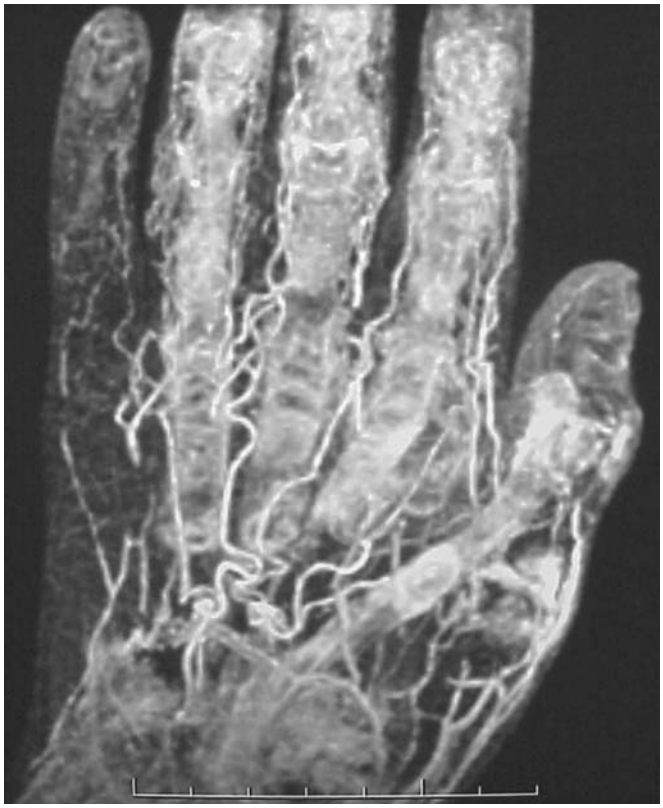

FIGURE 7-20. Late phase coronal maximum intensity projection of intravenous MR angiography. There is a generalised enhancement of the inflammed tendon sheaths. (Courtesy of David Connell, Melbourne, Australia.)

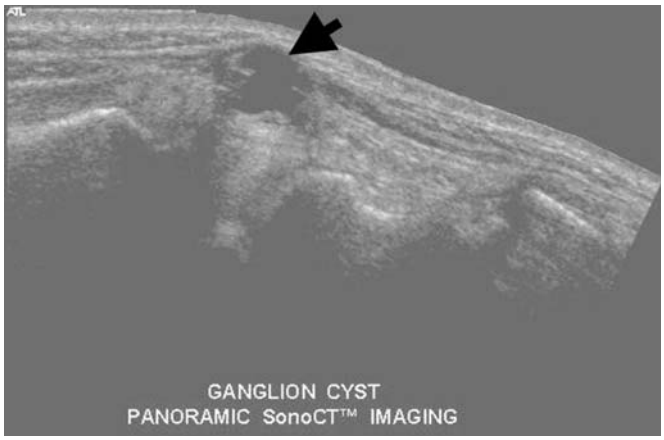

FIGURE 7-21. Panoramic sagital compound ultrasound of the wrist showing a ganglion cyst (arrow).

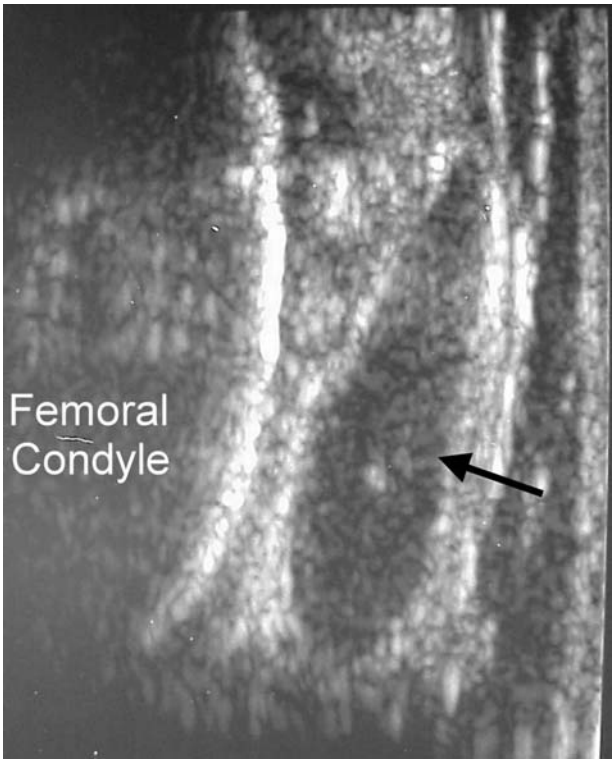

FIGURE 7-22. Coronal plane ultrasound of the lateral femoral condyle. The arrowed structure has deep acoustic enhancement suggesting a ganglion cyst, but internal echoes suggest a solid structure. Colour Doppler showed internal blood flow in this synovial sarcoma.

always be used, especially if there are any internal echoes (Figure 7-22). US and MRI are both good in the detection of dorsal carpal ganglia, but US is more cost-effective [36]. Those at the hip and knee are usually visible with US, but often stand out more clearly on T2 MRI as focal hyperintensities (bright).

Giant cell tumor of tendon sheath is a form of pigmented villonodular tenosynovitis (PVNS). These are more common on the volar aspect of the hand. US shows the mass to be hypoechoic with internal echoes but no posterior acoustic enhancement. They are well defined, close to a tendon and may show internal Doppler signal. They may have a characteristic appearance with MRI if hemosiderin is present and strongly enhance in a heterogeneous way [37,38]. They have a high local recurrence rate (not as high as PVNS of joints) and US can be used to detect early recurrence. MRI with contrast enhancement is relatively specific in the diagnosis of PVNS of joints, but less so with GCT of tendon sheath [38].

Fibroma [34] and synovial sarcoma of tendon sheath are rare. Like many other tumors, they appear as hypoechoic masses on US without posterior acoustic enhancement and with internal Doppler blood flow. On MRI they are of intermediate signal on T1, bright on T2 and when small show homogeneous T1 enhancement following intravenous gadolinium contrast agent, or more heterogeneous enhancement if larger due to central necrosis.

Conclusion

The exact roles of US and MRI in tendon imaging are still evolving [39,40]. A major factor is local availability and expertise. Europe [28] and Australasia [11] tend to employ US as a first line study, and North America tends to employ MRI [41]. The rebate for the study may be another factor. Conventional radiographs are a useful adjunct to both US and MRI. Both US and MRI show similar accuracy for most pathologies. Cost is a significant factor, and indicates that US should be the first line investigation for most tendon imaging. MRI has a role in equivocal cases.

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Part II
Anatomical Sites and Presentation