Musculoskeletal Sonography: Important Imaging Pitfalls

OBJECTIVE. The purpose of this article is to describe the pitfalls that may be encountered when performing musculoskeletal sonography.

CONCLUSION. Sonography of the musculoskeletal system is a useful diagnostic technique, but awareness and understanding of the pitfalls will minimize errors in diagnosis.

Learning musculoskeletal sonography can be challenging. The sonographic properties of soft tissues, tendons, and ligaments result in pitfalls that have to be recognized. Pitfalls may occur for a variety of reasons. The sonographic properties of different tissues may be similar, as may be found in the shoulder. Anatomy may be nonintuitive, as in the elbow and hip, and anisotropy [1, 2] may result in misleading appearances. Anisotropy is the sonographic property of linearly organized tissues, such as tendon and ligaments (and to a lesser extent nerves) in which sonographic appearance is determined in part by the angle of insonation of the ultrasound beam [3] (Fig. 1). We present important pitfalls that we have encountered over the past decade of our practice.

General Considerations

Before starting the sonography examination, a short focused patient history is elicited and the area of concern is examined. A protocol-driven comprehensive sonography examination is required when imaging the shoulder and is advocated with other joints as well to identify causes of referred pain, develop an efficient examination, understand normal structures, and allow identification of subtle pathology; however, the patient is asked to indicate a point of most discomfort because this will often identify the site of the abnormality [4]. The patient is placed in a comfortable position that facilitates an easy examination as well as allowing dynamic maneuvers. A high-frequency linear transducer (10–12 MHz) is typically used, although in the hands and feet, higher-frequency transducers (15–17 MHz) provide exquisite anatomic detail, and occasionally in obese patients, particularly when examining the hip, a lower-frequency transducer (5–9 MHz) may be necessary.

Shoulder

Lying between the supraspinatus and the acromion and deltoid muscles is the subacromial–subdeltoid bursa, which extends beyond the distal insertion of the supraspinatus tendon [5] (Fig. 2). Sometimes it is difficult to differentiate tendon from bursa lying on its superficial surface because the echogenicity and contour may be similar. Overestimation of the thickness of the tendon as well as misinterpretation of the echogenicity of the tendon may result (Figs. 3 and 4). By identifying the bursa that passes beyond the supraspinatus insertion on the greater tuberosity and extrapolating proximally on a long-axis image of the supraspinatus tendon, one can get a reasonable idea of what constitutes bursa and what is the actual supraspinatus tendon.

The long head of the biceps brachii tendon is found in the bicipital groove of the proximal humerus. When the tendon of the long head of the biceps is dislocated or torn, there can be linear echoes in the bicipital groove that may simulate intact tendon fibers, although much thinner compared with the normal biceps tendon [6, 7] (Fig. 5). Careful evaluation medial to the proximal humerus for a dislocated tendon is necessary to exclude a dislocated biceps tendon. A long-standing tear of the long head of the biceps brachii tendon may result...
Pitfalls in Musculoskeletal Sonography

Hip and Thigh

The rectus femoris muscle originates proximally from two tendons: a direct (straight) head from the anterior inferior iliac spine that courses approximately parallel to the overlying skin and an indirect (reflected) head that originates from the lateral acetabulum and courses at an angle to the overlying skin. This orientation of the tendons results in the straight head being easily identified by its echogenic parallel linear appearance, whereas the indirect head usually shows marked anisotropy (Fig. 16), which may be misinterpreted as acoustic shadowing from calcification [9] or ossification or the shadowing caused by refraction of sound at the edge of a tendon tear. By scanning more laterally and obliquely angling the transducer, the reflected head may be identified (Fig. 17).

At the anterior recess of the hip, the anterior joint capsule reflects back superiorly along the femoral neck. In the absence of an effusion, the two layers of the capsule lying on each other may give the impression of complex fluid or synovitis in the hip joint (Fig. 18). Joint fluid may be identified separating these two layers (Fig. 19). It has been shown that a measurement of the thickness of the tissue adjacent to the anterior femoral neck should measure more than 7 mm. Asymmetry of this measurement of more than 1 mm between both sides suggests the diagnosis of fluid in the hip joint [10].

The sciatic nerve is proximate to the hamstring insertion at the hip. Knowledge of theatomic relationship of the sciatic nerve to the hamstring tendon is necessary to avoid confusing these linear fibrillar structures [11] (Fig. 20A). More proximally, the structures are even closer (Fig. 20B), emphasizing that care should be taken with needle placement at the hamstring origin when a medial approach is prudent.

Knee

The semimembranosus tendon curves anteriorly to attach to the posterior tibia where anisotropy may make it hypoechoic, simulating a Baker cyst (Fig. 21A). By angling the ultrasound beam along the long axis of the semimembranosus tendon, anisotropy [12] can be visualized confirming that this hypoechoic structure is a tendon (Fig. 21B).

When examining the lateral knee in a supine patient, the knee may be slightly flexed and in valgus so that the fibular collateral ligament may have a wavy contour (Fig. 22). This is a normal appearance and does not indicate a tear or laxity of the ligament.

Foot and Ankle

The insertion of the tibialis posterior tendon is complex, fanning out and inserting directly onto the navicular and also possibly an accessory ossicle. The tendon also sends a slip (deeper lateral division) to insert more distally at the middle cuneiform and the bases of the second, third, and fourth metatarsals. This complicated insertion (distal 1.5–2.0 cm) results in the tendon appearing thicker than it does along its more proximal length, and the different orientation of its fibers often shows anisotropy [13] (Figs. 23 and 24), which should not be misinterpreted as tendinosis or tear.

Conclusion

There are many pitfalls in musculoskeletal sonography due to misinterpretation of normal anatomic structures as well as misinterpretation of pathologic conditions. Knowledge of such pitfalls will improve accuracy in the sonographic diagnosis of musculoskeletal disorders.

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References


Fig. 1—Sonography in 54-year-old woman with normal long head of biceps tendon (arrow) showing anisotropy. GT = greater tuberosity, LT = lesser tuberosity, Del = deltoid muscle, Sub = subscapularis muscle. 
A, In sonogram obtained with tendon fibers at right angles to beam, tendon appears echoic. 
B, In sonogram obtained with tendon fibers at angle to beam, tendon appears hypoechoic.

Fig. 2—63-year-old woman with shoulder pain and bursal thickening. Sonogram in long axis of supraspinatus tendon (SST) shows subacromial—subdeltoid bursal thickening (all arrowheads) extending beyond insertion of supraspinatus tendon on greater tuberosity (GT) of humerus. Bursa is easily differentiated from supraspinatus tendon. Note outer layer of supraspinatus tendon (black arrowheads) is echogenic but less so than peribursal fat layer (white arrowheads). Bursa lies between these two echogenic interfaces. D = deltoid muscle.

Fig. 3—43-year-old man with right shoulder pain and bursal thickening. Sonogram in long axis of supraspinatus tendon (SST) shows bursal thickening (all arrowheads) extending beyond insertion of supraspinatus tendon on greater tuberosity (GT) of humerus. Bursa in this patient is not as easily differentiated from supraspinatus tendon. Note visualized outer layer of supraspinatus tendon (white arrowheads) is echogenic but less so than peribursal fat layer (black arrowhead). D = deltoid muscle.

Fig. 4—39-year-old woman with right shoulder injury, pain, and bursal thickening. Sonogram in long axis of supraspinatus tendon (SST) shows bursal thickening (arrowheads) extending beyond insertion of supraspinatus tendon on greater tuberosity (GT) of humerus. Bursa and peribursal fat in this patient are difficult to differentiate from supraspinatus tendon because echogenic interface between supraspinatus tendon and bursa is not appreciated. D = deltoid muscle.
Fig. 5—73-year-old man with right shoulder injury and dislocated biceps tendon. 
A, Long-axis sonogram through bicipital groove shows linear echoes (arrows) not consistent with tendon fibers. Hum = humeral diaphysis. 
B, Short-axis sonogram through bicipital groove (curved arrow) shows echoes (straight arrows) not consistent with normal tendon. Long head of biceps brachii tendon (arrowhead) lies over lesser tuberosity (LT). 
C, Long-axis sonogram through dislocated biceps tendon (arrows) shows normal tightly packed linear appearance lying over lesser tuberosity proximally.

Fig. 6—85-year-old woman with right shoulder pain after fall, with long-standing complete tear of long head of biceps brachii tendon. 
A, Long-axis sonogram through bicipital groove shows linear echoes (arrows) but no visualization of normal biceps tendon. Hum = humeral diaphysis. 
B, Axial sonogram through biceps muscle shows echogenicity of long head (LH arrow) secondary to fatty change. Normal-appearing short head of muscle (SH arrow) is seen medially representing normal short head of biceps brachii. Curved arrow indicates humeral diaphysis.
Fig. 7—54-year-old woman with normal supraspinatus tendon. SST = supraspinatus tendon, Delt = deltoid, Gt Tub = greater tuberosity.
A, Inserting supraspinatus tendon fibers curve away from ultrasound beam and appear hypoechoic (arrows), which should not be interpreted as tear.
B, By angling transducer to bring orientation of these fibers at right angles to ultrasound beam, hypoechoic area fills in with normal-appearing tendon (asterisk).

Fig. 8—54-year-old woman with normal long head of biceps tendon showing anisotropy.
A, When long head biceps tendon (arrows) is at right angle to ultrasound beam, normal echogenic fibrillar pattern is seen.
B, When long head biceps tendon (arrows) is oriented at angle to ultrasound beam, echogenic fibrillar pattern is not as well seen or is lost, simulating tear or tendonosis.

Fig. 9—42-year-old man with normal subscapularis tendon imaged in short axis. Multipennate tendon shows echogenic tendon slips (T) with intervening hypoechoic slips of muscle that may simulate cleft or tear. Delt = deltoid muscle, Les Tub = lesser tuberosity of humerus.
Fig. 10—20-year-old woman with medial right forearm subcutaneous nodule. Sonogram in long axis shows normal posterior interosseous nerve before (curved arrow) and after (straight arrow) entering supinator muscle (Sup). Apparent change in caliber is normal because nerve becomes flattened in supinator muscle. Rad = radius, C = capitellum.

Fig. 11—61-year-old man with left medial elbow pain. Sup = supinator muscle.
A. Sonogram along long axis of normal posterior interosseous nerve shows apparent narrowing of nerve as it enters supinator muscle. Curved arrow indicates nerve before entering supinator, and straight arrow indicates nerve after entering supinator.
B. Sonogram along short axis of normal posterior interosseous nerve (curved arrow) before it enters supinator muscle shows rounded appearance. Arrowheads indicate radius.
C. Sonogram along short axis of normal posterior interosseous nerve (arrow) within supinator muscle shows more flattened appearance. Rad = radius.
Fig. 13—51-year-old asymptomatic man with normal sonographic anatomy at wrist. Fl Dig = flexor digitorum superficialis and flexor digitorum profundus tendons, PL = flexor pollicis longus, A = radial artery, Pro Quad = pronator quadratus muscle, Rad = radius, U = ulna, Fl Dig Sup = flexor digitorum superficialis muscle, Fl Dig Prof = flexor digitorum profundus muscle, MN = median nerve.

A. Axial sonogram just proximal to distal volar wrist crease shows median nerve (curved arrow) lying superficial (anterior) to flexor digitorum superficialis and flexor digitorum profundus tendons, lateral to palmaris longus tendon (straight arrow), and medial to flexor carpi radialis (arrowhead) and flexor pollicis longus.

B. Axial sonogram obtained more proximally shows median nerve (curved arrow) lying between flexor digitorum superficialis muscle and flexor digitorum profundus muscle, having moved proximally to deeper anatomic plane. Palmaris longus tendon (straight arrow) and flexor carpi radialis tendon remain in same superficial plane. Flexor carpi radialis tendon has now merged with its muscle (arrowhead).

C. Sonogram along long axis of median nerve shows median nerve passing from superficial at wrist (right of image) to lie between flexor digitorum superficialis and flexor digitorum profundus more proximally.

Fig. 12—78-year-old woman with normal extensor retinaculum. Sonogram through long axis of extensor digitorum tendons (ED) shows extensor retinaculum as hypoechoic structure (arrows). This should not be misinterpreted as fluid collection or tenosynovitis. Rad = distal radius, Carp = carpal bones.

Fig. 14—51-year-old man with normal median nerve and flexor tendons showing effect of anisotropy. T = flexor tendons, Uln = ulna, Rad = radius.

A. Sonogram with ultrasound beam at right angles to median nerve (curved arrow) and long flexor tendons (T) including flexor carpi radialis (arrowhead) shows normal cross-section appearances. Straight arrow indicates radial artery.

B. By angling transducer, flexor tendons (T, arrowhead) show marked anisotropy, becoming hypoechoic. Median nerve (curved arrow) shows much less anisotropy. Straight arrow indicates radial artery.
**Pitfalls in Musculoskeletal Sonography**

**Fig. 15**—Sonogram in 62-year-old woman shows bifid median nerve (N) lying superficial to flexor digitorum tendons. Note small persistent median artery (arrow).

**Fig. 16**—28-year-old man with right inguinal pain with normal rectus femoris origin.

**A.** Axial sonogram just distal to origin of rectus femoris muscle shows echogenic tendon (S) of direct (straight) head lying adjacent to area of intense anisotropy (A) of indirect head of same muscle. Sar = sartorius muscle.

**B.** Sagittal sonogram at origin of rectus femoris muscle shows tendon of direct (straight) head (S) and area of intense anisotropy (A) of indirect head. AIIS = anterior inferior iliac spine.

**Fig. 17**—Sonogram in 18-year-old woman shows normal tendon of reflected head (arrowheads) of rectus femoris muscle (RF). Curved arrow indicates acetabular labrum. Acet = acetabulum, Fem = femoral head.
Fig. 18—28-year-old man with right inguinal pain. Sonogram of normal anterior hip joint shows capsule \( \text{arrowheads} \) over anterior femoral neck \( \text{Fem} \) with trace of fluid \( \text{arrow} \). H = femoral head.

Fig. 19—3-year-old girl with hip joint effusion. Anterior hip joint capsule is composed of two layers. Large arrowheads indicate anterior layer and small arrowheads indicate posterior layer, shown separated from each other by effusion \( \text{Eff} \). A = acetabulum, Fem = femoral neck.

Fig. 20—23-year-old man with normal proximal posterior thigh. Axial images show relationship between sciatic nerve and adjacent structures. F = femur, AM = adductor magnus muscle, BF = biceps femoris muscle, Glut = gluteus maximus muscle.

A, Note similarity in echogenicity between sciatic nerve \( \text{curved arrow} \) and semimembranosus tendon \( \text{straight arrow} \) and conjoint tendon of biceps femoris long head and semitendinosus \( \text{arrowhead} \).

B, More proximally, sciatic nerve \( \text{curved arrow} \) is very close to semimembranosus tendon \( \text{straight arrow} \) and conjoint tendon \( \text{arrowhead} \).

Fig. 21—23-year-old man evaluated to rule out Baker cyst. G = medial head of gastrocnemius muscle, Fem = medial femoral condyle, A = popliteal artery, SM = hypoechoic structure.

A, Sonogram over popliteal fossa reveals hypoechoic structure that may be interpreted as complex fluid-filled Baker cyst lying adjacent to tendon \( \text{arrow} \) of medial head of gastrocnemius muscle.

B, In axial plane, by angling transducer in cranial caudal direction, hypoechoic structure becomes hyperechoic and is shown to be tendon of semimembranosus muscle.
Fig. 22—75-year-old woman with normal fibular collateral ligament. Sonogram along long axis of fibular collateral ligament (straight arrows) shows normal wavy appearance, which should not suggest tear. Ligament merges with tendon of biceps femoris (asterisks) to insert into fibula (out of field of view). Curved arrow indicates popliteus tendon. Fem = femur, Tib = tibia.

Fig. 23—51-year-old man with fifth-toe pain. As normal tibialis posterior tendon approaches its insertion into navicular bone (N), it widens (arrowheads and arrows), with deepest fibers showing anisotropy (arrows). These deeper fibers (arrows) are composed of lateral division of tendon insertion and run at oblique angle to larger and more superficial fibers (arrowheads). This thickening and hypochoic appearance should not be routinely misinterpreted as tendinosis. T = talus.

Fig. 24—Sonogram with extended field of view of normal tibialis posterior tendon in 58-year-old woman shows echogenic linear fibrillar echotexture of tendon (large arrowheads) and effect of mild anisotropy on tendon (curved arrows). Distally, tendon appears hypoechoic from more marked anisotropy of complex insertion of tendon (small arrowheads) into navicular bone (Nav). Tal = talus, Sp = superomedial calcaneonavicular component of spring ligament.