Musculoskeletal Sonography: A Dynamic Tool for Usual and Unusual Disorders

Viviane Khoury[1]
Étienne Cardinal[2]
Nathalie J. Bureau[2]

OBJECTIVE. The purpose of this study is to illustrate a wide variety of musculoskeletal disorders that can be diagnosed with dynamic sonography.

CONCLUSION. Dynamic sonography is a useful tool for the evaluation of a variety of musculoskeletal disorders. Many of these disorders cannot be diagnosed by any other imaging method.

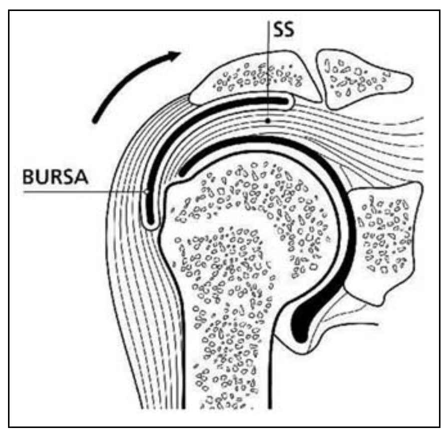
Sonography is a useful technique for the investigation of a number of musculoskeletal disorders. Advances in sonographic technology, including higher resolution probes, power Doppler sonography, extended field-of-view imaging, and compound imaging, have contributed to expand its clinical applications. Sonography has the well-known advantages of low cost, accessibility, portability, noninvasiveness, and multiplanar imaging. But perhaps one of its most important diagnostic advantages over other techniques is its real-time imaging capability, allowing for dynamic evaluation. The real-time imaging feature of sonography is of particular interest because some disorders of muscles, tendons, nerves, and joints are better—or in some cases, only—seen dynamically, that is, during motion of the extremity, muscle contraction, probe compression, or position change of the patient. In this article, we will illustrate a wide variety of musculoskeletal disorders that can be diagnosed with dynamic sonography.

Dynamic Sonography of Tendon Disorders

Shoulder Impingement Syndrome

In shoulder impingement syndrome, pain is generated when the greater tuberosity of the humerus or soft-tissue structures (supraspinatus tendon and subacromial–subdeltoid bursa) encroach on the coracoacromial arch (acromion, coracoacromial ligament, and acromioclavicular joint) in abduction or abduction–flexion internal rotation of the shoulder (Fig. 1A). Dynamic sonography has been shown to be an ideal diagnostic tool to make the diagnosis of shoulder impingement because it can directly show this dynamic process in addition to evaluating the rotator cuff and other abnormalities known to be associated with impingement [1, 2].

For dynamic sonography, the patient is seated on a rotating stool. Two dynamic maneuvers may be used: In the first, the transducer is placed in the oblique coronal plane with its medial margin at the anterolateral edge of the acromion. The shoulder is abducted anterolaterally (flexion and abduction) while in internal rotation (thumb down) (Figs. 1B and S1B). In the second, the transducer is placed in the coronal plane with its medial margin at the lateral edge of the acromion. The shoulder is abducted while in the neutral position; the elbow is flexed for ease (Figs. 1C and S1C).



A

Fig. 1—Shoulder impingement syndrome.
A, Diagram of coronal section through glenohumeral joint shows anatomic relationship of supraspinatus tendon, subacromial–subdeltoid bursa, and acromion. Arrow points to movement of tendon and bursa with shoulder abduction. SS = supraspinatus tendon.
(Fig. 1 continues on next page)

Keywords: dynamic sonography, musculoskeletal imaging, real-time imaging, sonography

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[1]Department of Radiology, Notre-Dame Hospital, University of Montreal, 1850 Sherbrooke St. E, Montreal, QC, Canada H2L 4M1. Address correspondence to V. Khoury (viviane.khoury@umontreal.ca).

[2]Department of Radiology, St-Luc Hospital, University of Montreal, Montreal, QC, Canada.

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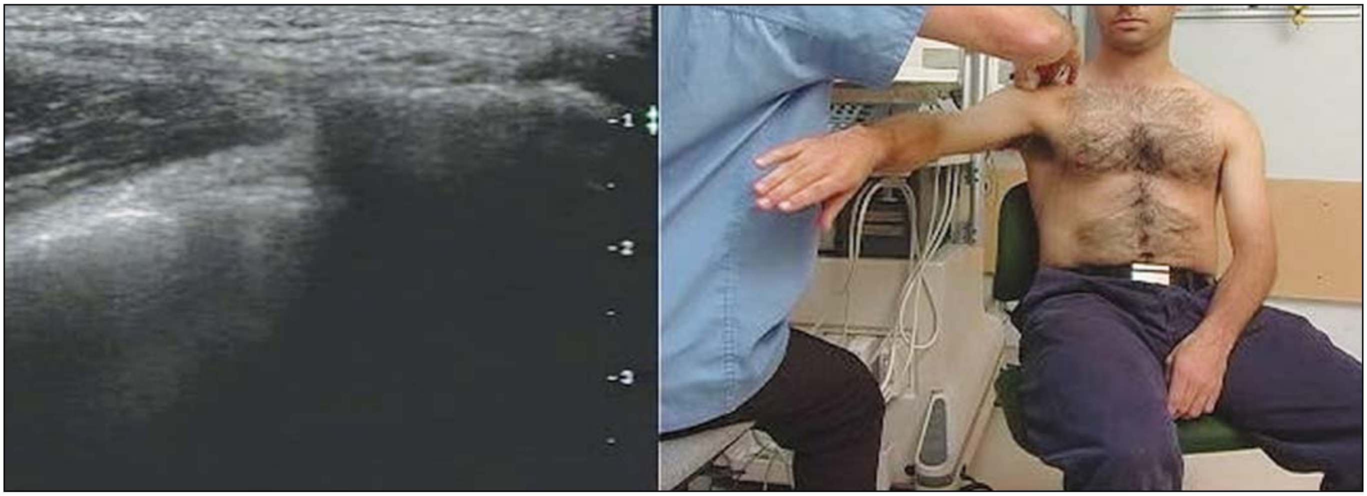

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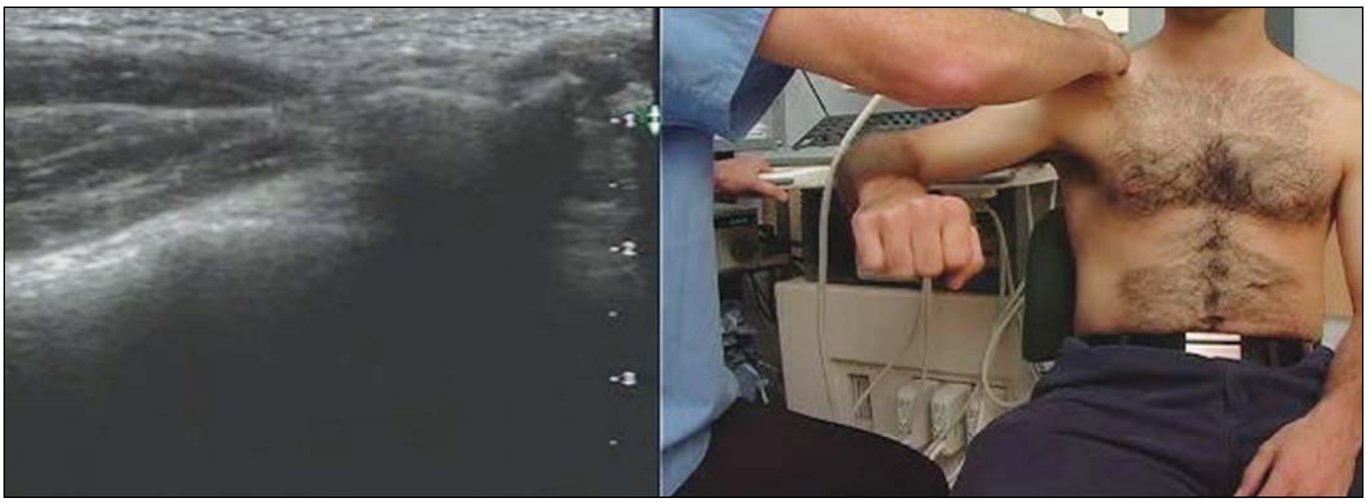

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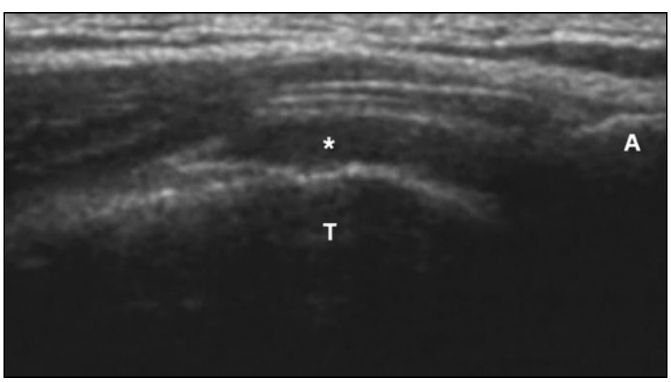


D

Fig. 1 (continued)—Shoulder impingement syndrome.
B and **C,** Sonogram (*left*) and photograph (*right*) of dynamic maneuver technique; see text for explanation of maneuver. There is complete passage of tendon and subacrominal–subdeltoid bursa under acromion. For video see supplemental Figures S1B and S1C. In both maneuvers, video of sonogram shows smooth gliding of tendon and subacrominal–subdeltoid bursa under acromion.
D, Coronal sonogram of moderate shoulder impingement syndrome shows bunching up of subacromial–subdeltoid bursa (*asterisk*) lateral to acromion (A) during shoulder abduction. T = greater tuberosity. For video, see supplemental Figure S1D.

This dynamic evaluation may be used to classify the severity of shoulder impingement syndrome [3]. In mild impingement, there are no objective sonographic findings of impingement during shoulder motion; however, correlation exists between passage of the tendon under the acromion and painful symptoms. With moderate impingement, there is accumulation of subacromial–subdeltoid bursal synovium or fluid lateral to the acromion. The supraspinatus tendon may catch on the acromion (ratchet motion) (Figs. 1D and S1D). With severe impingement, there is superior migration of the humeral head and the tendon bunches up or bulges laterully because the greater tuberosity cannot glide under the acromial acoustic shadow.

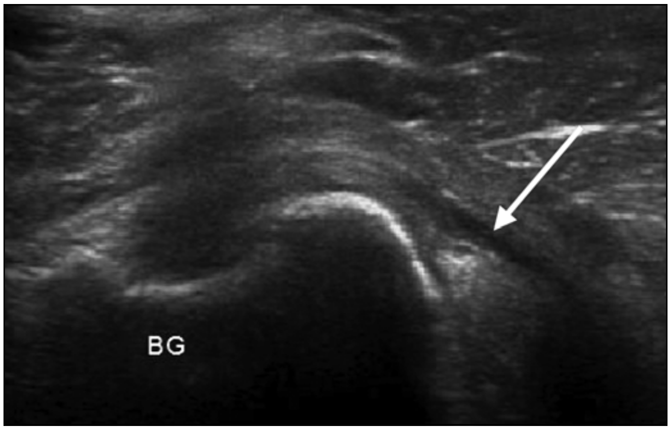


Fig. 2—Long head of biceps tendon dislocation. Transverse sonogram shows medial dislocation of long head of biceps tendon (*arrow*) out of bicipital groove (BG) during external rotation of glenohumeral joint.

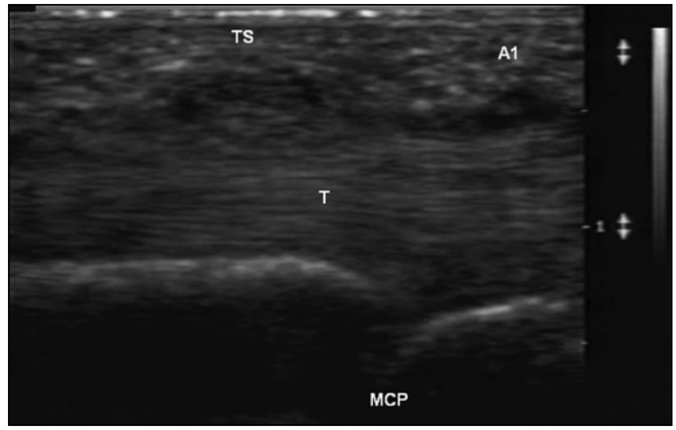


Fig. 3—Trigger finger. Longitudinal sonogram of trigger finger at level of metacarpophalangeal (MCP) joint shows focal tenosynovitis (TS) on palmar aspect of flexor tendon (T) and thickened A1 pulley. There is hesitation of flexor tendon movement during extension. For video, see supplemental Figures S3A (normal) and S3B (trigger finger).

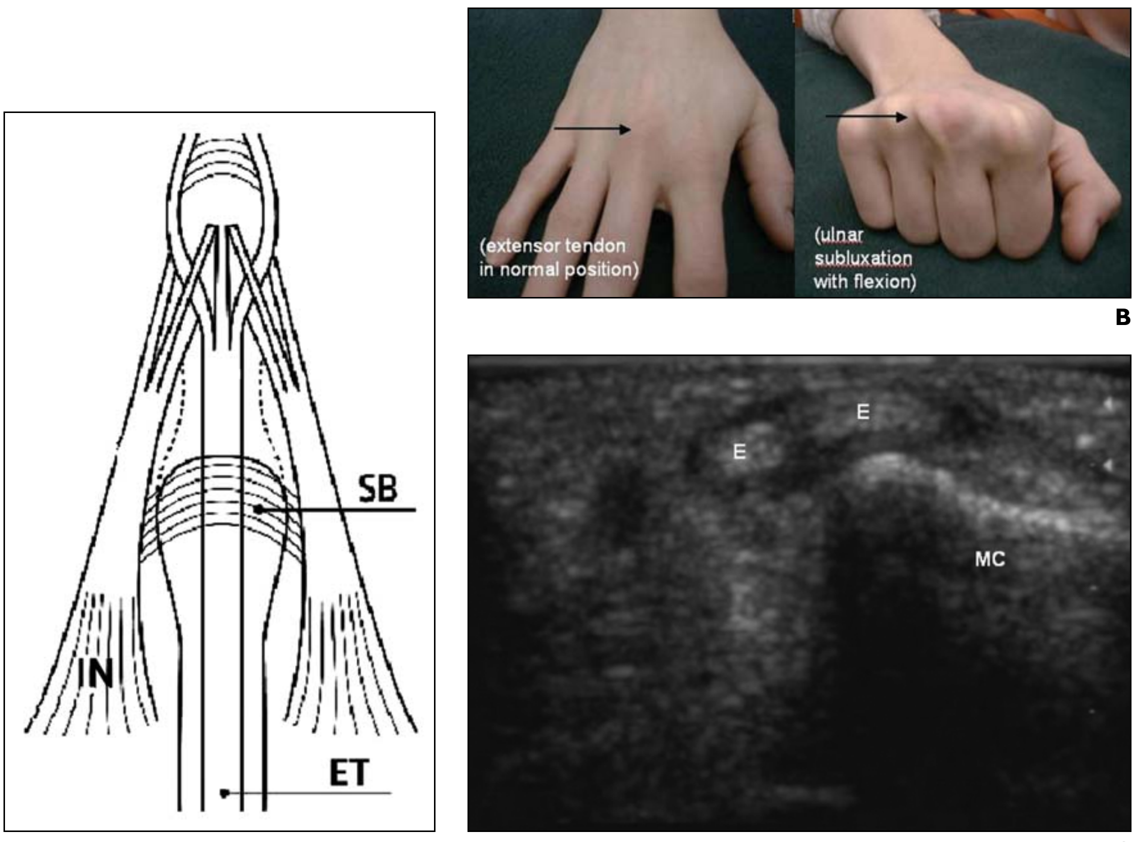


Fig. 4—"Boxer knuckle." **A,** Extensor tendon anatomy: diagram of dorsal tendon apparatus of finger. ET = extensor tendon; SB = sagittal bands; IN = intrinsic muscle.
B, Ulnar dislocation of third extensor tendon at metacarpophalangeal joint is evident with flexion. (Courtesy of Dhanju J, Toronto, ON, Canada)
C, Transverse sonogram of dorsal aspect of third metacarpophalangeal (MCP) joint (different patient than **B**) shows initial anatomic position of extensor tendon of third finger when MCP joint is in extension. Note fluid in extensor tendon sheath in keeping with tenosynovitis and focal split of tendon. With flexion, there is ulnar subluxation of (split) extensor tendon (E) relative to metacarpal head (MC). For video, see supplemental Figure S4C. (Courtesy of Dhanju J, Toronto, ON, Canada)

Long Head of the Biceps Dislocation or Subluxation

The long head of the biceps tendon may dislocate medially out of the bicipital groove in the setting of a subscapularis tendon tear or a shallow bicipital groove. The long head of the biceps tendon usually dislocates deep in relation to the subscapularis tendon or, less commonly, lies within or anterior to it. Subluxation may occur with the tendon being perched on the lesser tuberosity. In some cases, a long head of the biceps tendon dislo-

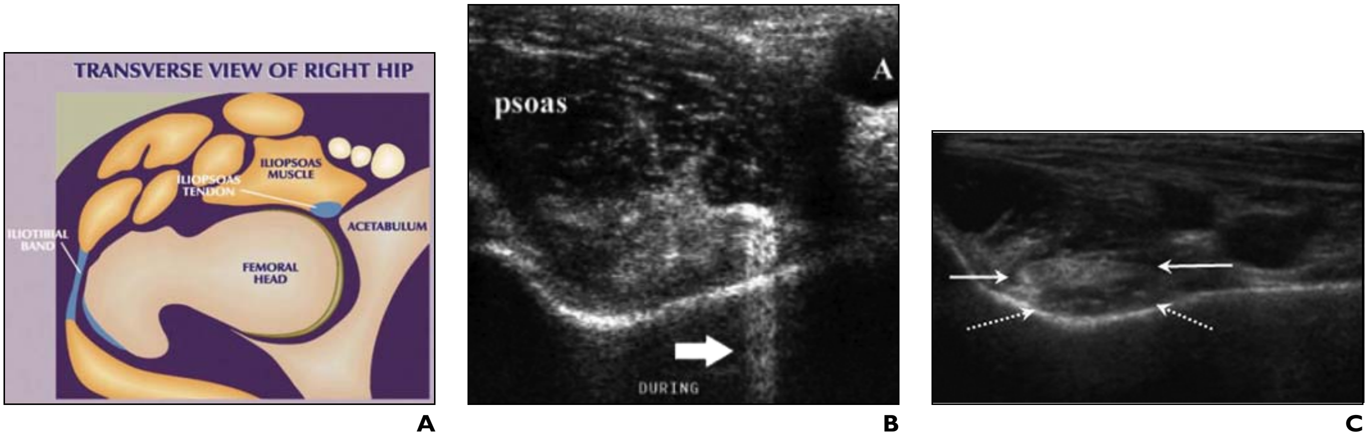


Fig. 5—Snapping iliopsoas tendon.
A, Diagram of transverse section of right hip shows relationship of iliopsoas tendon, hip joint, and surrounding structures. For video of snapping iliopsoas tendon, see supplemental Figures S5A–S5C.
B, Streak artifact, manifested by linear, hyperechoic striated band oriented superoinferiorly (*arrow*), in this case of iliopsoas tendon snapping. This artifact is also evident in video (near end) in supplemental Figure S5B. A = femoral artery.
C, Snapping iliopsoas tendon over cyst. In this case, iliopsoas tendon (*solid arrows*) was seen to snap over synovial cyst (*dashed arrows*).

cation or subluxation may be transient and seen only on a dynamic maneuver [4].

For dynamic sonography, the biceps tendon at the level of the bicipital groove is scanned in the transverse plane. In dislocation, the bicipital groove is empty, and the tendon is in an abnormal location medial to the lesser tuberosity (Fig. 2). In subluxation, the tendon is perched on the lesser tuberosity. Dynamic scanning is of interest in cases where the abnormality is transient, with the tendon being in its normal location in the bicipital groove while in the neutral position and subluxing or dislocating during external rotation.

Trigger Finger

Trigger finger, or stenosing tenosynovitis, is diagnosed when a patient presents with a symptomatic locking or clicking of a finger or thumb. The condition is a mechanical problem caused by a mismatch between the relative size of the flexor tendon and its sheath [5]. Trauma with laceration of the flexor tendon is an extremely rare cause [6]. Sonography may be used to identify a variety of pathologic changes affecting the flexor tendons, including thickening, altered echotexture, diffuse or focal thickening of the synovial sheath, and associated peritendinous cysts or a thickened A1 (annular) pulley on the palmar aspect of the flexor tendon sheath at the level of the palmar plate of the metacarpal joint [7–9]. During finger flexion and extension, impingement of the thickened segment of the tendon and its synovial sheath on the A1 pulley can be seen using sonography.

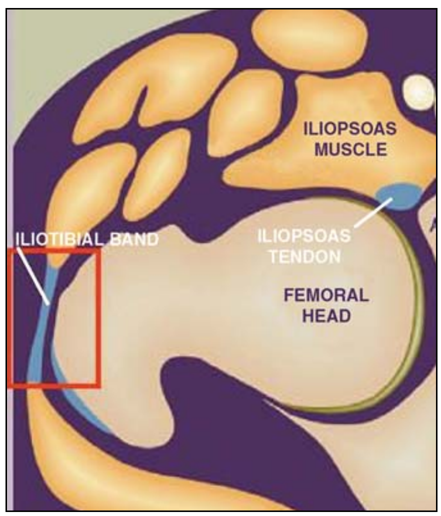


Fig. 6—Snapping iliotibial band: Diagram of transverse section through iliotibial band rotated 90° clockwise to show orientation of sonograms in videos. Boxed region indicates area scanned in videos. For videos, see supplemental Figures S6B–S6D.

For dynamic sonography, the flexor tendon of the finger is scanned longitudinally at the level of the metacarpophalangeal joint during active flexion and extension. In trigger finger, the tendon catches during movement, and the gliding movement is not smooth (Figs. 3, S3A, and S3B). Comparison with an unaffected digit may be helpful. The tendon is also examined on longitudinal and transverse scanning for associated tenosynovitis, peritendinous cysts, and thickening of the A1 pulley.

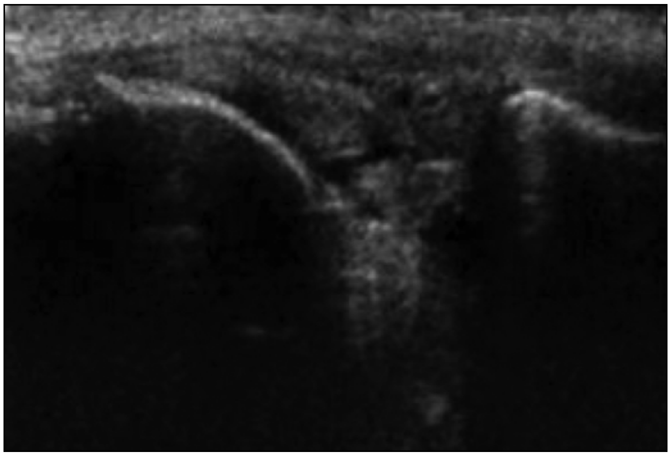
"Boxer Knuckle"

"Boxer knuckle" refers to metacarpal joint derangement, of which the most serious is traumatic disruption of the extensor hood due to injury of the sagittal bands [10] (Fig. 4A). Clinical symptoms include pain, swelling, loss of full joint extension, and either ulnar or radial dislocation or subluxation of the extensor tendon (Fig. 4B). In some cases, extensor tendon dislocation or subluxation may be difficult to diagnose clinically, and dynamic sonography has been shown to be useful in diagnosing injuries of the extensor hood mechanism [11].

For dynamic sonography, the extensor tendon dorsal to the metacarpophalangeal joint in the affected finger is scanned both longitudinally and in the transverse plane. Comparison with the contralateral side may be helpful. Transverse scanning at the level of the metacarpal head is performed during either active or passive flexion and extension of the finger. The extensor tendon is examined for dislocation or subluxation relative to the metacarpal head; associated findings such as tenosynovitis or tendon split may be seen (Figs. 4C and S4C).

Snapping Hip Syndrome

Snapping hip syndrome refers to a painful audible snap in the hip during motion. Causes of snapping hip may be extraarticular, including snapping of the iliopsoas tendon, friction of the iliotibial band or gluteus maximus against the greater trochanter, and snapping of the iliofemoral ligament over the femoral head [12]. A significant portion (50%) of



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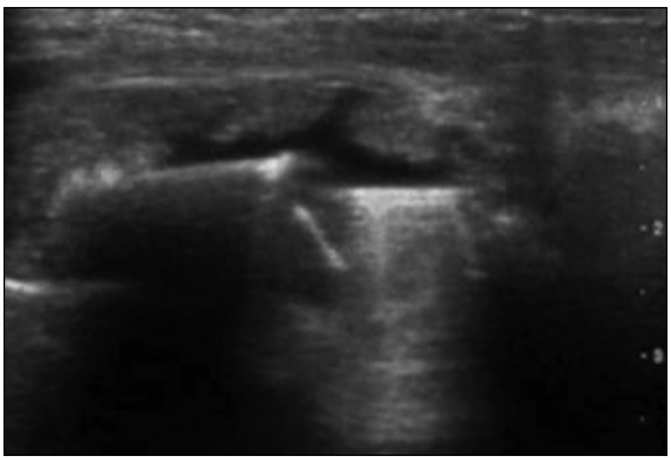

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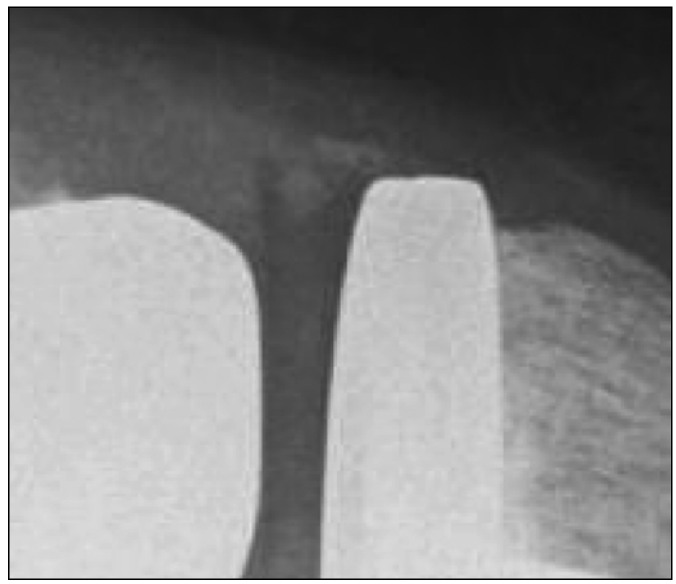


C

Fig. 7—Snapping knee syndrome.
A, Snapping meniscus. Coronal sonogram of medial aspect of femorotibial joint shows heterogeneous torn meniscus. During flexion and extension, there is abnormal jerking movement of heterogeneous torn meniscus. Note streak artifact in video, which correlates with clinical snap. For video, see supplemental Figure S7A.
B, Snapping knee with prosthesis. Coronal sonogram of medial side of knee (oriented on its side) shows abnormal movement of polyethylene component (hyperechoic line with ring-down artifact) that is misaligned with adjacent tibia. Initially polyethylene component is aligned with adjacent tibia. However, with knee flexion and extension, there is abnormal movement of component (hyperechoic line with ring-down artifact). For video, see supplemental Figure S7B.
C, Anteroposterior radiograph of knee (on its side) zoomed in on medial aspect to show orientation of sonogram in **B**.

snapping hip cases may be asymptomatic [13]. Intraarticular causes include labral tears, intraarticular bodies, osteochondral fractures, and transient subluxation of the femoral head. When the clinical diagnosis is uncertain, sonography is well suited to evaluate the snapping hip because it can identify the cause of the snap and establish an immediate temporal correlation between the abnormality and the generation of painful symptoms [13].

For dynamic sonography of iliopsoas tendon snapping, the transducer is placed anteriorly in a transverse or oblique transverse plane just above the hip joint while the patient performs the motion that produces the snap. This usually involves passage of a flexed, abducted, and externally rotated hip back to full extension, with the snap occurring about halfway during motion (Figs. 5A, 5B, S5A, and S5B). Straight hip flexion and extension or internal-to-external rotation may occasionally produce the snap. With snapping, there is an abrupt mediolateral or rotatory motion of the iliopsoas tendon during the dynamic maneuver (Fig. S5C). Rarely, an underlying synovial cyst may be associated with a snapping iliopsoas tendon (Figs. 5B and S5C).

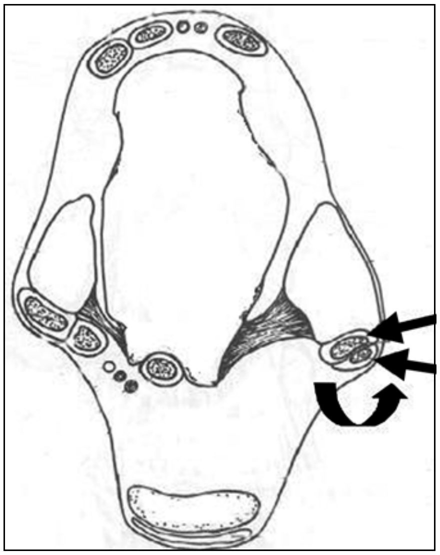
For dynamic sonography of iliotibial band snapping, the patient lies on the opposite side while the abnormal hip is being scanned transversely during flexion and extension to reproduce the snapping of the iliotibial band. The normal iliotibial band (coursing laterally to the trochanter and distal gluteus medius tendon) will glide smoothly over the greater trochanter during hip motion (Figs. 6A, 6B, S6A, and S6B). With snapping, there is abnormal jerking movement of the iliotibial band as it abruptly snaps over the greater trochanter (Figs. 6C and S6C).

With the use of tissue harmonic imaging, a streak artifact may be seen behind a rapidly moving soft-tissue structure such as a snapping tendon [14, 15]. This streak artifact is a linear, hyperechoic striated band oriented superoinferiorly (Figs. 5B and S5C). This is a useful artifact during dynamic sonography because it may help locate and identify the quickly or abruptly moving tendon (or other soft-tissue structure). The artifact, however, may be machine dependent.

Snapping Knee Syndrome

Snapping knee syndrome refers to a painful snap during knee motion and may be due to a heterogeneous group of disorders. This syndrome may be provoked by abnormal tendon motion around the knee. Medially, the snapping can be caused by the gracilis or semitendinosus tendon passing over the medial tibial condyle during knee flexion [16]. Lateral snapping can be provoked by the

Fig. 8—Peroneal tendon dislocation.
A, Illustration shows anatomy of peroneus brevis (*upper arrow*) and longus tendons (*lower arrow*) in transverse section through ankle. Curved arrow indicates direction of peroneal tendon subluxation or dislocation.
B, Dynamic maneuver in peroneal tendon evaluation. During dorsiflexion and eversion of the ankle, the peroneal tendons maintain their normal position posterior to the lateral malleolus. For video, see supplemental Figure S8B.
C, Transverse sonogram shows dislocation of peroneal tendons (P), with positioning lateral to fibula (f) during dorsiflexion and eversion of ankle. For video, see supplemental Figure S8C.
D, Transverse sonogram shows dislocation of one portion of split peroneus brevis tendon. L = peroneus longus tendon, f = fibula, arrowheads = split peroneus brevis tendon. For video, see supplemental Figure S8D.



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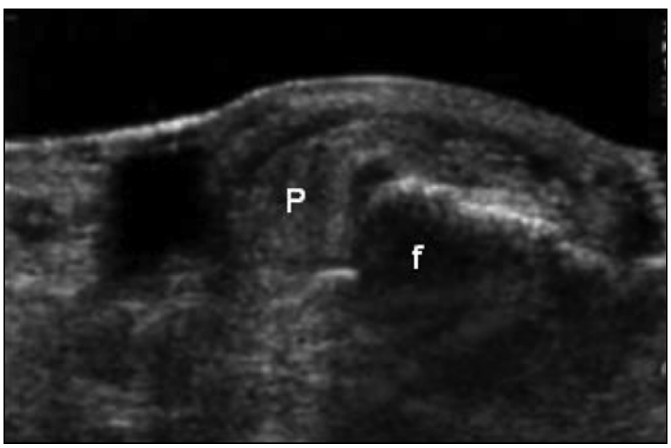

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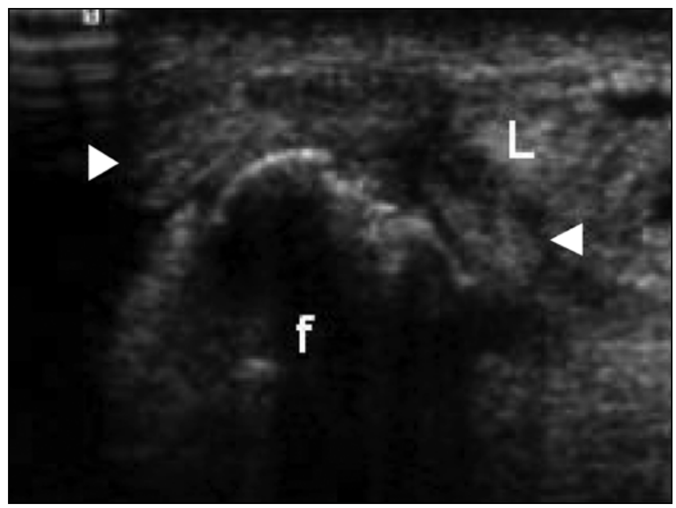

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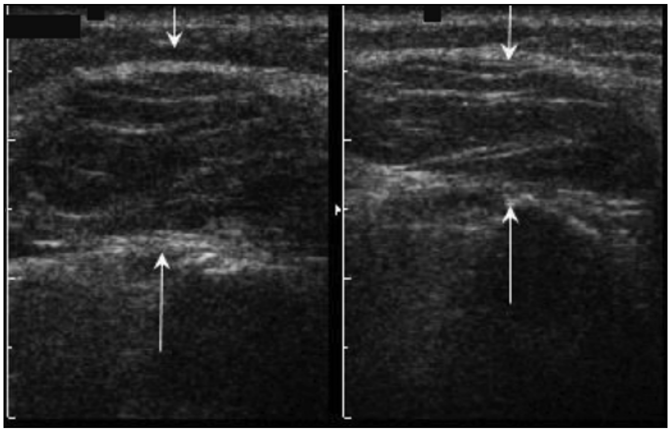
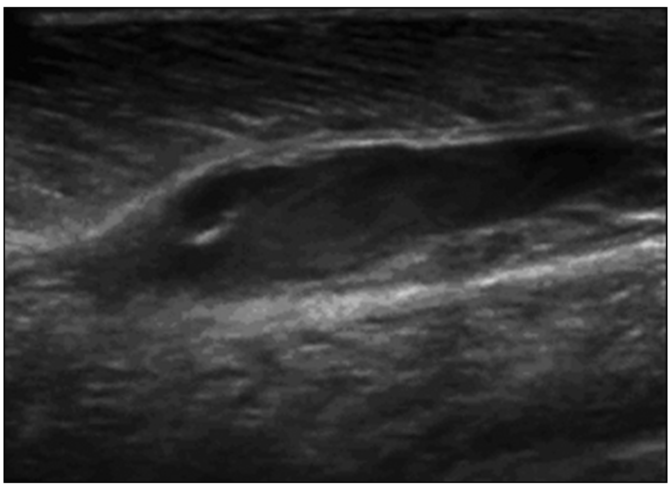
Fig. 9—Pseudomass due to chronic muscle tear. Longitudinal sonogram of quadriceps muscle during isometric contraction shows proximal retraction and bulging of muscle secondary to chronic tear more distally, simulating mass (M) For video, see supplemental Figure S9.



A

Fig. 10—Soft-tissue masses.
A, Lipoma. Sonograms of subcutaneous lipoma manifested by elliptic, well-defined mass (*arrows*) that is compressible. Mass is shown with (*right image*) and without (*left image*) transducer pressure.
B, Hematoma. Longitudinal sonogram of calf muscles shows heterogeneous, oval-shaped hypoechoic complex intramuscular mass. Compression with transducer shows swirling of liquified contents of mass, in this case representing hematoma. For video, see supplemental Figure S10B.
C, Venous malformation. Sonogram of calf muscle shows typical appearance, with hyperechoic fat, multiple dilated hypoechoic serpiginous vessels, and sluggish flow (hence little signal on color Doppler sonography). There is increased color signal with dynamic compression with sonography transducer. For video, see supplemental Figure S10C.



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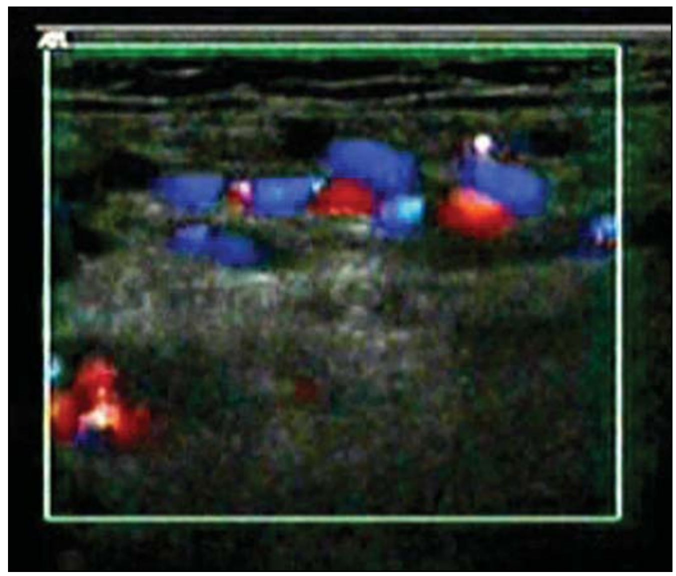

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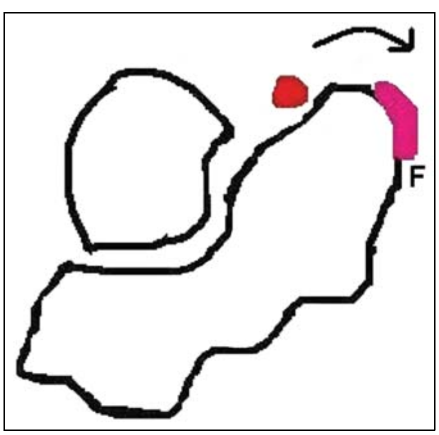

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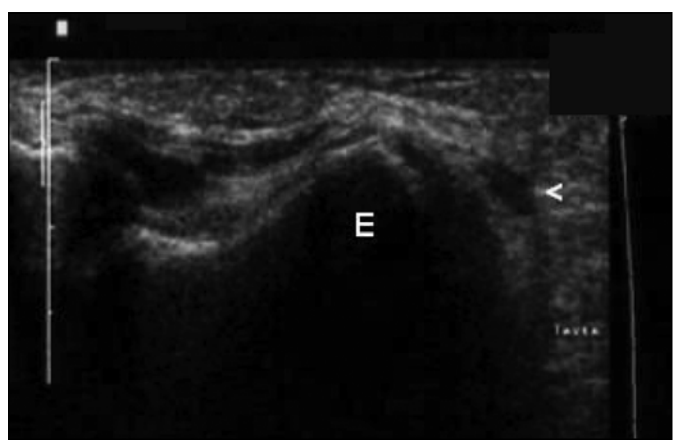

B

Fig. 11—Ulnar nerve dislocation.
A, Diagram of transverse section through elbow shows position of normal ulnar nerve (*pink*) posterior to medial epicondyle. Note common flexor tendon origin (F, *red*). Arrow refers to direction of ulnar nerve dislocation.
B, Transverse sonogram during elbow flexion shows abrupt dislocation of hypoechoic oval-shaped nerve over medial epicondyle and superficial to common flexor tendon insertion, correlating with clinical snap. E = epicondyle, arrowhead = dislocated ulnar nerve. For video, see supplemental Figure S11B.

A

B

Fig. 12—Joint disorders.
A, Sagittal sonogram of palmar and ulnar aspect of wrist shows multiple small round hyperechoic bodies in distended pisiform-triquetral joint recess. With motion and compression (for video, see supplemental Figure S12A), mobility of these bodies is well shown (sagittal, followed by transverse scan of same region). PISI = pisiform bone, FCU = flexor carpi ulnaris tendon, RAD = radius.
B, Coronal sonogram of right acromioclavicular joint shows increased mobility during shoulder motion. For video, see supplemental Figure S12B. ACRO = acromion, CLAV = clavicle.

biceps femoris tendon flipping over the fibular head during knee flexion due to an anomalous insertion of the tendon on the fibular head or anterolateral aspect of the proximal tibia [17, 18]. Spontaneous or posttraumatic lateral snapping of the popliteus tendon in its groove on the lateral femoral condyle has also been described [19, 20].

Snapping knee may also be caused by an intraarticular nodular mass in rheumatoid arthritis. The mass is characteristically situated in the anterolateral aspect of the lateral femoral condyle. At sonography, the mass can be identified because it appears to jump and slip in and out of the patellofemoral articulation during flexion and extension [21].

Other causes of snapping knee syndrome include discoid meniscus [22], torn meniscus (Figs. 7A and S7A), fabellar snapping, and loosened polyethylene component after total knee arthroplasty [23] (Figs. 7B, 7C, and S7B).

Peroneus Tendon Subluxation

The peroneus brevis and longus tendons, the primary everters of the foot, course behind the lateral malleolus in the retrofibular groove. The superior peroneal retinaculum forms a fibroosseous tunnel with this groove, maintaining the tendons in their normal position. Peroneal tendon dislocation usually involves passage of one or both tendons anterolaterally over the lateral malleolus (Fig. 8A). Most cases are due to posttraumatic disruption of the superior peroneal retinaculum and may be acute or chronic. Diagnosis, which may be difficult clinically, is important because prompt surgical repair is the preferred treatment [24]. Since the tendons often are in their anatomic position at rest, static imaging techniques such as CT and MRI cannot reliably document episodic or transient dislocation. Dynamic sonography is ideally suited and has been shown to be an effective technique for the diagnosis of peroneal tendon dislocation [25].

For dynamic sonography, the patient is supine or seated, with the plantar foot on the examination table in slight inversion. Scanning is performed in the transverse plane while simultaneously dorsiflexing and everting the ankle (Figs. 8B and S8B). During dorsiflexion and eversion of the ankle, the peroneal tendons maintain their normal position posterior to the lateral malleolus. In peroneal tendon subluxation or dislocation, the peroneal tendons are abnormally displaced lateral to the fibula during dorsiflexion and eversion of the ankle (Figs. 8C and S8C). There may also be dislocation of one portion of a longitudinally split peroneal tendon (Figs. 8D and S8D).

Dynamic Sonography of Muscle Disorders

Muscle Hernia

A muscle hernia is a protrusion of muscular tissue through a fascial defect. Hernias mostly occur in the lower leg, usually involving the tibialis anterior muscle. Because of their small size and dynamic features, these lesions can be overlooked at MRI. Although most muscle hernias are treated conservatively, sonography is useful to make the diagnosis and exclude alternative ones such as muscle tear and tumor, the latter being a frequent concern especially of the patient [26].

For dynamic sonography, the skin should be marked because the hernia may be difficult to feel during the examination. Probe pressure should be light so as to not reduce the hernia. Sonography shows the muscle bulging and the echogenic fascial defect or fascial thinning. Dynamic examination shows the reduction of the herniated muscle substance when pressure is applied through the probe. Other dynamic maneuvers, such as muscle contraction or the standing position, may be necessary to show the hernia. Prominent arterial pulsation is identified using color or power Doppler sonography in a minority of cases when vessels penetrate the disrupted fascia [26].

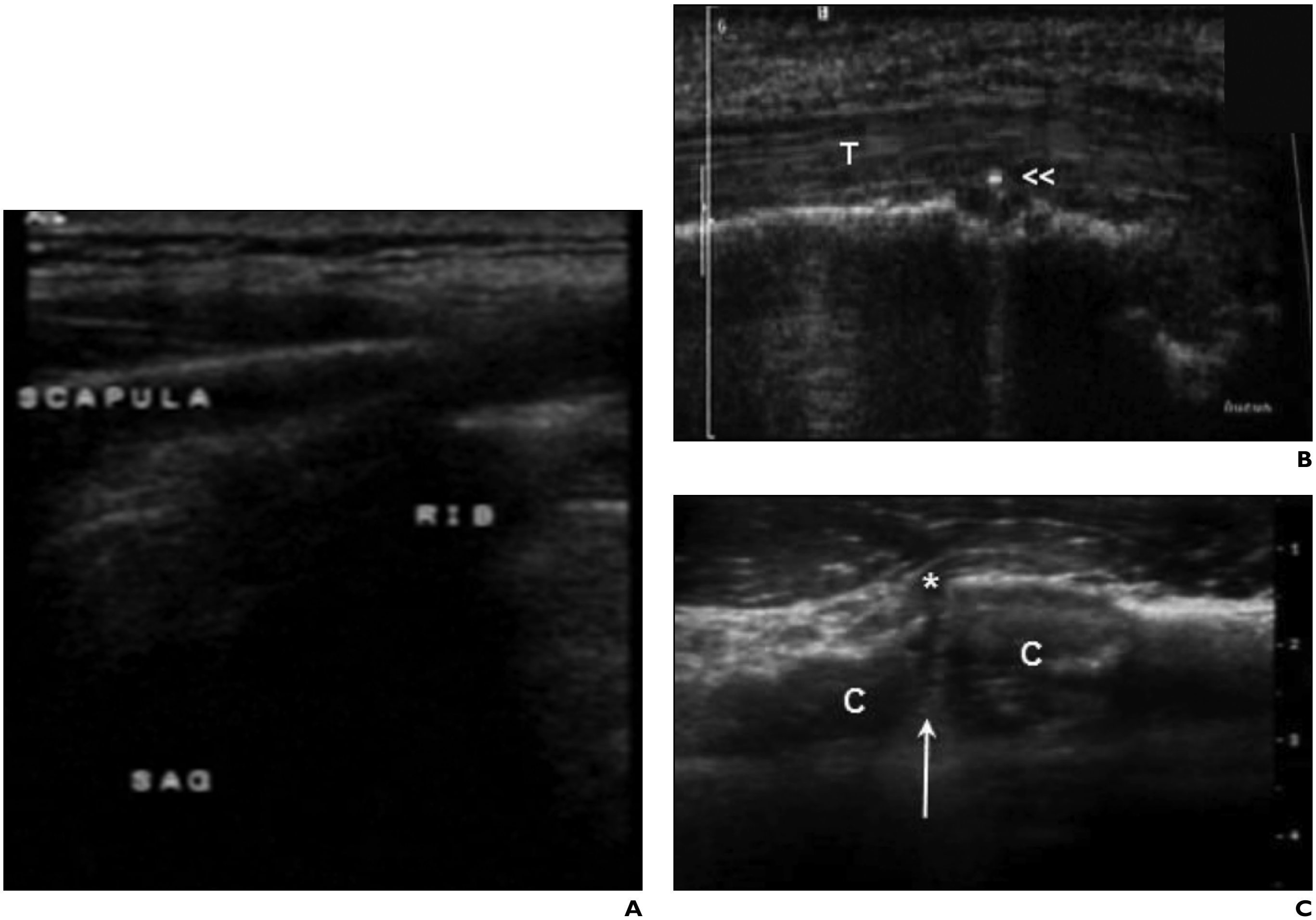

Fig. 13—Miscellaneous conditions.
A, Snapping scapula. Sagittal sonogram shows abnormal grating movement of scapula against ribs during motion. For video, see supplemental Figure S13A.
B, Tendon impingement by screw. Longitudinal, followed by transverse sonograms of medial side of ankle show impingement of tibialis posterior tendon (T) by tip of protruding screw (*arrowheads*) with ring-down artifact through cortex. For video, see supplemental Figure S13B.
C, Costal cartilage fracture. Longitudinal sonogram along axis of right anterior rib at sternal junction shows fracture (*arrow*) of hypoechoic costal cartilage (C) with small anechoic hematoma (*asterisk*). With probe compression, there is abnormal movement at fracture site with slight separation of fragments. For video, see supplemental Figure S13C.

Muscle Tear

On sonography, muscle tears may appear as small areas of focal disruption, hyperechoic infiltration, heterogeneous mass (in the presence of a hematoma or hemorrhage), or a combination of these findings; perifascial fluid is common. In acute high-grade tears, sonography will show torn muscle fragments floating in hemorrhagic fluid, presenting the appearance of the bell-clapper sign [27]. Dynamic sonography is useful when the hematoma is small or has resolved. In such cases, muscle contraction or transducer pressure may better reveal the separation of disrupted frayed ends of the muscle tear. Also, with chronic tears and associated focal atrophy, there may be areas of muscle asymmetry causing the appearance of a pseudomass. Dynamic sonography is well suited to diagnose a pseudomass provoked by a chronic muscle tear and rule out a true mass. During isometric muscle contraction, the proximal segment of the torn muscle will partially retract and cause a focal bulging (Figs. 9 and S9).

Dynamic Sonography of Soft-Tissue Masses

Lipoma

Subcutaneous lipomas are typically elliptic, well-defined lesions containing short, linear reflective striations that run parallel to the skin. Sonography has the advantage of showing their characteristic compressibility (Fig. 10A).

Abscess and Hematoma

Abscesses and hematomas often have liquified contents, which are well shown on sonography with dynamic compression (Figs. 10B and S10B), differentiating them from purely solid masses. The differential diagnosis of a compressible, liquified soft-tissue mass includes necrotic tumor.

Venous Malformation (Hemangioma)

On static sonographic imaging, venous malformations appear as hypoechoic serpiginous vessels with sluggish flow (hence little signal on color Doppler sonography) surrounded by hyperechoic fat. Dynamic compression sonography with a transducer generates increased color signal in these soft-tissue masses (Figs. 10C and S10C). Also, venous malformations of the lower extremity can be made more conspicuous by examining the lesion with the patient standing [28].

Dynamic Sonography of Nerve Disorders

High-resolution sonographic probes are well suited to evaluate all peripheral nerves [29, 30]. Sonography has been shown to reveal not only nerve abnormalities due to trauma and tumors but also entrapment syndromes and abnormal nerve mobility.

At the level of the elbow, the ulnar nerve is normally located between the olecranon process and the medial epicondyle (Fig. 11A). Ulnar nerve subluxation occurs as it is slides out of the cubital tunnel and over the medial epicondyle during elbow flexion [31]. Ulnar nerve dislocation has been reported in approximately 16% of healthy subjects.

For dynamic sonography, the elbow is scanned transversely and the position of the ulnar nerve is assessed during flexion and extension of the elbow, normally positioned posterior to the medial epicondyle apex. It is important to note that the position of the hypoechoic medial muscle belly of the triceps should also be assessed for abnormal snapping over the medial epicondyle with elbow flexion because it may coexist with ulnar nerve dislocation [32].

With ulnar nerve dislocation, the abrupt medial displacement of the nerve medial to the medial epicondyle produces a snapping sensation felt through the transducer (Figs. 11B and S11B). One potential pitfall is that excessive transducer pressure may inhibit the ulnar nerve from dislocating, thus resulting in misdiagnosis. This can be avoided by intermittently decreasing transducer pressure on the soft tissues throughout the dynamic examination [32].

Dynamic Sonography of Joint Disorders

Intraarticular Bodies

Intraarticular bodies are cartilaginous or osteocartilaginous fragments from acute injury or from chronic conditions including osteoarthritis, neuropathic joint disease, and primary synovial osteochondromatosis. Sonography is an excellent technique for the detection of intraarticular bodies and is often superior to radiography. If they are noncalcified, cartilaginous fragments may also be missed on CT and MRI in the absence of intraarticular contrast material or fluid. On sonography, intraarticular bodies appear as hyperechoic foci (whether calcified or not) of varying sizes, most readily seen in the presence of a joint effusion [33]. They are usually found in synovial recesses or in the dependent portion of the joint. They may be loose, in which case real-time imaging with graded compression will show movement of the bodies (Figs. 12A and S12A). They may also be trapped in synovial folds or adherent to the synovial lining. Intraarticular saline injection has been shown to increase sonographic detection of intraarticular bodies in the elbow [34].

Joint Subluxation and Instability

Almost any joint can be evaluated for instability with sonography. Sonography can be used to evaluate for abnormal widening of the joint with movement or applied stress (the acromioclavicular joint is one example, as shown in Figures 12B and S12B).

In addition to its ability to assess joint laxity, sonography can directly evaluate associated ligamentous abnormalities. For example, in the elbow, sonography can show ulnohumeral joint widening with valgus stress joint laxity and associated abnormalities of the ulnar collateral ligament [35].

Dynamic Sonography of Miscellaneous Conditions

Snapping Scapula

Snapping or grating scapula is a condition of the scapulothoracic articulation in which the patient complains of an audible snapping sound that may or may not be associated with pain. Snapping scapula may be caused by skeletal or soft-tissue abnormalities, or it may be of idiopathic or unclear cause [36]. The classical bone abnormality associated with this syndrome is an osteochondroma. Other causes include rib and scapular bone deformities, including posttraumatic causes, and abnormal scapular angulation. Soft-tissue causes include bursitis, interstitial myofibrosis, and muscle atrophy. Three-dimensional CT has been described in the evaluation of this syndrome [37] as has fluoroscopy. The use of sonography, which avoids radiation in the generally young population affected by this condition, may be ideally suited at least as a first-line technique along with radiographs. The abnormal, often jerking, movement of the scapula against the rib cage can be directly visualized as can some underlying causes (Figs. 13A and S13A).

Tendons Around Hardware

Unlike CT and MRI, sonographic imaging of soft tissue around hardware is not degraded by metallic artifacts. Sonography can be used not only in the detection of abnormal fluid collections around hardware but also for identification of tendons impinging on plates or screws (Figs. 13B and S13B).

Costal Cartilage Fracture

Costal cartilage fractures are not visualized on conventional radiography and may be difficult to diagnose by other imaging methods. Sonography is well suited to evaluate the superficial hypoechoic costal cartilage. A cartilage fracture will appear as a break separated by hematoma. In addition, the abnormal motion of the cartilage fragments may be seen with breathing or probe compression (Figs. 13C and S13C).

Conclusion

Dynamic sonography is a useful tool for the evaluation of a wide variety of musculoskeletal disorders that are best or only shown dynamically—that is, during motion, muscle contraction, probe compression, or position change of the patient. Many of these disorders cannot be diagnosed by any other imaging method.

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