# Ultrasound Evaluation of Soft Tissue Masses and Fluid Collections

**Stacy E. Smith, M.D.,[1] John Salanitri, M.B.B.S., F.R.A.N.Z.C.R.,[2] and David Lisle, M.B.B.S., F.R.A.N.Z.C.R.[2]**

**ABSTRACT**

Musculoskeletal ultrasound has utility as a first-line screening modality in the evaluation of soft tissue masses. The sonographic appearances of cysts or lipomas may be sufficient to obviate the need for further imaging. For other complex cystic or solid masses, ultrasound is an inexpensive, widely available imaging modality that can evaluate lesion vascularity, guide diagnostic and therapeutic aspiration or biopsy procedures, and be used for follow-up examinations to determine response to therapeutic interventions.

**KEYWORDS:** Soft tissue, mass, ultrasound, fluid collection

The wide availability of musculoskeletal ultrasound, its relative low cost (compared with magnetic resonance imaging [MRI]), and the unique ability for dynamic lesion evaluation gives this imaging modality an important role in the evaluation of the patient presenting with a soft tissue mass. Technological innovations such as extended field-of-view imaging that provides panoramic images over a large field of view, tissue harmonic imaging (to decrease near-field artifacts and improve lesion boundary delineation), and spatial compound imaging (to decrease image graininess) have resulted in significantly improved ultrasound image quality and renewed interest in this modality.[1–4]

## INDICATIONS

The high negative predictive value of musculoskeletal ultrasound permits its use as the first-choice imaging screening modality to confirm or exclude the presence of a soft tissue mass at a site of clinical concern.[3] Following the confirmation of a lesion, sonographic assessment of its nature (i.e., solid versus cystic), size, shape, number, vascularity (using color or power Doppler), and anatomical relationships to adjoining structures aids in characterization and determining whether further imaging or biopsy is required.[5]

For some benign soft tissue masses (e.g., lipomas, hemangiomas, cysts, abscesses and foreign bodies), the ultrasound findings may be sufficient to obviate the need for further imaging. However, other solid benign and malignant soft tissue masses demonstrate considerable overlap in their sonographic appearances and although color Doppler may improve the diagnostic specificity for these lesions, further evaluation with other imaging modalities and biopsy may be required.[4–6]

Symptomatic benign soft tissue masses (e.g., ganglion cysts, Morton's neuromas) may be injected with local anesthetic or corticosteroids under ultrasound guidance, thus maximizing the efficacy of the therapeutic intervention.[7]

[1]Department of Diagnostic Radiology and Nuclear Medicine, Division of Musculoskeletal Imaging, University of Maryland School of Medicine, Baltimore, Maryland; [2]Queensland Diagnostic Imaging, Holy Spirit Northside Hospital, Brisbane, Queensland, Australia.

Address for correspondence and reprint requests: Stacy E. Smith, M.D., Department of Diagnostic Radiology and Nuclear Medicine, Division of Musculoskeletal Imaging, University of Maryland School of Medicine, 22 South Greene St., Baltimore, MD 21201 (e-mail: ssmith@umm.edu).

Musculoskeletal Ultrasound; Guest Editor, Kambiz Motamedi, M.D.

Semin Musculoskelet Radiol 2007;11:174–191. 
DOI 10.1055/s-2007-1001882. ISSN 1089-7860.

## ADVANTAGES OF ULTRASOUND FOR THE EVALUATION OF SOFT TISSUE MASSES

Ultrasound is ideally suited for performing focused examinations targeted at the area of clinical concern indicated by the patient. The direct interaction of the sonologist with the patient can result in improved diagnostic efficacy. For small masses, the spatial resolution of musculoskeletal ultrasound exceeds that of MRI with high frequency (9 to 13 MHz) transducer probes having in-plane resolutions of 200 to 450 μm and sector thicknesses of 0.5 to 1 mm.

Ultrasound can be used to evaluate for complications of orthopedic devices affecting the adjacent soft tissues because the artifacts caused by orthopedic implants and devices that may degrade computed tomography (CT) or MRI image quality are not as problematic with ultrasound.[8] The relatively limited depth of view of ultrasound compared with other cross-sectional imaging modalities is a disadvantage.

Doppler ultrasound techniques (color or power) provide assessment of soft tissue mass vascularity, including the nature (arterial versus venous) and direction of blood flow that complements the gray-scale images, resulting in increased specificity. Pathological conditions (inflammatory, infective, or neoplastic) affecting the musculoskeletal system often result in alterations of regional blood flow.[9] Serial examinations with Doppler ultrasound following therapeutic interventions (e.g., chemotherapy or surgery) may be useful to determine response to therapy and to detect early disease recurrence that may be confirmed with other imaging modalities.

For cystic lesions, ultrasound's dynamic nature can demonstrate fluid motion within a mass with pressure from the transducer probe, information that cannot be obtained by other imaging modalities. Because ultrasound machines are portable, ultrasound-guided diagnostic and therapeutic interventions can be performed at the patient's bedside or in the Imaging Department with the patient seated or in other positions that would be impossible with CT or MRI. Ultrasound's real-time capabilities is invaluable for percutaneous biopsy of soft tissue masses with continuous visualization of the needle tip, thus avoiding inadvertent injury to neurovascular bundles or other important soft tissue structures. Concomitant use of power Doppler can improve the biopsy yield by guiding the radiologist to mass regions with increased vascularity, thus avoiding nondiagnostic sampling of avascular, necrotic regions.[6,9] Complications occurring following the biopsy procedure can be immediately detected by ultrasound.

For pediatric patients, ultrasound is considered the first-choice modality for the evaluation of soft tissue masses due to its noninvasiveness, lack of ionizing radiation, injections for iodinated or gadolinium contrast agents, and need for patient sedation.[10]

## NON-NEOPLASTIC MASSES

Table 1 lists the non-neoplastic processes presenting as soft tissue masses that may be evaluated with ultrasound. These lesions have varying presenting clinical findings that must be taken into account with the sonographic findings to formulate a differential diagnosis.[11]

### Benign Cysts

Musculoskeletal ultrasound has excellent utility in determining whether a palpable soft tissue mass is cystic. Purely cystic lesions with posterior acoustic enhancement on ultrasound with no identifiable vascularity on color Doppler are benign, and no further imaging is usually required.[5] If there are symptoms of pain secondary to mechanical compression of adjacent soft tissue structures by the cyst, ultrasound-guided aspiration or injection may be curative.

### Synovial Cysts

Cysts lined by synovial tissue are often found in characteristic locations and may communicate with a joint space.[5] Baker cysts (popliteal cysts) are located in the medial portion of the popliteal fossa and shown by ultrasound as anechoic well-defined masses with a smooth or rounded caudal margin (Fig. 1) and often with visualization of the communicating neck to the knee joint. These cysts are commonly associated with inflammatory or osteoarthritis, meniscal tears, and chronic effusion.[12] Complicated Baker cyst (e.g., prior hemorrhage or synovitis) may demonstrate heterogeneous echotexture secondary to debris, thickened synovium, or echogenic loose bodies. Ruptured Baker cysts have an irregular caudal margin with hypoechoic fluid tracking along the popliteal fossa soft tissues. In children, the site of communication of the popliteal cyst with the joint may not always be identified.

Acromioclavicular joint cysts present in the elderly as a shoulder mass following herniation of the synovial membrane through the joint capsule and are often associated with degenerative shoulder joint disease

**Table 1 Non-Neoplastic Masses Evaluated by Ultrasound**

| | |
|---|---|
| Benign cysts | Ganglion cysts, synovial cysts, paralabral or parameniscal cysts |
| Bursitis | See Table 2 |
| Post-traumatic lesions | Muscle tears, fat necrosis, hematomas, myositis ossificans |
| Infectious processes | Cellulitis, abscess, myositis, pyomyositis |
| Benign reactive masses | Giant cell tumor of tendon sheath, Morton's neuroma |
| Inflammatory masses | Foreign bodies |

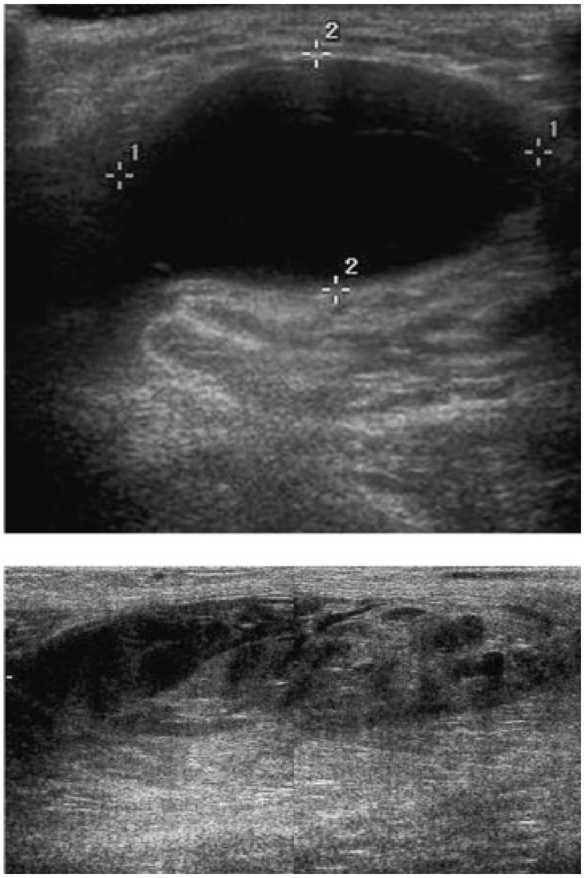


**Figure 1** Baker cyst. (A) Well-defined hypo/anechoic popliteal synovial cyst arising between the medial head of the gastrocnemius and semimembranosis. (B) Complicated Baker cyst for comparison with complex echoes extending into the proximal calf.

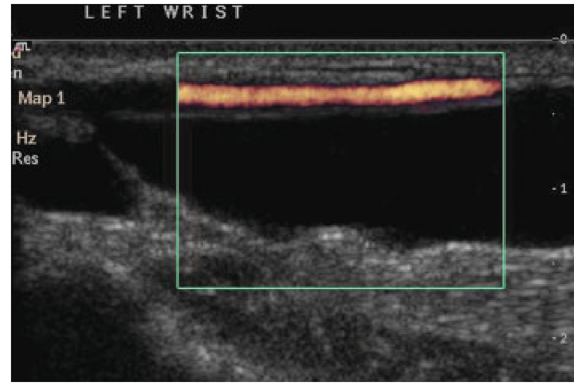



**Figure 2** Ganglion cyst of the wrist. Elongated hypoechoic ganglion cyst of the left wrist displacing the radial artery (color flow) from the deeper flexor tendon.

and rotator cuff tear.[13] Ultrasound findings include a superficially located hypoechoic mass arising from the superior aspect of the acromioclavicular joint with motion of fluid from the glenohumeral joint into the acromioclavicular cyst ("Geyser" sign) in cases with concomitant rotator cuff tear.[1] Other common sites of synovial cysts include the hip and iliopsoas bursa, particularly in association with rheumatoid arthritis.

### Ganglion Cysts

Ganglion cysts are most commonly encountered in the hand, wrist, foot, and ankle. The dorsal wrist ganglion cyst is the most common hand soft tissue mass located superficial to the frequently torn scapholunate ligament but may appear to be remote if it has a long pedicle. Dynamic evaluation with ultrasound can differentiate a dorsal ganglion cyst (as a well-defined noncompressible unilocular anechoic mass with posterior acoustic enhancement) from a dorsal radiocarpal joint space recess that compresses under pressure from the ultrasound transducer.[14] Occasionally ganglion cysts may be multiseptated. Volar ganglion cysts of the wrist are most commonly located between the radial artery and tendon of the flexor carpi radialis (Fig. 2). Ganglion cysts in the knee regions may be associated with the popliteus tendon and have a multiseptated appearance (Fig. 3).[12]

### Meniscal and Paralabral Cysts

Meniscal and paralabral cysts are associated with meniscal or labral tears that appear sonographically as hypoechoic clefts in the otherwise echogenic meniscus or labrum and have an elongated shape characteristically located in the knee, shoulder, and hip.[1–5,14] Classically shoulder paralabral cysts are seen in the region of the suprascapular notch or spinoglenoid recess and may cause pain and muscle atrophy due to compression of the suprascapular nerve.[15,16]

## BURSITIS

Bursal distension with fluid may be secondary to several pathological processes including reactive, inflammatory, infectious, or traumatic causes. Ultrasound can detect both distended superficial and deep bursae in characteristic anatomical locations (Table 2) with common sites including the shoulder subacromial-subdeltoid bursa, the elbow olecranon bursa (Fig. 4), the hip trochanteric bursa, and the knee prepatellar and suprapatellar bursae as well as the iliopsoas bursa (Fig. 5). Ultrasound confirms that the palpable mass is composed of anechoic or hypoechoic fluid within a distended bursa that may show real-time fluctuation with transducer probe pressure and posterior acoustic enhancement. The degree of sonographic reflectivity depends on the nature of the fluid within the lesion. If bursitis is due to inflammation or hemorrhage, increased bursal wall thickness with synovial hypertrophy is seen with increased vascularity confirmed with color Doppler.[6]

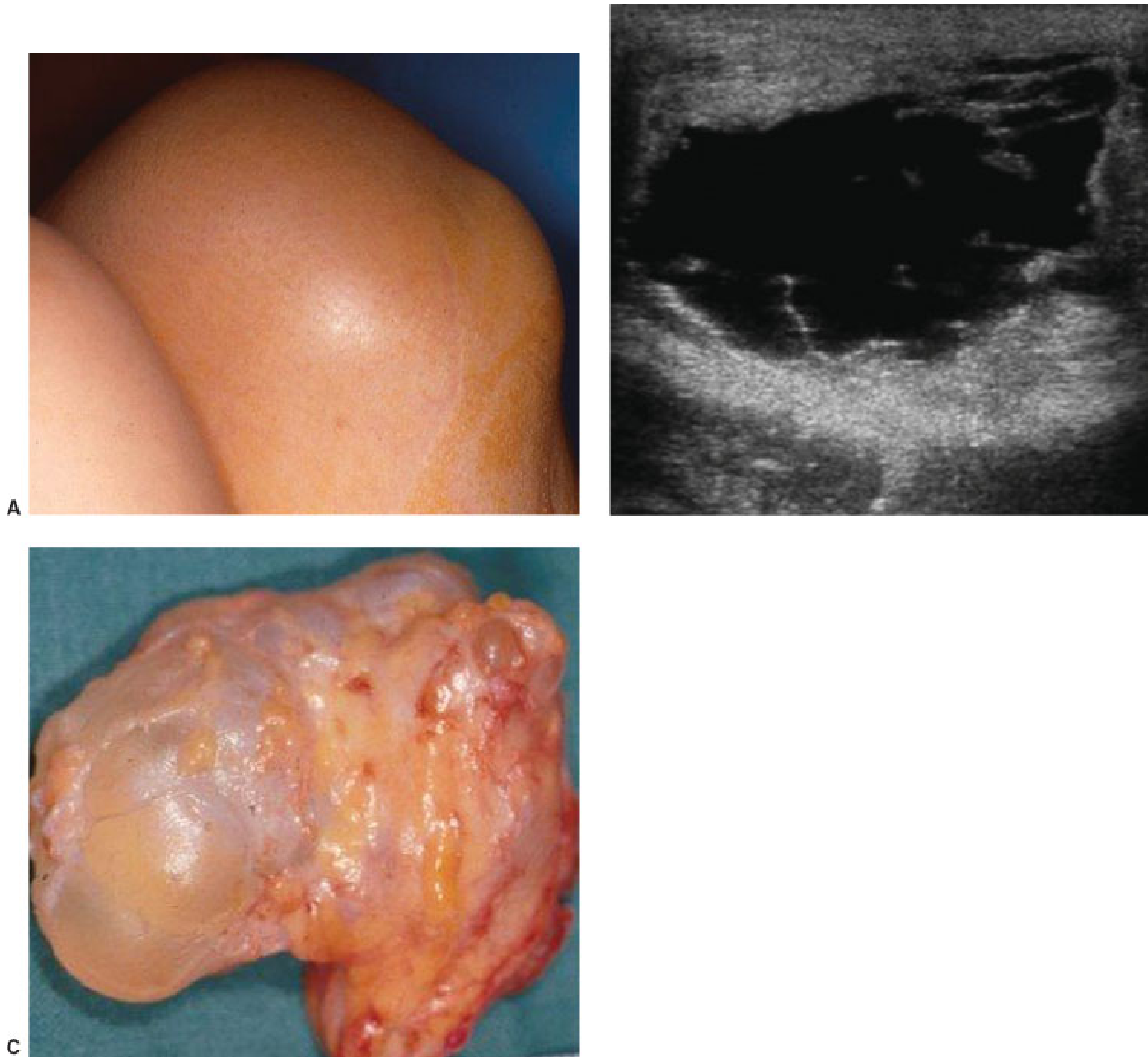



**Figure 3** Ganglion cyst of the knee. (A) Palpable fluctuant mass of the anterolateral knee is demonstrated to be a (B) multiseptated hypoechoic structure on transverse ultrasound image consistent with ganglion. (C) Corresponding gross specimen.

## POST-TRAUMATIC LESIONS

Traumatic injuries to the soft tissues may produce soft tissue swellings that may clinically present as a mass. Ultrasound has a role to differentiate among the various causes of such soft tissue masses, which include hematoma, ruptured myotendinous complex, myositis ossificans, muscle hernia, or focal muscle contusion.

### Muscle Tears

Muscle may be torn by either direct trauma compressing muscle against the underlying bone resulting in muscle fiber maceration and hematoma formation or indirect trauma with distraction of muscle fibers ranging from an elongation-type injury with preserved muscle integrity to complete muscle rupture with retraction.[14] Sonographic findings in the acute phase include formation of an irregular cavity with shaggy margins containing echogenic hematoma that becomes anechoic over the subsequent 72 hours (Fig. 6). With healing, echogenic scar tissue progressively fills in the muscle defect with fibrosis or areas of myositis ossificans producing foci of posterior acoustic shadowing. Muscle cysts are an infrequent complication of muscle tear that appear with ultrasound as hypoechoic simple intramuscular cysts with perceptible synovial-lined thin walls and areas of nodular thickening.

Muscle hernias occurring with fascial defects may be difficult to diagnose with CT or MRI because they may be small and intermittent, only occurring after strenuous exercise. Ultrasound can diagnoses these lesions with targeted examinations performed at rest and immediately after strenuous exercise reproducing the typical pain. The fascial defect appears as a hypoechoic gap in the hyperechoic fascia with acutely herniated hyperechoic muscle protruding into the overlying subcutaneous soft tissues. With time, the herniated

**Table 2 Locations of Inflamed Bursae Evaluated by Ultrasound**

| | |
|---|---|
| Superficial; elbow | Olecranon (concave spheroid shape) |
| Superficial; hip | Subcutaneous trochanteric |
| Superficial; knee | Prepatellar (spheroid shape), subcutaneous infrapatellar, subcutaneous tibial tuberosity |
| Superficial; foot and ankle | Subcutaneous Achilles tendon, first metatarsal |
| Deep; shoulder | Subacromial-subdeltoid |
| Deep; elbow | Bicipitoradial |
| Deep; hip | Obturator, Iliopsoas, deep trochanteric |
| Deep; knee | Iliotibial tract, fibular collateral ligament, tibial collateral ligament, subfascial prepatellar, popliteal, deep infrapatellar (bilobed shape), gastrocnemius-semimembranosus (Baker cyst), suprapatellar |
| Deep; foot and ankle | Retrocalcaneal (bean shaped) |

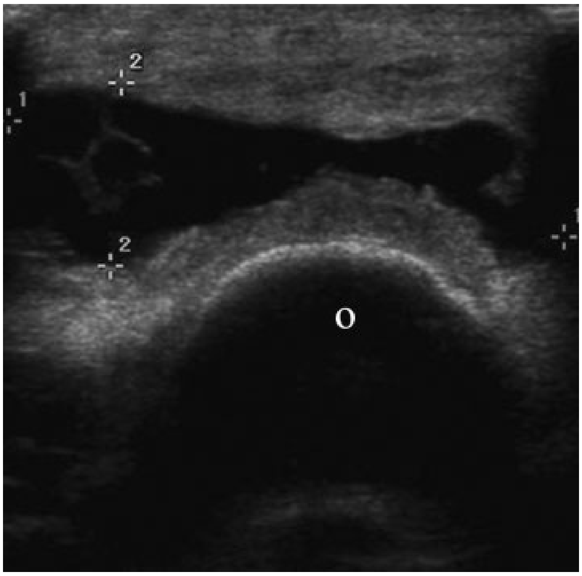



**Figure 4** Olecranon bursitis. Thickened echogenic synovium about a post-traumatic hypoechoic olecranon fluid collection posterior to the olecranon (o) that was easily aspirated and then injected with corticosteroid under ultrasound guidance.

muscle becomes hypoechoic secondary to edema and necrosis.

## Hematoma

The sonographic appearance of hematomas depends on the age and location. Acute and subacute hematomas may be hyperechoic relative to the adjacent muscle and contain fluid-fluid levels due to serum, cellular elements, and fibrin, whereas chronic hematomas are typically hypoechoic but may have a complex or anechoic ("crank case oil") appearance (Fig. 7).[5,6] Doppler ultrasound may be helpful by demonstrating the absence of internal vascularity because the appearance may be difficult to distinguish from a necrotic sarcoma. As well, because the

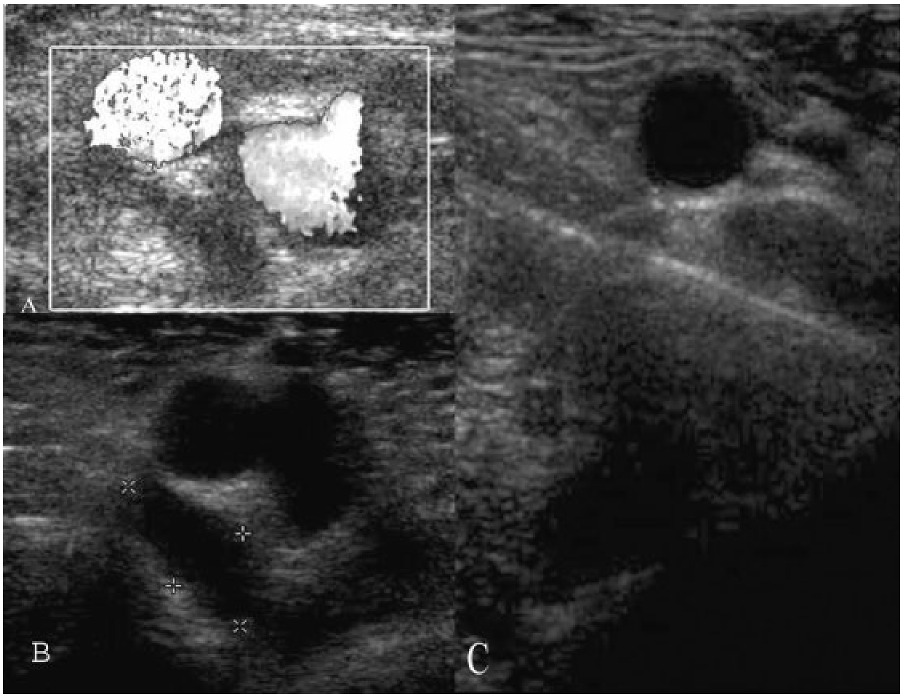



**Figure 5** Iliopsoas bursitis with injection. (A) Color Doppler confirms femoral artery and vein anterior to the (B) hypoechoic elongated fluid collection (white markers) within the iliopsoas bursa. (C) Ultrasound-guided aspiration and injection of the bursal fluid.

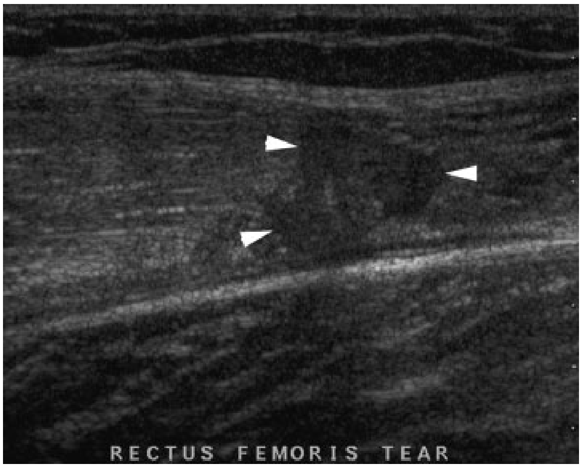



**Figure 6** Rectus femoris muscle tear. Central hypoechoic mixed intramuscular lesion (arrowheads) represents a subacute hematoma with moderate retraction of muscle fibers.

sonographic appearances may be identical to abscess, ultrasound-guided aspiration may be necessary to differentiate between these two entities.

Pseudoaneurysm is a hematoma usually of mixed echogenicity extending from a defect in an adjacent artery caused by trauma or surgery.[1] Color Doppler can help confirm that the mass is vascular and often shows a characteristic jetlike swirl of blood flow at the communicating defect (Fig. 8).

## Myositis Ossificans

Myositis ossificans may occur as a complication of surgery or trauma and is most common in the intramuscular location of the thigh.[17] Initial ultrasound findings are a soft tissue mass with disorganized heterogeneous internal architecture containing echogenic foci and increased vascularity on color Doppler that may be mistaken for a soft tissue tumor. Later scans performed 2 to 6 weeks following injury demonstrate peripheral hyperechoic muscle calcification with posterior acoustic shadowing with intact soft tissue planes and no abnormal soft tissue extending beyond the calcification margins (unlike parosteal sarcoma) (Fig. 9).[18] Ultrasound may detect soft tissue ossifications at an earlier stage than radiographs.

## Fibromatosis Colli

Fibromatosis colli occurs in infants with torticollis and presents clinically as a palpable firm bulge in the center of the sternocleidomastoid muscle. Ultrasound demonstrates focal or diffuse fusiform enlargement of the isoechoic muscle with either a homogeneous or hetero-

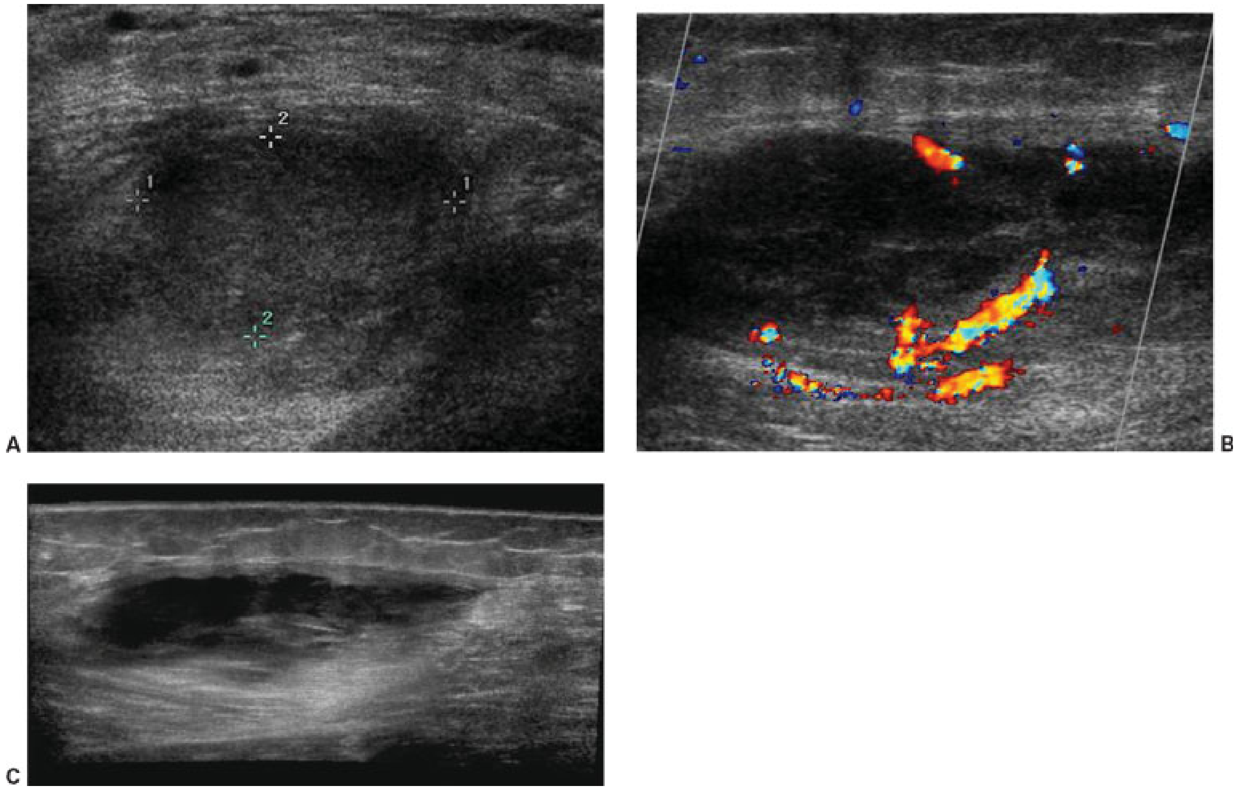



**Figure 7** Intramuscular hematoma of the leg in various stages. (A) Transverse ultrasound image of acute intramuscular ill-defined hematoma with uniform central echogenicity. (B) Intramuscular mixed echogenicity collection representing mixed stages of subacute injury with minimal peripheral vascularity on color Doppler. (C) Anechoic chronic completely liquefied hematoma in the longitudinal plane.

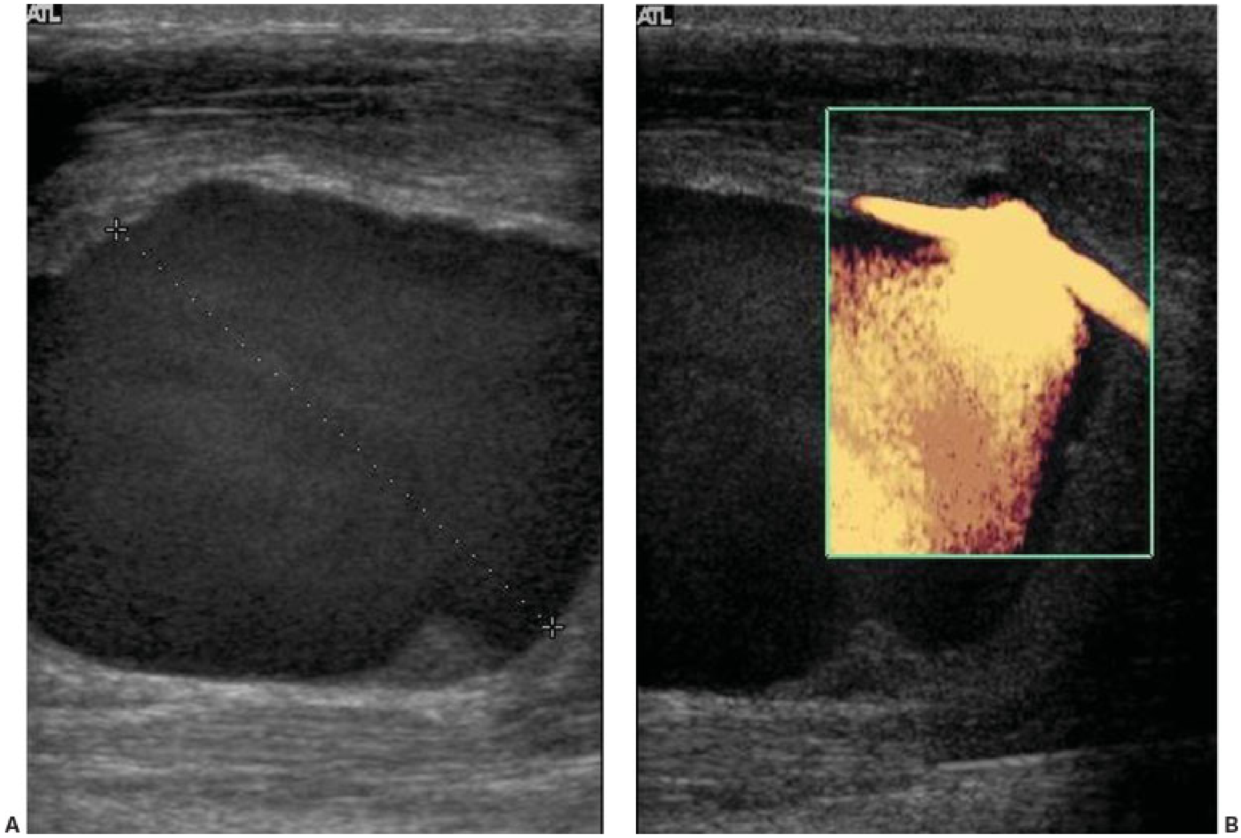



**Figure 8** Pseudoaneurysm. (A) Focal hypo/mixed echogenicity lesion within the upper arm with pulsatile palpable mass clinically after direct injury. (B) Color Doppler confirms a focal wall defect within the ulnar artery with a jet of blood extending into the region of communication with the pseudoaneurysm.

geneous echotexture. Unlike soft tissue sarcoma, the surrounding fascial planes are intact and there is no associated lymphadenopathy.

## INFECTIOUS INFLAMMATORY PROCESSES

Infectious inflammatory masses that may be imaged with ultrasound include abscesses, cellulitis, and focal myositis.

### Cellulitis

Because cellulitis and abscess may have similar clinical physical findings, ultrasound has a role in diagnosis. Cellulitis is an acute infection of skin and the subcutaneous tissues either secondary to direct bacterial inoculation, hematogenous spread, or via continuity from another infective focus. Ultrasound findings are identical to subcutaneous edema presenting as subcutaneous edema with distended hypoechoic branching lymphatic channels interspersed between hyperechoic fatty lobules, often with a cobblestone pattern.

### Abscess

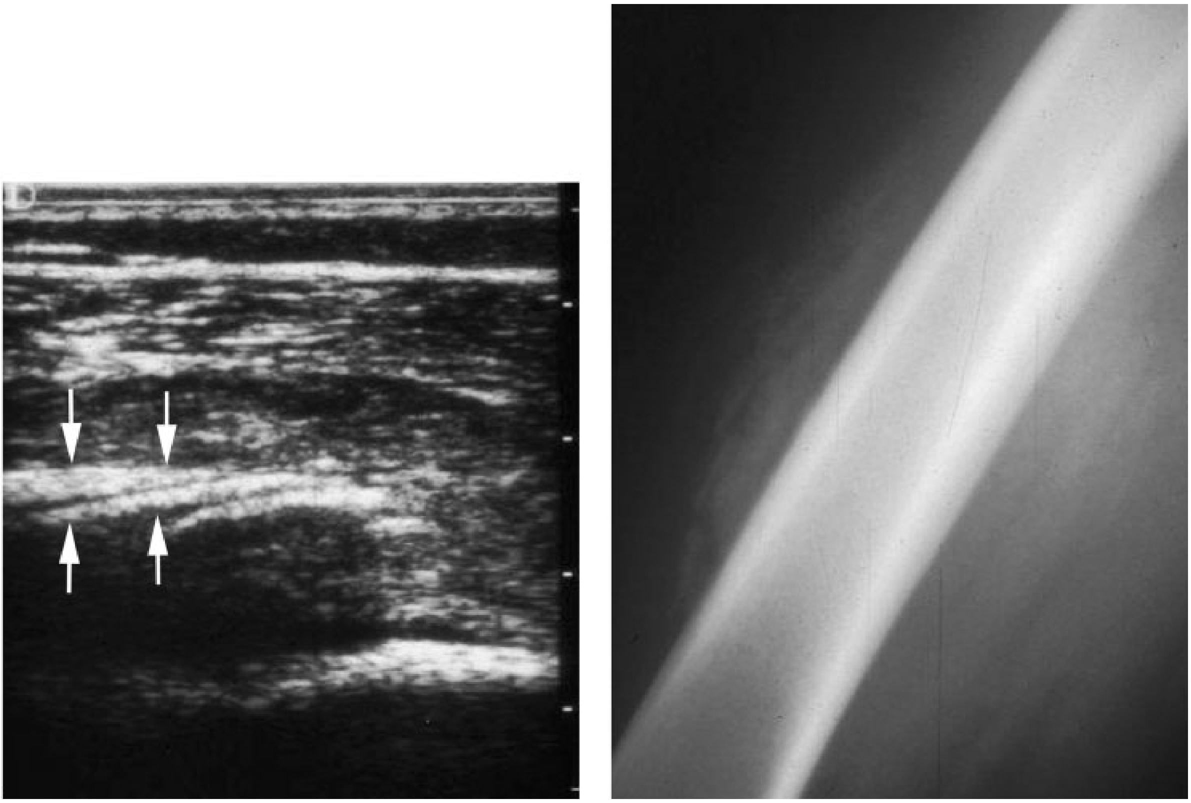
Abscesses have a variable sonographic appearance, ranging from simple anechoic fluid collections to more complex, irregularly walled heterogeneous cystic collections with internal echogenic debris, similar to hematomas (Fig. 10).[19] Color Doppler ultrasound may demonstrate peripheral surrounding hyperemia; however, ultrasound-guided aspiration may be required both for diagnosis and to aid the correct choice of antimicrobial chemotherapy.[20]

### Myositis and Pyomyositis

Myositis may be due to either viral or bacterial infections, with the latter more common in the tropics. Usually the lower limb is affected, initially feeling firm or wood-like and only later becoming fluctuant. Ultrasound can be invaluable in the nonspecific early clinical stages demonstrating hyperechoic muscle fibers separated by hypoechoic distended fibroadipose septae later evolving into a hypoechoic abscess with internal echogenic debris.[19] If the abscess is caused by a gas-forming microbe, echogenic foci with "dirty" posterior shadowing may be seen.

## BENIGN REACTIVE MASSES

Noninfectious inflammatory masses include neuromas, giant cell tumor of the tendon sheath, rheumatoid nodules, granuloma annulare, and foreign body granulomas.

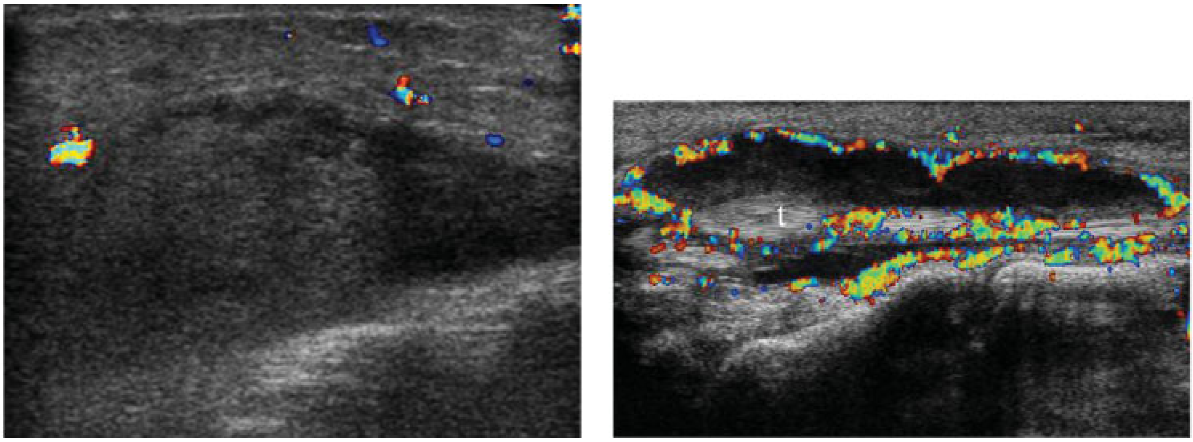


A B

**Figure 9** Myositis ossificans. (A) Highly echogenic linear foci (arrows) within the deep soft tissues of the femur with deeper hypoechoic changes adjacent to the femoral cortex. Ultrasound depicted this ossification prior to visualization of ossification on the femoral radiograph (B).

## Giant Cell Tendon of the Tendon Sheath

Giant cell tendon of the tendon sheath (GCTTS) is the second most commonly encountered hand mass (after ganglion cysts) and considered a localized form of pigmented villonodular synovitis.[11,21] GCTTS presents as a slowly enlarging firm nodule most commonly located on the volar surface of the thumb or index finger at the level of the interphalangeal or distal interphalangeal joint but may also occur in the feet, ankles, or knees.[21] Ultrasound findings are well-defined hypoechoic nodules in close relationship with the intact tendon sheath (Fig. 11) with nearly all having some detectable internal vascularity on color Doppler.[5,22]




A B

**Figure 10** Abscess. (A) Nonspecific heterogeneous mass within the lower leg with hypoechoic asymmetrical inflammatory peripheral margin with mild increased peripheral vascularity. (B) Infected tenosynovitis of the third flexor tendon (t) in the longitudinal plane with color Doppler shows peripheral mild hypervascularity, inflammatory thickening of the synovium, and central hypoechoic mixed mobile fluid.

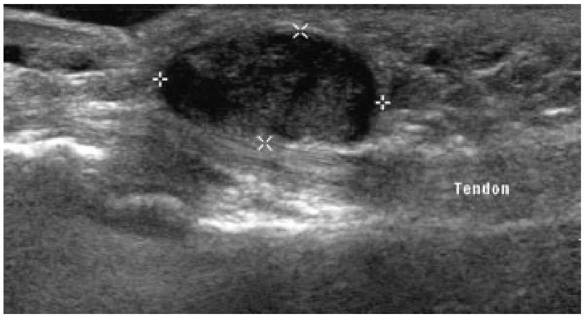



**Figure 11** Giant cell tumor of tendon sheath: Focal hypoechoic nodule intimately associated with the adjacent linear striated tendon is characteristic.

## Neuromas

Postamputation stump neuromas imaged by ultrasound appear as ovoid hypoechoic nodules at the site of amputation (Fig. 12).[22–24] Morton's neuromas are pseudotumors, classically occurring in middle-age women. Repetitive trauma to the neurovascular bundles trapped by the intermetatarsal ligaments leads to perineural fibrosis about the plantar digital nerves most often in the second and third intermetatarsal spaces at the level of the metatarsal heads.[17,23] Ultrasound findings are a hypoechoic well-defined mass that may have associated bursal fluid.[7] Ultrasound's real-time dynamic capabilities means the sonologist can confirm that the detected ultrasound mass correlates to the patient's symptoms by reproducing the patient's characteristic pain by exerting pressure over the mass between the transducer probe and the examiner's fingers on the sole of the foot.

## Granuloma Annulare

Granuloma annulare is an uncommon benign inflammatory dermatosis characterized by localized or generalized papules that may fuse into an annular arrangement

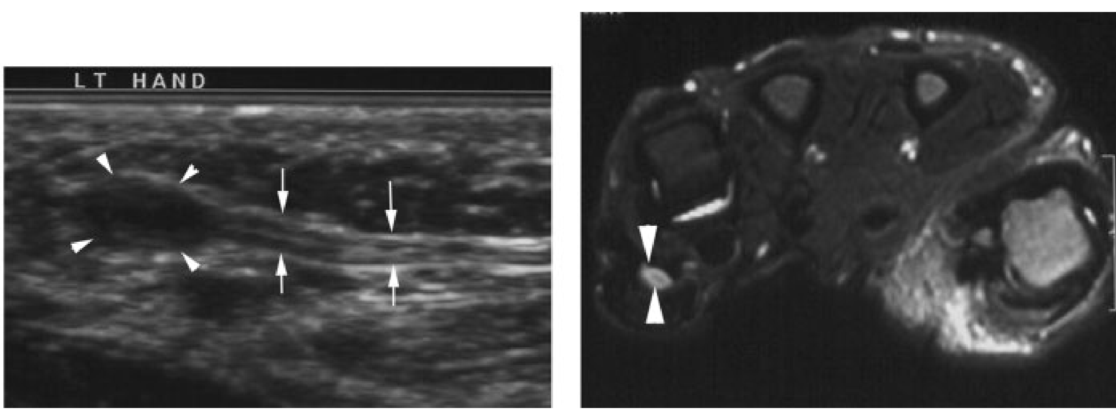



**Figure 12** Stump neuroma post fifth finger amputation. (A) Bulbous hypoechoic terminal stump neuroma (white arrowheads) noted at the end of the linear striated heterogeneous echogenicity nerve (white arrows) at the amputation site. (B) Axial T2-weighted fat-saturated magnetic resonance image depicts a focal abnormal hyperintense signal lesion with a central hypointensity at the same level.

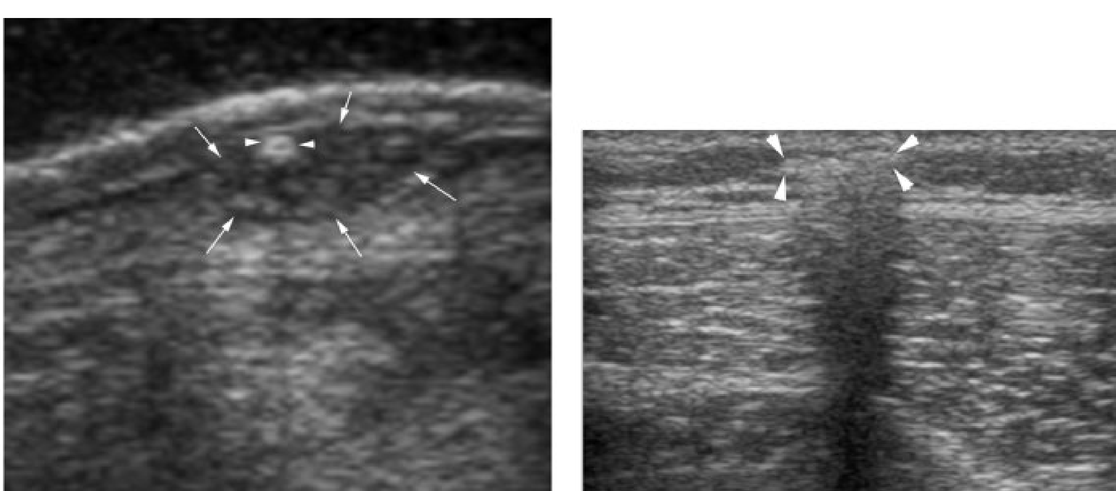


**Figure 13** Foreign body. (A) Posterior acoustic shadowing from an echogenic piece of glass (arrows) in the superficial tissues of the thigh in a patient after a motor vehicle trauma. (B) Hypoechoic inflammatory reaction (arrows) surrounding an echogenic piece of embedded wood (arrowheads) in the subcutaneous tissues of the heel.

and may present in the initial three decades of life as a nonspecific mass. Ultrasound findings are similar to rheumatoid nodules being elongated hypoechoic masses with vascularity identified on color Doppler.

### Foreign Bodies

Radiolucent wood or plastic foreign bodies are visualized by ultrasound as brightly echogenic masses that may or may not have posterior acoustic shadowing (Fig. 13A).[6] An associated inflammatory soft tissue reaction is usually present after 24 hours, appearing as a hypoechoic halo surrounding the foreign body with increased vascularity on color Doppler (Fig. 13B).[1,6,25] The high spatial resolution of ultrasound is important in the detection of small superficial foreign bodies that can be removed with ultrasound guidance.

## BENIGN NEOPLASTIC MASSES

Ultrasound evaluation of a soft tissue tumor includes assessment of its size, margins, vascularity, relationship to adjacent structures, and the number of the lesions. Although ultrasound may be able to give a specific diagnosis in some lesions, often further imaging with CT or MRI is necessary.

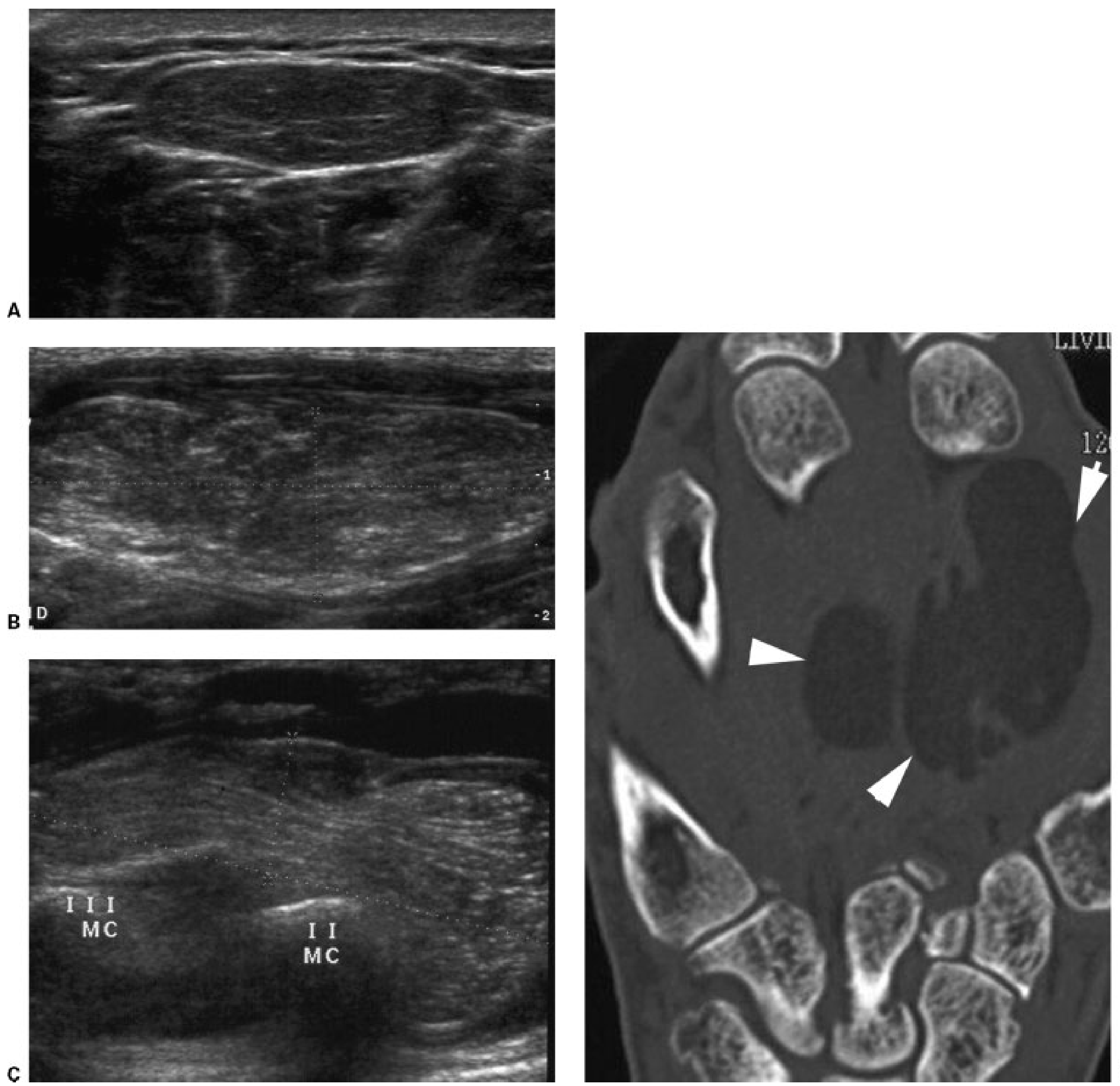
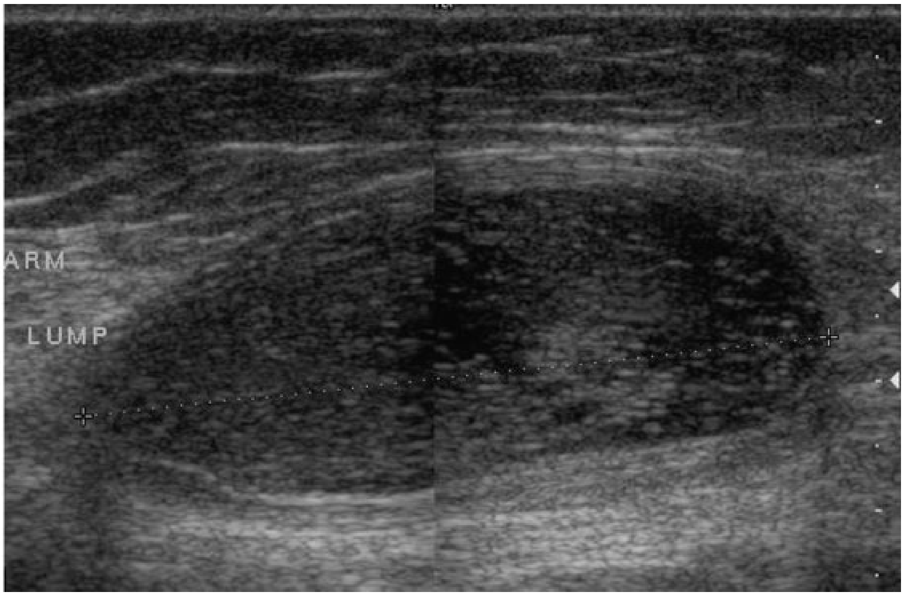



**Figure 14** Lipomatous lesions. (A) Superficial subcutaneous lipoma: An elliptical shaped hypoechoic lesion similar to fat or slightly higher echogenicity to fat with multiple linear striations is typical. (B and C) Larger slightly more hyperechoic lipoma of the dorsum of the hand over the second and third metacarpals with striations interspersed within hypoechoic fat on transverse and longitudinal planes corresponds to a homogeneous low attenuation lipoma (white arrowheads) on nonenhanced coronal computed tomography image (D).




E

**Figure 14** (*Continued*) (E) A deep larger more heterogeneous lesion in another patient proved to be a liposarcoma.

## Lipoma

Lipomas are composed of mature adipose tissue and are the most common benign soft tissue tumor.[11,26] Usually solitary and $< 5$ cm, multiple lipomas may occur in association with a chromosome 12 abnormality.[26] Locations include the superficial subcutaneous soft tissue as well as intra- or intermuscular locations. They often present as a slowly growing mass that may stabilize in size following an initial growth spurt and are usually asymptomatic unless an adjacent neurovascular bundle is compressed. Ultrasound findings include a well-defined mass in the subcutaneous or deeper soft tissues with long axis parallel to the skin surface and variable echogenicity (usually isoechoic or hyperechoic to subcutaneous fat) (Fig. 14).[1–5,26–29] The presence of heterogeneous solid components in the fatty mass or increased vascularity with color Doppler should raise concern for low-grade liposarcoma (Fig. 14E), particularly if the mass is deep in location and $> 8$ cm.[28]

## Hemangiomas and Other Vascular Malformations

Hemangiomas are the most common benign soft tissue lesion in the pediatric population and should be considered in children presenting with a mass with pain on exercise (believed to be caused by hypoxic effects of the adjacent muscles on the hemangioma).[10] They represent 7% of all benign tumors in adults (women more than men).[11] Depending on the predominant vessel type, hemangiomas may be divided into five types, including capillary and cavernous. Hemangiomas may be either superficial (subcutaneous) or deep (intramuscular) in location. Capillary hemangiomas are often superficial, spontaneously regress, and on ultrasound appear as hypoechoic or hyperechoic masses with little or no flow on color Doppler. Cavernous hemangiomas are often larger and have a heterogeneous echotexture with hypoechoic vascular channels and hyperechoic foci representing either calcified phleboliths or fat within them (Fig. 15).[1–6,30] Their borders may not always be well defined. Arteriovenous hemangiomas have high-velocity arterial-type Doppler flow patterns on color Doppler in addition to arteriovenous shunting. Lymphangiomas present as compressible soft masses in children that may be present at birth located in the axillae, the neck, or back. The ultrasound appearance depends on whether they are microcytic or macrocytic, and they usually are avascular on color Doppler.

## Benign Nerve Sheath Tumors

Schwannomas (nerve sheath lesions) are well-encapsulated lesions that arise from the Schwann cells of the nerve sheath. They are slightly less common than neurofibromas (nerve lesions) that are encapsulated, contain reactive fibroblasts, mast cells, and collagen, and often infiltrate the nerve separating the nerve fascicles.[23] It is difficult to distinguish these lesions from one another by ultrasound. Both have an equal incidence in the sexes and present as slowly growing soft tissue lesions. The majority of neurofibromas are solitary and not associated with neurofibromatosis syndromes. Neurogenic tumors have a characteristic ultrasound appearance as well-defined round or fusiform hypoechoic heterogeneous masses (due to multiple nerve fascicles) with posterior acoustic enhancement located in the appropriate nerve distribution.[31] A specific diagnosis can be made if the hypoechoic nerve is identified entering and exiting the mass (Fig. 16).[23]

## Fibromatoses

The fibromatoses are a family of benign fibrous tissue proliferation with biological behavior in between benign fibrous lesions and fibrosarcoma.[11] These may either be superficial (plantar fibromatosis or Dupuytren's contracture, Fig. 17) or deeply located (extra-abdominal desmoid tumor).[32] Plantar fibromatosis is a localized nodular fibrous proliferation of the plantar fascia that presents as a painful hypoechoic subcutaneous nodule in the mid or medial sole of the foot aggravated by walking and is bilateral in 20 to 50%.[32–34]

Extra-abdominal desmoid tumors are benign myofibroblastic lesions that originate from the muscle aponeurosis superficial to the abdominal cavity.[32] Although not malignant, they are locally invasive and recur following surgery. Ultrasound appearances are that of an ill-defined, irregular, infiltrative hypoechoic mass.

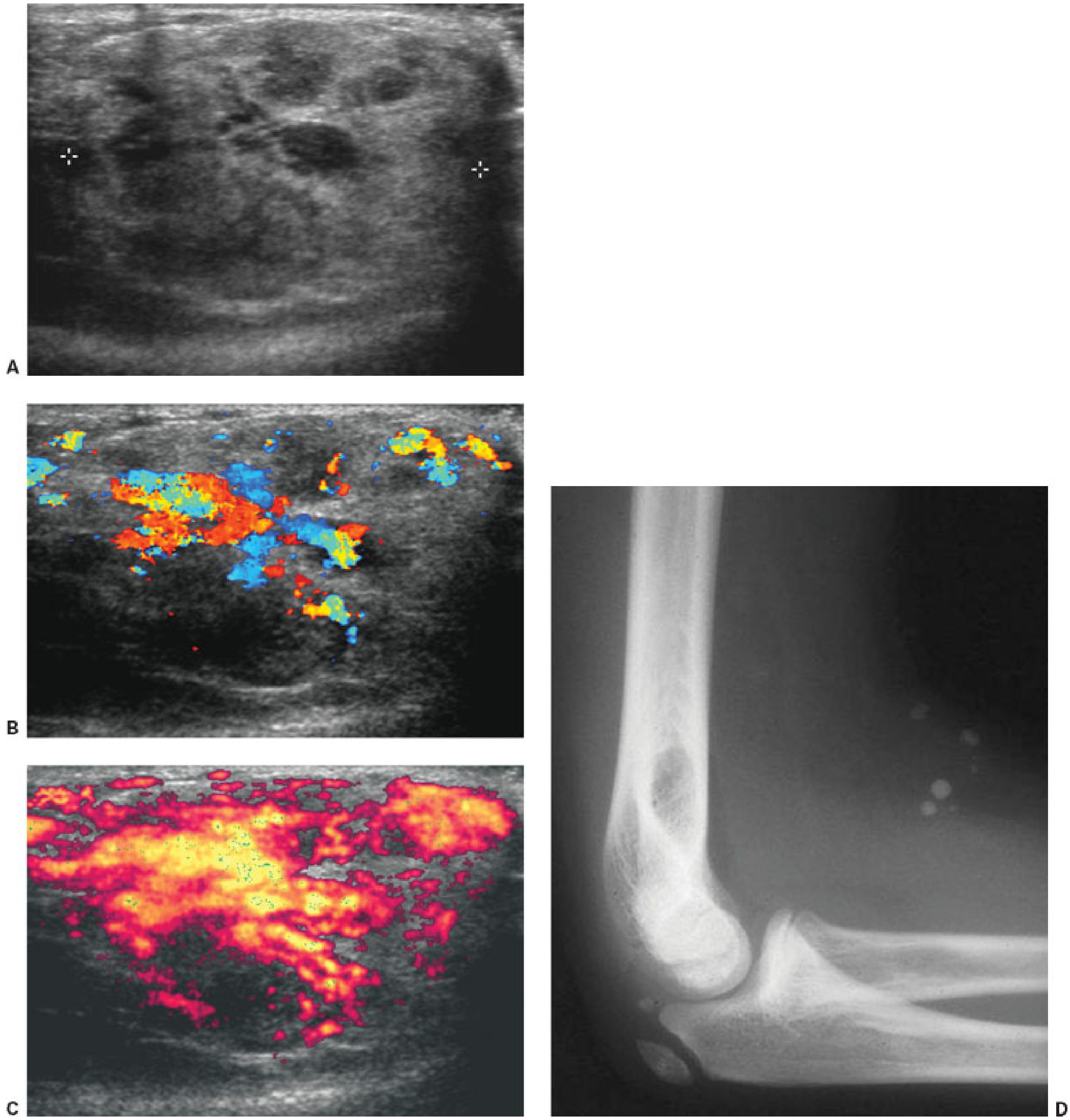
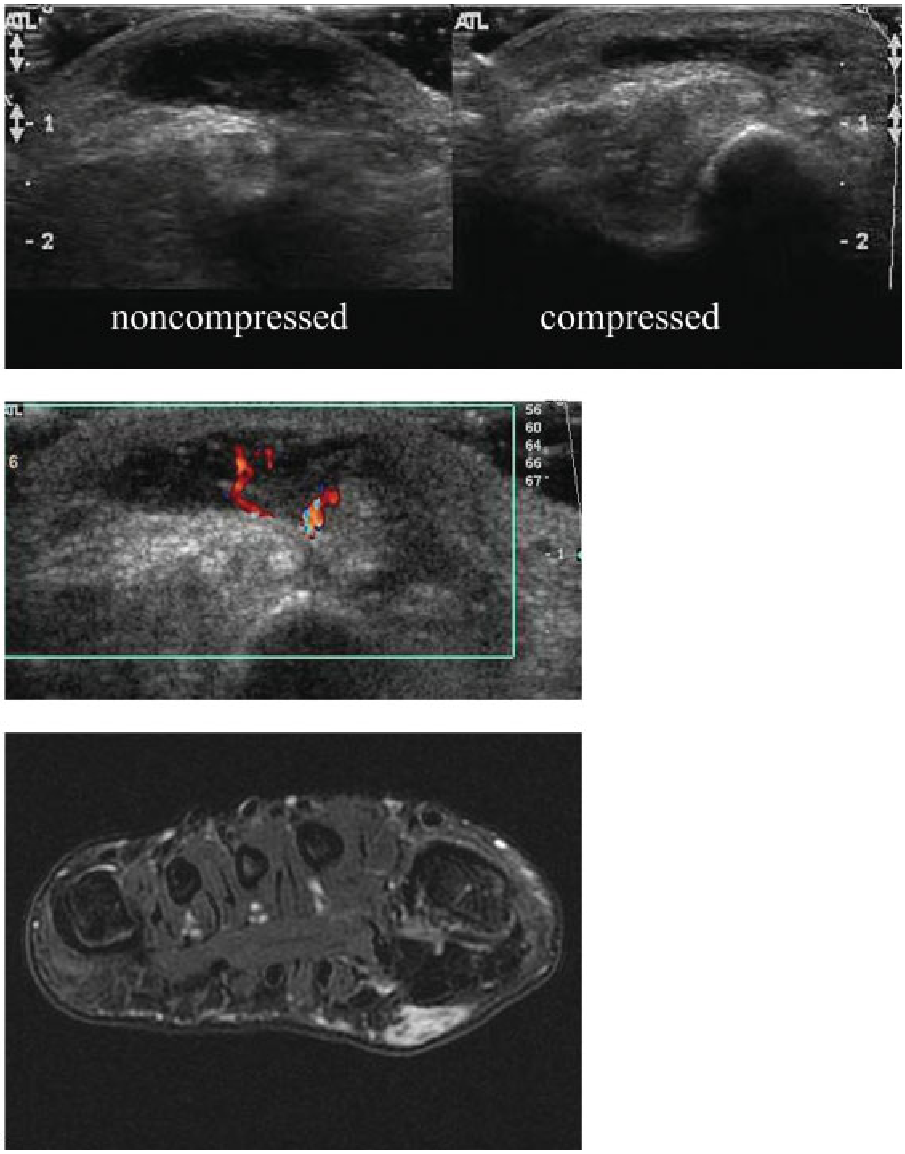



**Figure 15** Hemangioma. Palpable solitary lesion of the forearm in a 14-year-old girl. (A) Mixed hypoechoic pattern and multiple cystic hypoechoic vessels that compressed on real-time imaging. (B) Color Doppler and (C) power Doppler imaging confirm a highly vascular cavernous hemangioma. (D) Multiple phleboliths in another patient are visible radiographically.




E

F

G

**Figure 15** (*Continued*) Hemangioma. Another patient with a hemangioma of the plantar aspect of the foot. (E) Real-time compression of a predominantly hypoechoic subcutaneous lesion demonstrating (F) mild vascularity on color Doppler and (G) mixed signal intensity (fat and vessels) on axial T2-weighted fat-saturated magnetic resonance image. (Plantar hemangioma images courtesy of Donna Blankenbaker, M.D., Department of Diagnostic Radiology, University of Wisconsin School of Medicine and Public Health.)

## Myxoma

Soft tissue myxomas arise from fibroblasts with excessive mucopolysaccharide production most commonly found within the thigh, upper arm, calf, and gluteal muscles.[11] Ultrasound findings are an encapsulated, fluctuant hypoechoic mass with cystic areas.[5] Differentiation from a low-grade myxoid liposarcoma may be difficult.

## Glomus Tumors

Glomus tumors are usually small lesions that arise from the subungual neuromyoarterial glomus of the fingers and are typically seen as a small rounded lesion beneath the fingernail with increased blood flow on color Doppler.

## Pseudotumors

Elastofibroma dorsi occurs in elderly patients in a characteristic location at the inferior scapula pole, deep to the scapula, serratus anterior, and latissimus dorsi and superficial to the bony thoracic cage. Ultrasound appearances re also characteristic with curvilinear hyperechoic atty areas interspersed within echogenic fatty tissue.[35] Dynamic evaluation of the shoulder in abduction may make this mass more conspicuous.

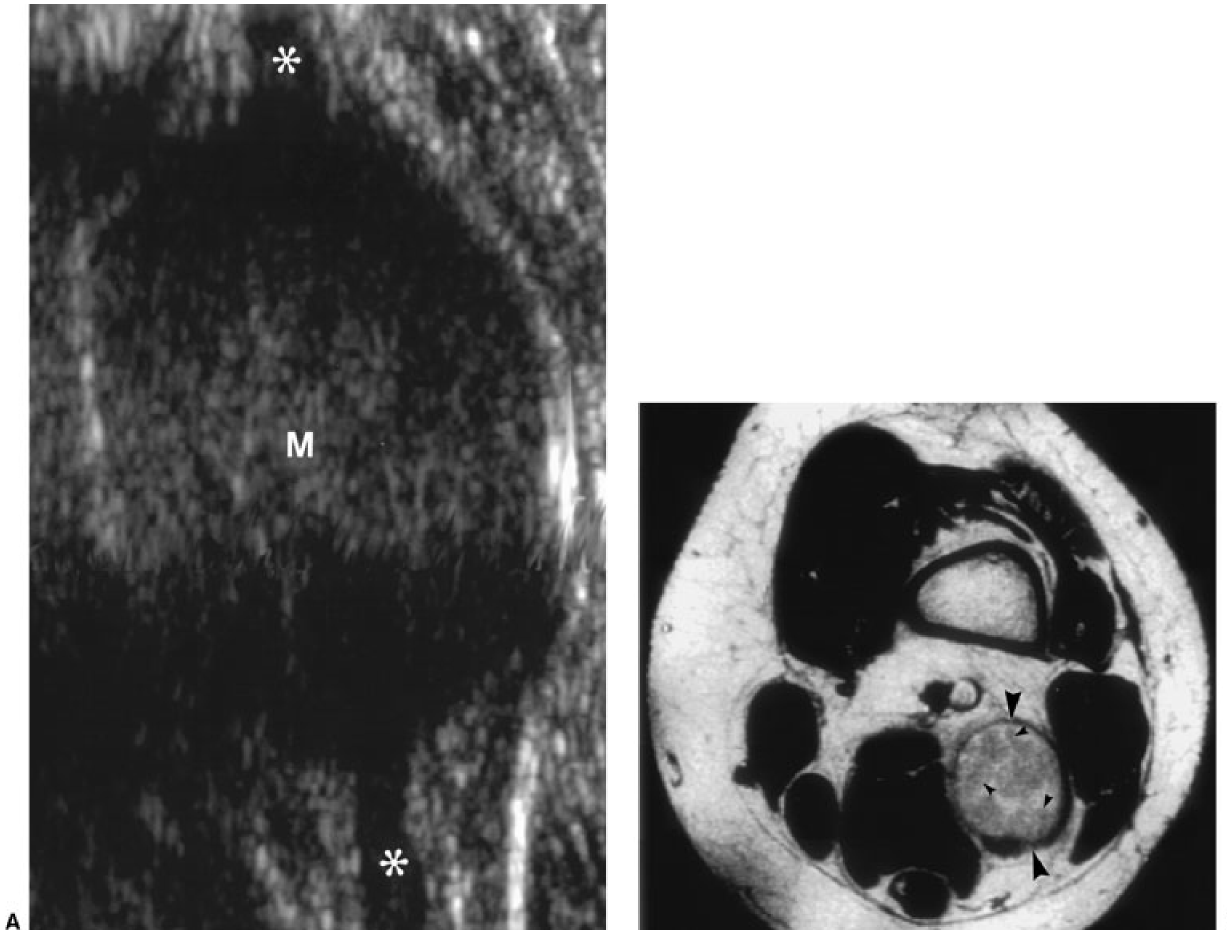



**Figure 16** Peroneal neurilemoma (schwannoma). (A) Fusiform focal hypoechoic mixed lesion (M) with entering and exiting central nerve roots (asterisks) (making it hard to differentiate from neurofibroma) in an intermuscular location displacing echogenic fat. (B) Axial T2-weighted magnetic resonance image shows the intermuscular lesion within the capsule (large black arrowheads) with typical fascicular sign (small black arrowheads) confirming a neurogenic lesion. (Reprinted with permission from Murphey MD, Smith S, Smith SE, Kransdorf MJ, Temple T. Imaging of musculoskeletal neurogenic tumors: radiologic-pathologic correlation. Radiographics 1999;19:1253–1280.)

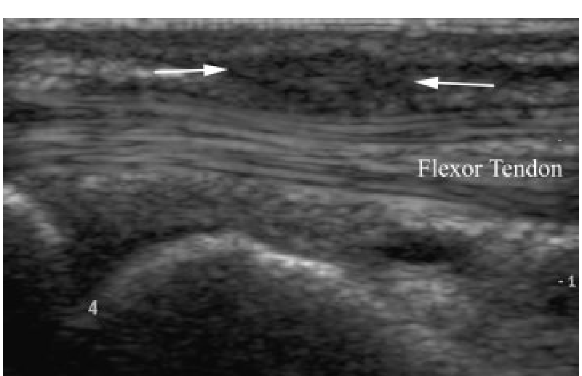



**Figure 17** Fibromatosis. Rounded hypoechoic solid fibroma (arrows) on the palmar aspect of the flexor tendon is the earliest sign of Dupuytren's contracture of the hand. A plantar fibroma of the foot would be intimately related to the plantar fascia and have a similar appearance on ultrasound.

Tumoral calcinosis is characterized by accumulation of calcium salts in juxta-articular soft tissues, usually adjacent to the trochanters, olecranon process, or the shoulders. Ultrasound findings are that of an echogenic soft tissue mass with posterior acoustic shadowing and no associated soft tissue component.

Prominent central hilar echogenic fat in a lenticular hypoechoic smooth bean-shaped mass is characteristic of a lymph node. Enlarged size, heterogenicity, and irregularity suggesting necrosis raise the possibility of neoplastic involvement rather than a simple reactive or inflammatory node.

## MALIGNANT TUMORS

Malignant soft tissue tumors are either primary or metastatic in origin. Of the primary soft tissue tumors, sarcomas are the most commonly encountered with

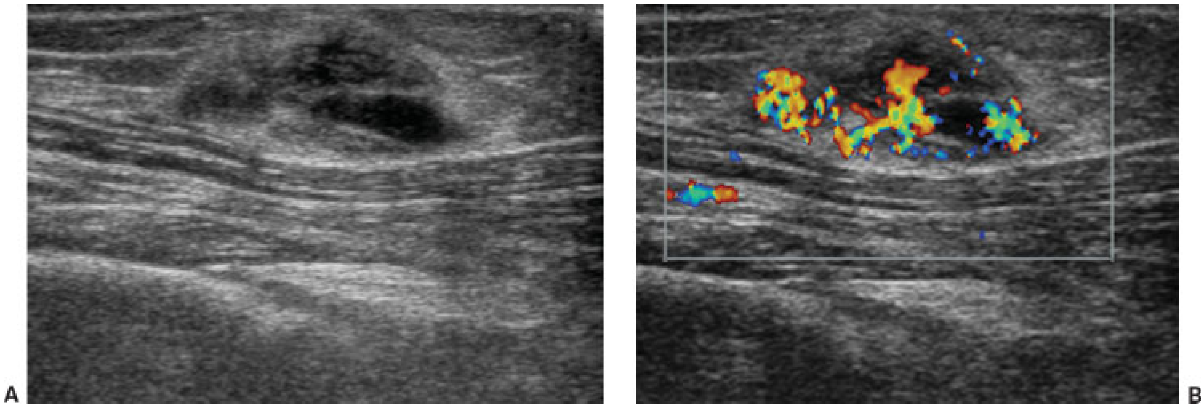


**Figure 18** Forearm soft tissue myeloma. (A) Predominantly hypoechoic lesion with hyperechoic septae and margins with increased vascularity on color Doppler (B) is nonspecific. Biopsy-proven myeloma.

increasing frequency with increasing age. Rhabdomyosarcoma is the most common soft tissue sarcoma in childhood and adolescents; malignant fibrous histiocytoma is the most common sarcoma in adults 50 to 70 years of age, followed by liposarcoma (Fig. 14E).

The sonographic appearances of soft tissue sarcomas or, less commonly, a metastatic lesion may be

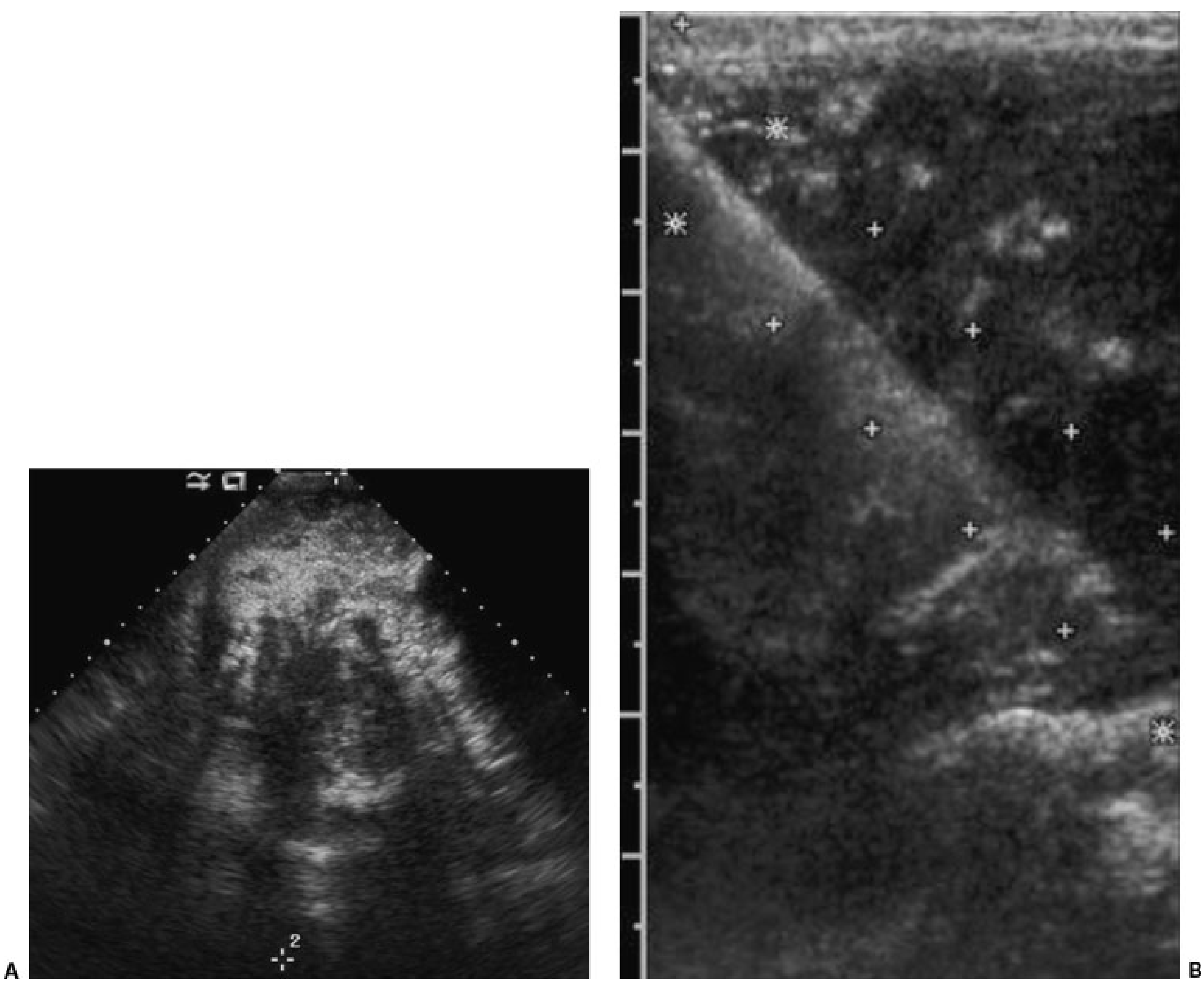


**Figure 19** Osteosarcoma. (A )Widespread highly echogenic foci (ossification) throughout a large heterogeneous palpable and painful upper arm mass in a 14-year-old boy. (B) Image from real-time ultrasound-guided biopsy of the mass depicts multiple echogenic foci with needle tip noted adjacent to the humeral cortex.

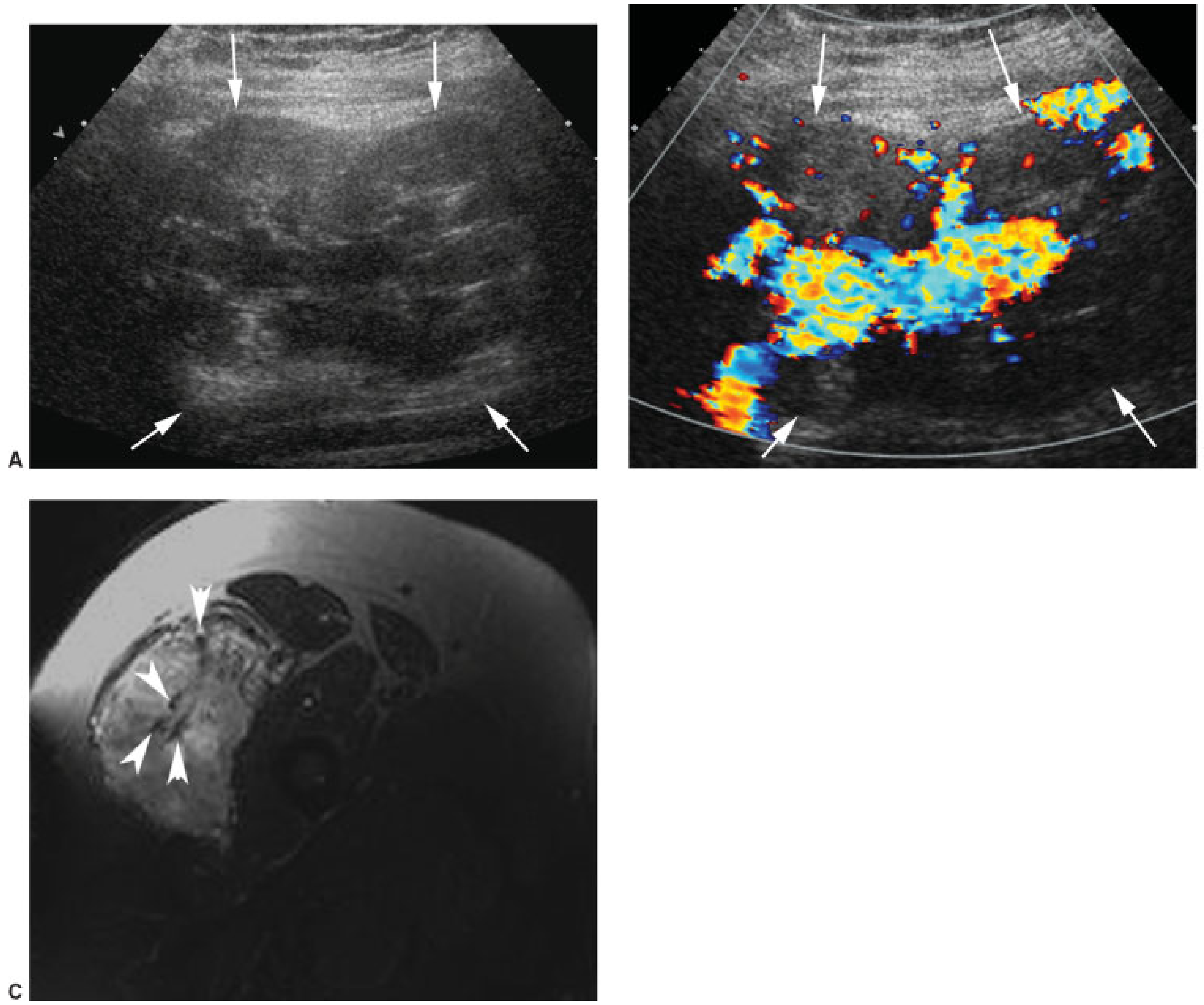



**Figure 20** Alveolar soft part sarcoma of the thigh. (A) A 32-year-old man demonstrates a large lobular irregular peripherally iso/hypoechoic soft tissue mass with large central hypoechoic feeding vessels within the vastus lateralis muscle. (B) Color Doppler confirms the prominent central vascularity characteristic of this malignant lesion and can help guide biopsy away from the large vascular structures. (C) Multiple feeding vessels, seen as hypointense signal voids (white arrowheads) within the edematous mass lesion, are confirmed on an axial T2-weighted magnetic resonance image.

nonspecific, being a hypoechoic mass with increased vascularity on color Doppler (Fig. 18).[1–6] Anechoic regions within the tumor correspond to areas of necrosis. Hyperechoic foci of calcification or ossification (i.e., chondrosarcomas or osteosarcomas) may demonstrate posterior acoustic shadowing (Fig. 19). Findings more indicative of a malignant soft tissue mass include irregular margins, heterogeneous echotexture, and infiltration of adjacent soft tissue structures resulting in architectural distortion (Fig. 20).[29] The extent of tumor vascularity demonstrated by color or power Doppler depends on the degree of neovascularization, which may vary considerably. Two types of blood flow have been described in soft tissue sarcomas: high-velocity systolic arterial flow with enhanced diastolic flow (secondary to arteriovenous shunting) (Fig. 20C) or low-velocity flow with subtle systolic-diastolic variation within thin-walled venous sinusoids. Although early reports suggested that color and power Doppler ultrasound may distinguish malignant from benign tumors, other authors have not found the differences in blood flow patterns or resistive indexes to be a useful differentiating feature in benign and malignant soft tissue tumors.[36] Ultrasound does have an important role in the biopsy of malignant soft tissue masses, following consultation with the operating orthopaedic surgeon. The use of color Doppler may enhance the biopsy yield by guiding selective targeting of the regions of the mass demonstrating increased blood flow, thus avoiding necrotic or cystic regions. Unlike CT or MRI, ultrasound is a portable modality that allows biopsy approaches to the lesions in multiple imaging planes, free of the constraints that may occur due to the CT or MRI scanner gantry.

Ultrasound has proven to play a role in monitoring tumor stability versus recurrence following surgery or chemotherapy; however, there are concerns regarding

**Figure 21** Postsurgical assessment of gluteal region. Patient with previous dermatofibrosarcoma protuberans resection demonstrates linear mildly hypoechoic fibrous scar (markers) in the superficial fat without recurrence or residual tumor.

operator dependency and interobserver variability.[37–39] The lack of formal imaging planes with ultrasound may make longitudinal comparison studies more difficult. However, in some cases where orthopaedic hardware produces substantial artifacts on MRI or CT, ultrasound may be able to demonstrate a hypoechoic mass with increased peripheral vascular flow that was not present on the initial baseline postoperative scan performed within 4 weeks of surgery. It can be useful in confirming focal fibrous scar at the site of surgery rather than recurrent mass (Fig. 21).

## CONCLUSION

Ultrasound has proven to be a useful modality for confirmation, initial assessment, evaluation, as well as therapeutic and diagnostic interventions of soft tissue masses. It has also shown areas of utility in assessing the postoperative patient.

## REFERENCES


1. McNally EG. Practical Musculoskeletal Ultrasound. Philadelphia: Elsevier; 2005
2. van Holsbeeck M, Introcaso JH. Musculoskeletal Ultrasound. St. Louis: Mosby-Year Book; 2001
3. Fornage BD. Soft tissue masses: the underutilization of sonography. Semin Musculoskelet Radiol 1999;3:115–134
4. Beggs I. Ultrasound of soft tissue masses. Imaging 2002;14:202–208
5. Hwang S, Adler RS. Sonographic evaluation of the musculoskeletal soft tissue masses. Ultrasound Q 2005;21:259–270
6. Lin J, Jacobson JA, Fessell DP, Weadock WJ, Hayes CW. An illustrated tutorial of musculoskeletal sonography. Part 4, Musculoskeletal masses, sonographically guided interventions, and miscellaneous topics. AJR Am J Roentgenol 2000;175:1711–1719
7. Adler RS, Softka CM. Percutaneous ultrasound-guided injections in the musculoskeletal system. Ultrasound 2003;19:3–12
8. Westhoff B, Wild A, Werner A, Schneider T, Kahl V, Krauspe R. The value of ultrasound after shoulder arthroplasty. Skeletal Radiol 2002;31:695–701
9. Teh J. Applications of Doppler imaging in the musculoskeletal system. Curr Probl Diagn Radiol 2006;35:22–34
10. Bellah R. Ultrasound in pediatric musculoskeletal disease: techniques and applications. Radiol Clin North Am 2001;39(4):597–618
11. Kransdorf MJ, Murphey MD, Smith SE. Imaging of soft tissue neoplasms in the adult: benign tumors. Semin Musculoskelet Radiol 1999;3:21–37
12. Winter TC, Teefey SA, Middleton WD. Musculoskeletal ultrasound: an update. Radiol Clin North Am 2001;39(3):465–483
13. Tshering Vogel DW, Steinbach LS, Hertel R, Bernhard J, Stauffer E, Anderson SE. Acromioclavicular joint cyst: nine cases of a pseudotumor of the shoulder. Skeletal Radiol 2005;34:260–265
14. Cardinal E, Buckwalter KA, Braunstein EM, Mih AD. Occult dorsal carpal ganglion: comparison of US and MR imaging. Radiology 1994;193(1):259–262
15. Jacobson JA. Ultrasound in sports medicine. Radiol Clin North Am 2002;40:363–386
16. Harish S, Saifuddin A, Bearcroft PWP. Soft-tissue masses in the shoulder girdle: an imaging perspective. Eur Radiol 2007;17:768–783
17. Siegel MJ. Magnetic resonance imaging of musculoskeletal soft tissue masses. Radiol Clin North Am 2001;39(4):701–720
18. Fornage BD, Eftekhari F. Sonographic diagnosis of myositis ossificans. J Ultrasound Med 1989;8(8):463–466
19. Cardinal E, Bureau NJ, Aubin B, Chhem RK. Role of ultrasound in musculoskeletal infections. Radiol Clin North Am 2001;39(2):191–201
20. Kothari NA, Pelchovitz DJ, Meyer JS. Imaging of musculoskeletal infections. Radiol Clin North Am 2001;39(4):653–671
21. Adler RS, Finzel KC. The complementary roles of MR imaging and ultrasound of tendons. Radiol Clin North Am 2005;43:771–807
22. Bancroft LW, Peterson JJ, Kransdorf MJ, Nomikos GC, Murphey MD. Soft tissue tumors of the lower extremities. Radiol Clin North Am 2002;40:991–1011
23. Murphey MD, Smith WS, Smith SE, Kransdorf MJ, Temple T. From the archives of the AFIP: Imaging of musculoskeletal neurogenic tumors: radiologic-pathologic correlation. Radiographics 1999;19:1253–1280
24. Ernberg LA, Adler RS, Lane J. Ultrasound in the detection and treatment of a painful stump neuroma. Skeletal Radiol 2003;32:306–309
25. Jacobsen JA, Powell A, Craig JG, Bouffard JA, van Holsbeeck MT. Wooden foreign bodies in soft tissue: detection at US. Radiology 1998;206:45–48
26. Weiss SW. Lipomatous tumors. Monogr Pathol 1996;38:207–239
27. Inampudi P, Jacobson A, Fessell DP, et al. Soft-tissue lipomas. Accuracy of sonography in diagnosis with pathologic correlation. Radiology 2004;233(3):763–767
28. Murphey MD, Arcara LK, Fanburg-Smith J. From the archives of the AFIP: imaging of musculoskeletal liposarcoma

with radiologic pathologic correlation. Radiographics 2005;25: 1371–1395
29. Gielen J, Ceulemans R, van Holsbeeck M. Ultrasound of Soft Tissue Tumors in Imaging of Soft Tissue Tumors. 3rd ed. Berlin: Springer; 2006:3–18
30. Olsen KI, Stacy GS, Montag A. Soft tissue cavernous hemangioma. Radiographics 2004;24:849–854
31. Reynolds DL, Jacobson JA, Inampudi P, et al. Sonographic characteristics of peripheral nerve sheath tumors. AJR Am J Roentgenol 2004;182:741–744
32. Robbin MR, Murphey MC, Temple HT, et al. Imaging of musculoskeletal fibromatosis. Radiographics 2001;21:585–600
33. Griffith JF, Wong TY, Wong SM, et al. Sonography of plantar fibromatosis. AJR Am J Roentgenol 2002;179:1167–1172
34. Rawool NM, Nazarian LN. Ultrasound of the ankle and foot. Semin Ultrasound CT MR 2000;21(3):275–284
35. Dalal A, Miller TT, Kenan S. Sonographic detection of elastofibroma dorsi. J Clin Ultrasound 2003;31:375–378
36. Kaushik S, Miller TT, Nazarian LN, Foster WC. Spectral Doppler sonography of musculoskeletal soft tissue masses. J Ultrasound Med 2003;22(12):1333–1336
37. Arya S, Nagarkatti DG, Dudhat SB, et al. Soft tissue sarcomas: ultrasonographic evaluation of local recurrences. Clin Radiol 2000;55:193–197
38. Kransdorf MJ, Murphey MD. Soft tissue tumors: post treatment imaging. Radiol Clin North Am 2006;44(3):463–472
39. Sofka CM. Optimizing techniques for musculoskeletal imaging of the postoperative patient. Radiol Clin North Am 2006;44:323–329