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Imaging Features of Soft Tissue Tumor Mimickers: A Pictorial Essay

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Abstract

Soft tissue lesions are commonly encountered and imaging is an important diagnostic step in the diagnosis and management of these lesions. While some of these lesions are true neoplasms, others are not. These soft tissue tumor mimickers can be due to a variety of conditions including traumatic, iatrogenic, inflammatory/reactive, infection, vascular, and variant anatomy. It is important for the radiologist and clinician to be aware of these common soft tissue tumor mimickers and their characteristic imaging features to avoid unnecessary workup and provide the best treatment outcome.

Keywords
- soft tissue tumors
- tumor mimickers
- magnetic resonance imaging
- computed tomography
- ultrasound

Introduction

Radiologists are often asked to assess soft tissue lesions during routine clinical practice since imaging is important in helping to arrive at the correct diagnosis and guide treatment. While some soft tissue lesions are true neoplasms, others are not. Many of these soft tissue tumor mimickers can be left alone and no treatment is necessary; however, in other cases, they can indicate a significant disease process. Imaging plays a crucial role in the diagnosis, management, and treatment plan for these lesions and ultrasound (US) and magnetic resonance imaging (MRI) are the best imaging modalities. It is important to be aware of these soft tumor mimickers as subjecting patients to inappropriate workup can lead to misdiagnosis, unnecessary medical tests, and produce anxiety for both the patient and physician. These soft tissue tumor mimickers can be grouped into six main categories (►**Table 1**): traumatic, iatrogenic, inflammatory, infectious, vascular, and variant anatomy. The purpose of this pictorial essay is to review the common soft tissue tumor mimickers with emphasis on their characteristic imaging and clinical features. We also highlight any pitfalls that can complicate accurate diagnosis.

Traumatic

Hematoma

A hematoma is a collection of blood products outside of blood vessels and can occur following trauma, with anticoagulation medication, from surgery, or in hemorrhagic tumors.[1] The patient often presents with an enlarging soft tissue mass that can be painful. Hematomas can have a complex appearance on imaging, which depends on the age of the blood products; however, a key feature of hematomas is the lack of internal vascularity which can help distinguish it from a true neoplasm. Hematomas on US appear as avascular echogenic masses early on, and can contain a variable amount of internal echoes during the first month.[2] Over time, the hematoma should decrease in size and complexity, becoming anechoic. On computed tomography (CT), hematomas often appear as nonenhancing heterogeneous masses with attenuation like muscle. Hematomas

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Table 1 Common lesions mimicking soft tissue tumors

Traumatic	● Hematoma ● Myositis ossificans ● Morel-Lavallée lesion ● Fat necrosis ● Muscle tear/strain and tendon ruptures
Iatrogenic	● Seroma ● Scar tissue ● Scar endometrioma ● Gossypiboma
Inflammatory/Reactive	● Foreign body granuloma ● Gouty tophi ● Bursitis ● Rheumatoid nodule ● Amyloid arthropathy ● Intramuscular sarcoid granuloma ● Synovial and ganglion cysts ● Epidermoid and sebaceous cysts
Infection	● Soft tissue abscess ● Cat-scratch disease ● Pyomyositis and infectious myositis
Vascular	● Pseudoaneurysm ● Myonecrosis
Variant Anatomy	● Accessory muscles

will have decreasing density over time as the blood products liquify which can be quantified with Hounsfield units. On MRI, hematomas will have a range of signal intensities depending on the age. Subacute soft tissue hematomas (►**Fig. 1**) typically have high T1 signal intensity that does not suppress with fat-suppression images, due to the release of methemoglobin from red blood cell breakdown.[2] Chronic hematomas can have a hemosiderin rim which can be detected with a gradient echo recall sequence. Administering contrast is helpful in showing the characteristic peripheral rim enhancement of the hematoma. An important pitfall is that hematomas can hide an underlying hemorrhagic tumor (►**Fig. 2**). Thus, it is important to evaluate the entire mass for nodular or mass-like enhancement. Hematomas should be followed clinically or with serial imaging exam until the mass has resolved.[3]

Myositis Ossificans

Myositis ossificans is a form of heterotopic ossification with formation of mature lamellar bone, usually located in the large skeletal muscles of the extremities. A palpable mass can be appreciated with associated pain and swelling. It typically occurs after trauma; however, many patients do not recall an inciting event.[4] Myositis ossificans can also occur in non-traumatic conditions, including burns, paraplegia, surgery, traumatic brain injury, hemophilia, polio, ankylosing

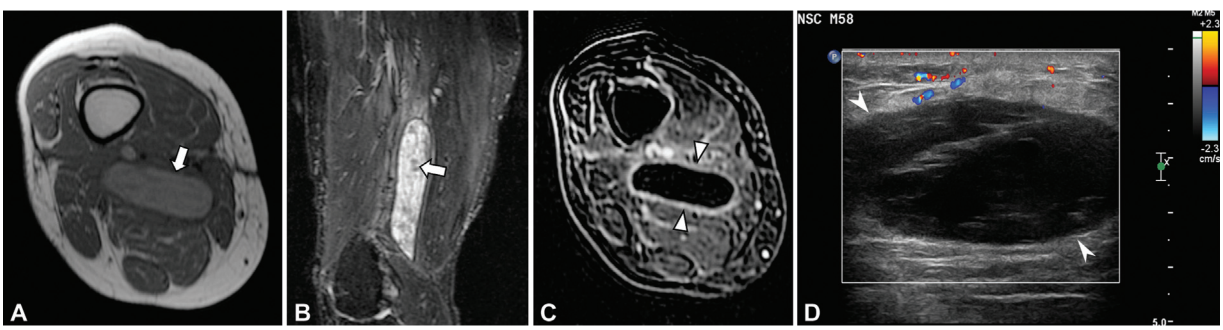

Fig. 1 A 48-year-old woman with posterior thigh mass (*arrows*) 3 months following a fall. The mass is hyperintense to muscle on the (**A**) axial T1 fat-suppressed magnetic resonance (MR) image and heterogeneously hyperintense on the (**B**) sagittal short-tau inversion recovery (STIR) MR image. On the (**C**) postcontrast subtraction image, there is only thin peripheral enhancement (*arrowheads*) consistent with a hematoma. (**D**) Color Doppler image shows a heterogeneous hypoechoic mass (*pointed arrows*) with peripheral vascularity.

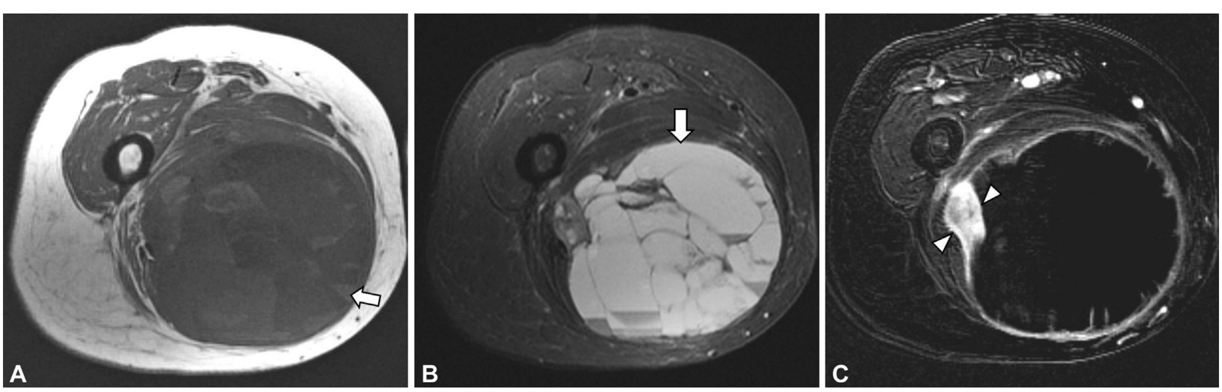

Fig. 2 A 45-year-old man with enlarging thigh mass (*arrows*) without history of prior trauma. (**A**) Axial T1 magnetic resonance (MR) image shows a large heterogeneous mass in the medial thigh containing areas of high T1 signal compatible with blood products. (**B**) Axial short-tau inversion recovery (STIR) image shows heterogeneous hyperintensity within the mass with fluid-fluid levels. (**C**) Postcontrast subtraction MR image shows a nodular area (*arrowheads*) of enhancement in the periphery of the hematoma; a pleomorphic leiomyosarcoma on biopsy.

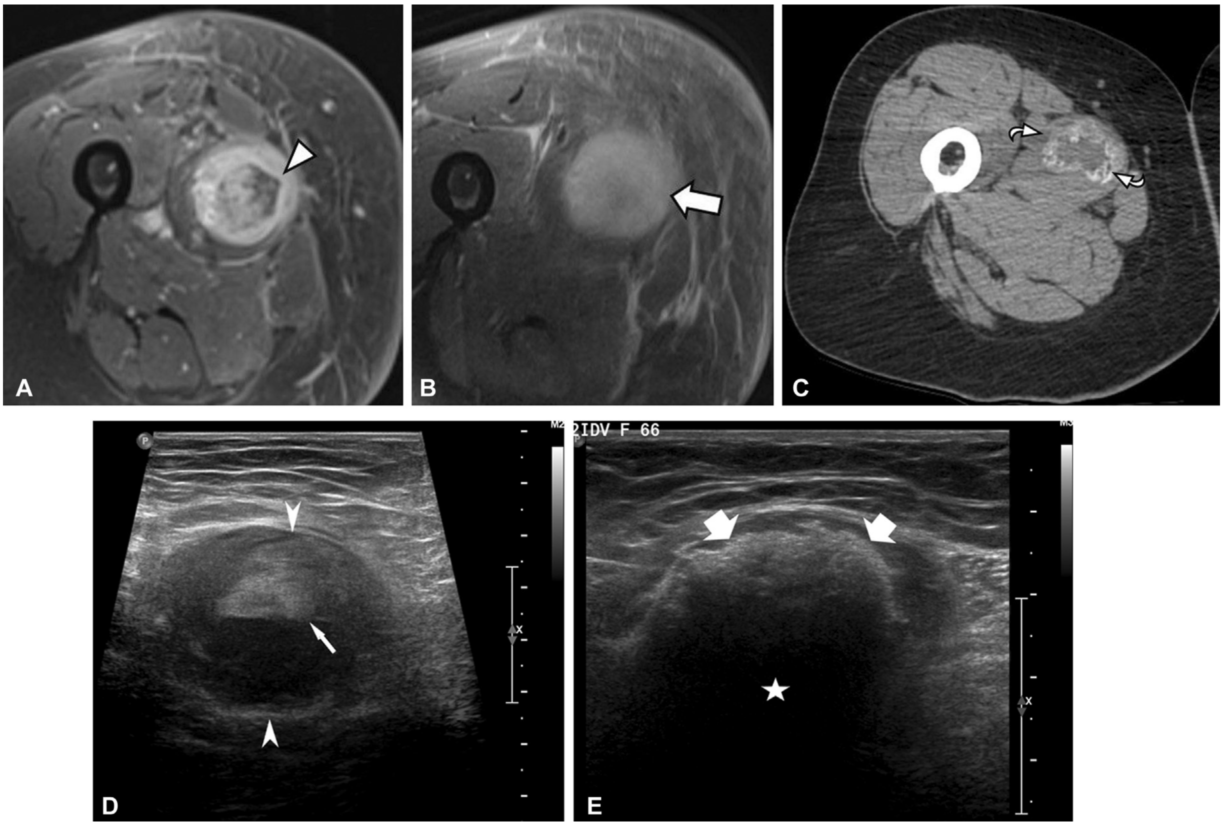

Fig. 3 A 45-year-old man with palpable medial thigh mass and remote history of trauma. The mass (*arrowhead*) has heterogeneous high signal on the (**A**) axial T2-weighted fat-suppressed magnetic resonance (MR) image and solid enhancement (arrow) on the (**B**) axial T1-weighted fat-suppressed postcontrast MR image. (**C**) Axial noncontrast computed tomography (CT) image in soft tissue window shows an intramuscular peripherally calcified lesion (*curved arrows*) in the adductor longus muscle with zonal ossification pattern consistent with myositis ossificans. Ultrasound image at presentation (**D**) shows a heterogeneous mass (*pointed arrows*) with a fluid level (*thin arrow*). Three months later, (**E**) the mass has peripheral calcification (*block arrows*) with posterior shadowing (*star*).

spondylitis, and diffuse idiopathic skeletal hyperostosis. Myositis ossificans has variable imaging appearance depending on the age of the lesion. In the initial stages, the mass can lack internal calcifications and have internal enhancement on MRI mimicking a sarcoma (►**Fig. 3**).[5] Radiographs or CT have the best sensitivity for visualizing calcification, especially during its early stages.[5] Ossification develops 3 to 8 weeks after onset, with a zonal ossification pattern, beginning peripherally and progressing centrally. Over time, the mass should ossify and the ability to distinguish it from a sarcoma improves.[4]

Morel-Lavallée Lesion

A Morel-Lavallée lesion forms after a traumatic closed degloving injury where there is separation of the subcutaneous tissue from the underlying fascia. The shearing forces disrupts the capillaries resulting in a mass/collection containing blood, hemolymph, and necrotic fat.[6] It is most commonly found adjacent to the greater trochanter, but can occur over any region.[7] In the acute phase, it is important to make the diagnosis as the collection can become superinfected and require treatment with surgical evacuation. In the chronic phase, the collection can enlarge, mimicking a tumor especially in patients who do not recall prior trauma. MRI is the best modality for assessment and the appearance is variable depending on chronicity and internal contents.[6] Morel-Lavallée lesions are most commonly low signal on T1-weighted (T1W) images and high on T2W images due to fluid content. However, they can contain areas of high T1 signal from blood products, fat, or lymph material (►**Fig. 4**). Additionally, Morel-Lavallée lesions can have low T1 and T2 signal from fibrous tissues and longstanding lesions can have a hemosiderin rim. Postcontrast images are also variable but in general should only have peripheral enhancement.[7] An important pitfall is mistaking areas of high T1 signal in the mass for a liposarcoma.

Fat Necrosis

Fat necrosis can present as a palpable, occasionally painful mass in the subcutaneous fat. The exact cause is unclear but is believed to be due to trauma and disruption of blood supply leading to infarction and saponification.[8] An inflammatory response then occurs leading to the formation of a fibrous pseudomembrane around the mass. Fat necrosis can be well-assessed on US or MRI and the amount of internal fat can be variable (►**Fig. 5**).[8] The lesions can have irregular and spiculated margins mimicking an aggressive lesion.[9] Moreover, there can be enhancement of the peripheral pseudocapsule and granulation tissue, but the distinguishing factor from a tumor is the absence of internal vascularity.[8]

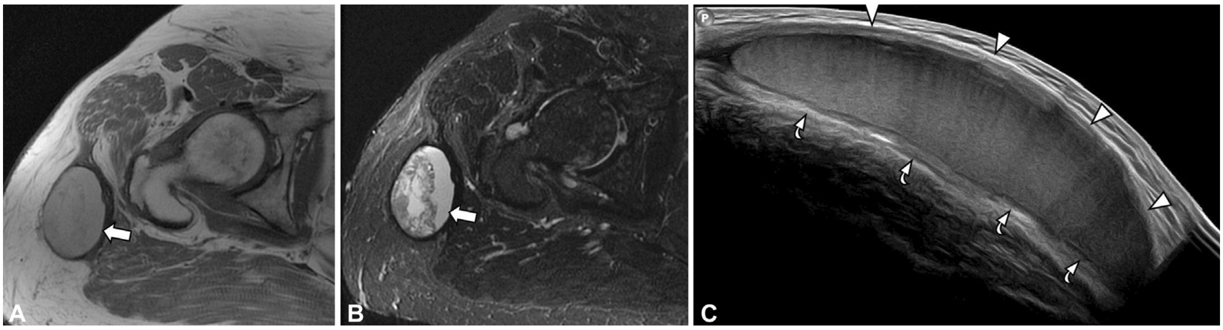

Fig. 4 A 42-year-old woman with a firm mass (*arrows*) over the greater trochanter. The mass is hyperintense on the (**A**) axial T1-weighted magnetic resonance (MR) image and heterogeneously hyperintense on the (**B**) axial short-tau inversion recovery (STIR) MR image relative to skeletal muscle, compatible with hemorrhage. (**C**) Panoramic ultrasound (US) image shows a complex collection separating the subcutaneous (*arrowheads*) and superficial fascial (*curved arrows*) layers consistent with a Morel-Lavallée lesion.

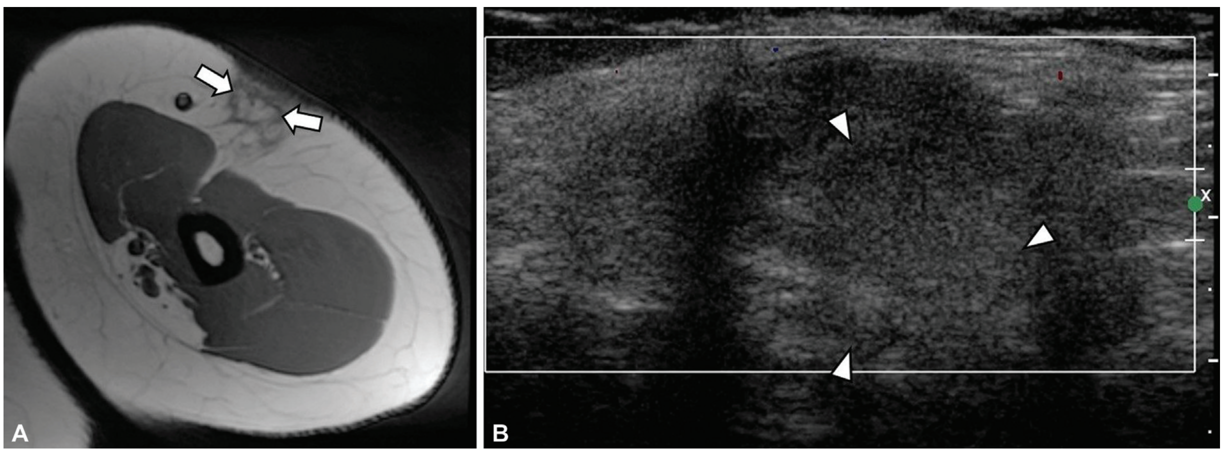

Fig. 5 A 67-year-old woman with palpable mass and skin dimpling to the lateral arm at site of prior trauma. (**A**) Axial T1-weighted magnetic resonance (MR) image shows a mass (*arrows*) in the upper arm with intrinsic T1 hyperintensity identical to subcutaneous fat and an irregular peripheral border of low signal. (**B**) Doppler ultrasound (US) image shows an echogenic lesion (*arrowheads*) without internal vascularity compatible with fat necrosis.

Muscle Tear/Strain and Tendon Ruptures

Muscle injuries are common, often occurring from sports-related activities or other traumatic events. In young healthy patients, the diagnosis is often easy to determine based on clinical history. However, in older patients or in patients who are poor historians, muscle injuries can be confusing and mimic soft tissue neoplasms. Muscles tear/strains can present as an enlarging mass, often near the myotendinous junction and commonly in muscles that cross two joints (biceps brachii, gastrocnemius, and rectus femoris).[10,11] MRI is the best imaging test as it can assess the location of the injury, presence of a hematoma (indicative of at least a grade 2 injury), and fatty infiltration which impacts surgical management. Tendon ruptures can distort the muscle and create focal nodularity at the tendon stump and occasionally with surrounding fluid collections (►**Fig. 6**).

Iatrogenic

Seroma

Seromas are collections of simple fluid following surgery and are present in up to 19% of patients undergoing soft tissue sarcoma surgery.[12] Edema from tissue in the surgical bed can accumulate forming a fluid collection. On imaging, seromas classically appear as cystic lesions with thin enhancing walls (►**Fig. 7**). However, they may contain hemorrhage or proteinaceous material.[13] A seroma can mimic a neoplasm with

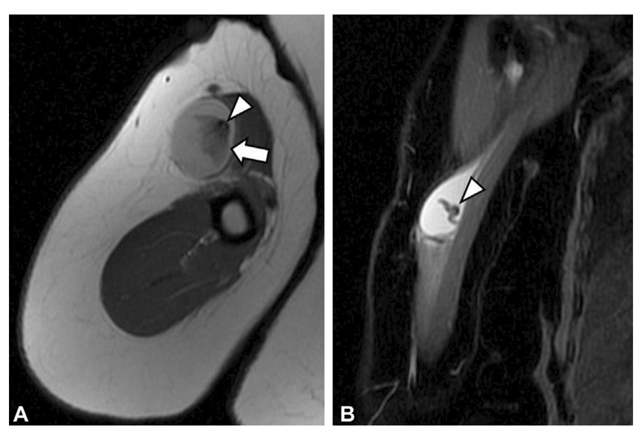

Fig. 6 A 51-year-old woman with arm weakness and palpable lump in the anterior arm. (**A**) Axial proton density and (**B**) coronal short-tau inversion recovery (STIR) magnetic resonance (MR) images show a fluid collection (*arrow*) surrounding the frayed and retraction end of the proximal biceps tendon long head (*arrowheads*).

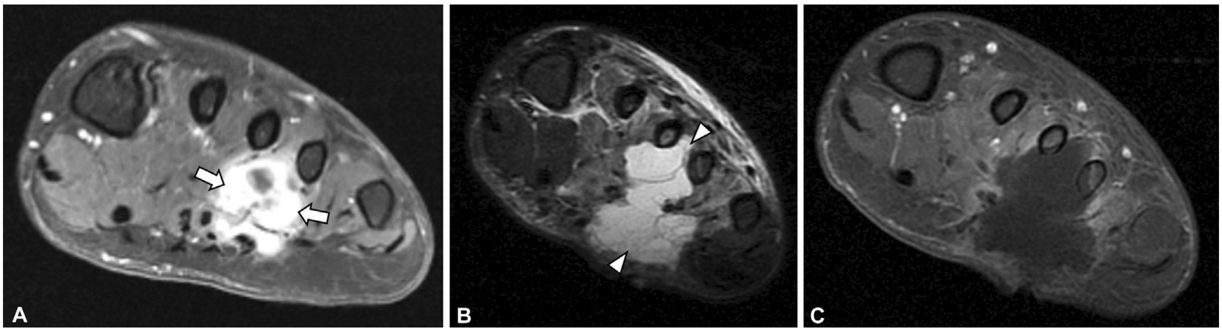

Fig. 7 A 38-year-old woman with postoperative fluid collection after resection of a synovial sarcoma in the foot. (**A**) Axial T1-weighted fat-suppressed postcontrast magnetic resonance (MR) image shows an enhancing mass (*arrows*) in the forefoot consistent with a synovial sarcoma. Postoperative axial (**B**) T2-weighted fat-suppressed and (**C**) T1 fat-suppressed postcontrast MR images show a fluid collection (*arrowheads*) without internal enhancement consistent with a postoperative seroma.

central necrosis. Necrotic tumors typically have more nodularity and thicker peripheral walls (►**Fig. 8**) than seromas, and seromas should decrease in size over time.[12]

Scar Tissue

Scar tissue can form after trauma or surgery and present as a palpable lump (►**Fig. 9**). Scars usually develop within 6 to 8 weeks after surgery and take 6 to 18 months for their maturation.[14] Imaging appearance is variable depending on the content of the scar tissue which is comprised of collagen, enlarged arterioles and capillaries, and inflammatory products.[13] On US and CT, scar tissue is typically hyperechoic and hyperdense, respectively. On MRI, the signal intensity can be dependent on the amount of dense collagen with more collagenous lesions having low signal on both T1W and T2W images.[15] Unfortunately, scar tissue can enhance mimicking a neoplasm. A key feature is that scar tissue typically has irregular borders as opposed to smooth borders of many neoplasms.[14]

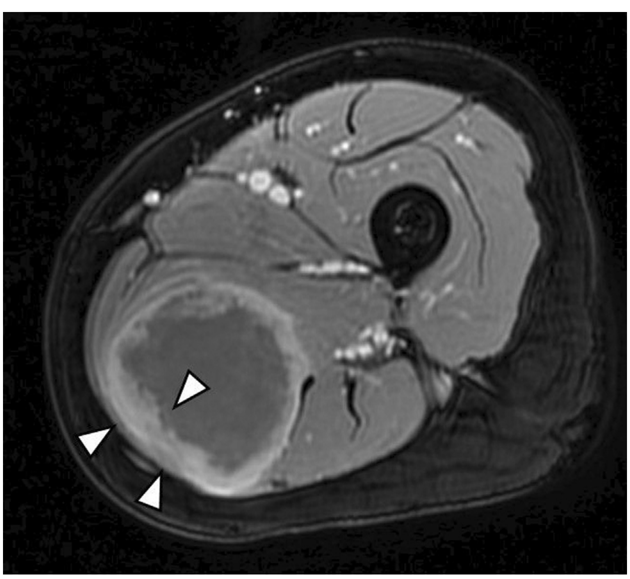

Fig. 8 Axial T1 fat-suppressed postcontrast magnetic resonance (MR) image of a 54-year-old man with thigh swelling shows a large mass in the posterolateral thigh with an enhancing thick irregular wall (*arrowheads*). Biopsy of the thickened wall revealed a necrotic high-grade pleomorphic sarcoma. Fluid collections with thick and irregular walls can be seen with necrotic tumors or abscesses.

Scar Endometrioma

Endometriosis is the presence of functioning endometrial tissue outside of the uterus and can involve multiple pelvic and extrapelvic organs. The term scar endometriosis is used to describe an endometriotic implant forming a nonneoplastic, well-circumscribed mass, in an abdominal or pelvic wall scar.[16] These masses can form after a variety of obstetrical or gynecological procedures such as cesarean section, hysterectomy, episiotomy, tubal ligations, and laparoscopic surgery for management of pelvic endometriosis.[16] The pathogenesis is believed to be direct seeding of endometrial tissue into the wound. These masses can occur several years after the surgery and symptoms can wax and wane in relation to the menstrual cycle due to estrogen responsive endometrial glandular tissue within the implants.[17] Imaging features on CT are nonspecific. On US, these lesions are usually hypoechoic with internal hyperechoic foci with internal vascularity mimicking a tumor.[1,17] MRI is more suggestive of this diagnosis when there are foci of intrinsic T1 hyperintense signal on precontrast T1 images (meth-

Fig. 9 A 45 year-old woman with prior cesarean section procedure. Axial computed tomography (CT) image in soft tissue windows shows two lesions (*arrows*) arising from the anterior abdominal wall consistent with hypertrophic scar tissue.

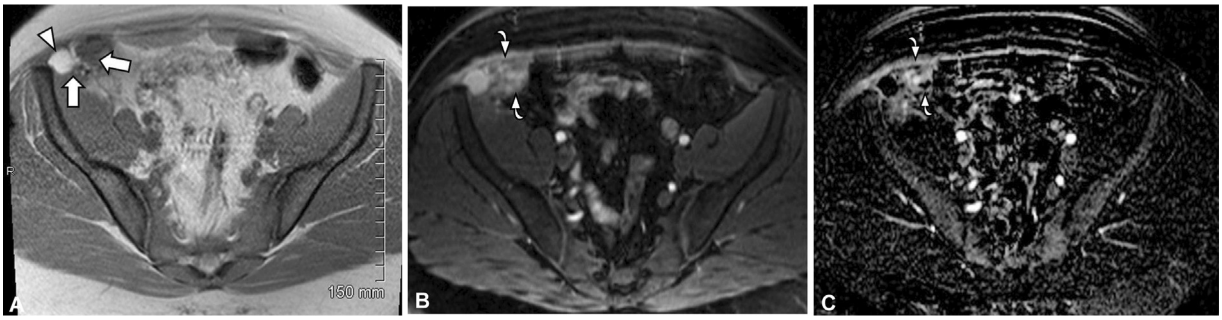

Fig. 10 A 41-year-old woman with history of laparoscopic hysterectomy 18 months prior and right lower abdominal wall mass and pain. (**A**) Axial T1-weighted magnetic resonance (MR) image shows a heterogeneous mass (*arrows*) at a laparoscopy port site with area of T1 hyperintensity (*arrowhead*). The mass (*curved arrows*) is predominantly hyperintense on the (**B**) axial short-tau inversion recovery (STIR) MR image and has heterogeneous enhancement on the (**C**) axial subtraction MR image. Biopsy showed endometrial tissue consistent with scar endometrioma.

hemoglobin) with mixed T2 hyperintense foci (endometrial glands) on a background of T2 hypointense tissue (fibrosis) within the lesion (►**Fig. 10**).

Gossypiboma

A gossypiboma, also known as a textiloma or cottonoid, is foreign material, typical cotton material or surgical sponge, left in the body after surgery.[18] The incidence of gossypibomas is relatively rare and their varied presentation poses a diagnostic challenge (►**Fig. 11**).[18] Patients can be asymptomatic for several years before symptoms occur complicating diagnosis. On US, they can appear as a well-defined mass with a wavy internal echoes and posterior acoustic shadowing.[19] The surrounding foreign body reaction can appear cystic or solid, with acoustic shadowing caused by the gauze, air pockets, or calcified regions in the gossypiboma.[19] CT is another modality which can help confirm the diagnosis. CT features include a low-density mass with hyperdense linear internal material or calcification in chronic masses.[19] MRI is less commonly used to detect gossypibomas. On MRI, the retained material is most commonly seen as a soft tissue density mass with a well-defined capsule, and is generally hypointense on T1W images, and hyperintense on T2W images.[19]

Inflammatory/Reactive

Foreign Body Granuloma

Foreign body granuloma is an inflammatory response to a foreign body. If not removed, a granulomatous reaction occurs as the body attempts to resorb or wall off the foreign body, forming a mass. They can be confused for a soft tissue neoplasm, especially if the history of trauma is forgotten or not obtained.[20] Symptoms can present months or years after the initial injury. The key to diagnosis is identifying the foreign body which is often surrounded by enhancing granulation tissue. The best imaging modality to detect a foreign body depends on the materal.[21] Radiographs and CT cannot detect radiolucent material like wood or plastic which are better imaged with US. Foreign bodies typically occur as low T1 and low T2 foci on MRI, but MRI is poor in detecting small foreign bodies.[21] US has the best sensitivity for detecting the foreign body (►**Fig. 12**) which can appear as an echogenic focus with posterior acoustic shadowing and hypoechoic halo.[22]

Gouty Tophi

Gouty tophi are deposits of monosodium urate crystals, protein matrix, and inflammatory infiltrate in the soft tissue

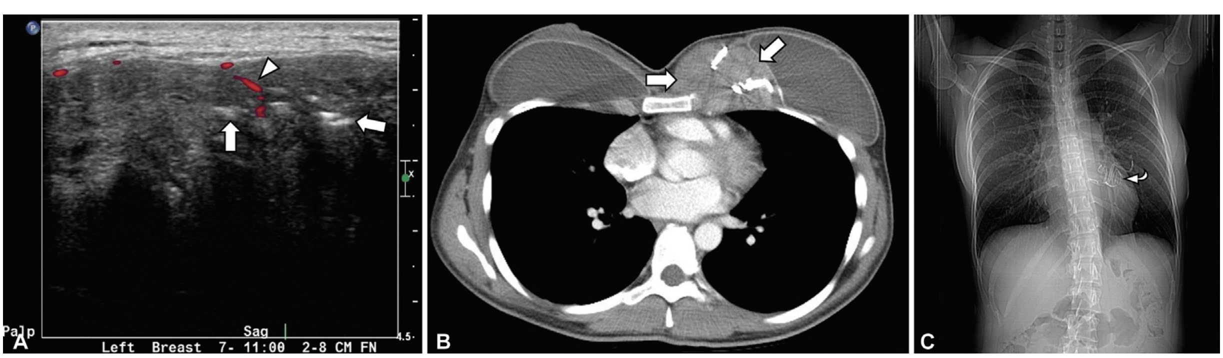

Fig. 11 A 34-year-old female presenting with left breast lump 5 few years following breast implant surgery. (**A**) Ultrasound (US) of the palpable area demonstrates a heterogeneous hypoechoic mass in the medial breast. Scattered echogenic foci of air (*arrows*) are located within the mass and there is surrounding hyperemia of the adjacent tissues (*arrowhead*). (**B**) Axial computed tomography (CT) of the chest with contrast shows an anterior chest wall hyperdense mass along the medial margin of the left breast implant. Linear high density material seen within the mass represents the radiopaque portion of a retained surgical sponge. (**C**) Scout view from the chest CT shows the entirety of the radiopaque surgical sponge (*curved arrow*).

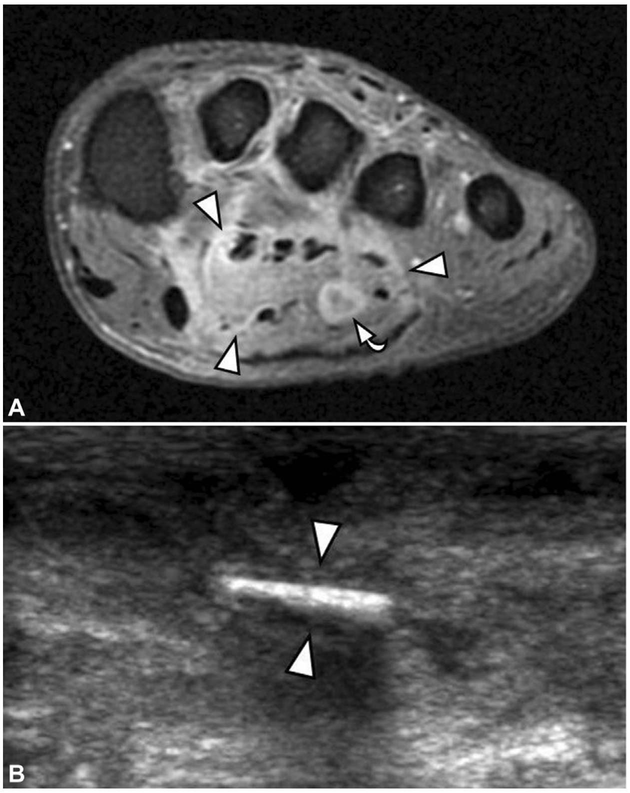

Fig. 12 A 20-year-old man with foot pain after walking barefoot in woods 3 months prior. (**A**) Axial T1 postcontrast magnetic resonance (MR) image of the foot demonstrates swelling and enhancement of the plantar foot muscles (*arrowheads*) and a small rim enhancing abscess (*curved arrow*). (**B**) Ultrasound image demonstrates a linear echogenic focus (*arrows*) with posterior acoustic shadowing found to be a wood splinter at surgery. Radiographs often will not detect radiolucent foreign bodies made of wood or plastic.

and present as "lumpy, bumpy" soft tissue masses.[23] They typically develop more than 5 to 10 years after the initial presentation of gout and in patients with untreated or poorly treated disease, often involving the joint capsule, tendons, and ligaments.[24] Tophi can cause ulceration and skin breakdown, and is most commonly found at the first metatarsophalangeal joint, olecranon, and prepatellar regions. On imaging, gouty tophi appears as soft tissue calcifications often adjacent to periarticular erosions with overhanging edges. The calcifications can be well seen on radiographs and CT. The use of dual-energy CT can be especially helpful as it can accentuate the difference between uric acid and calcium containing materials.[25] On US, gout appears as a hyperechoic foci in the soft tissues.[23] Gouty tophi can have variable appearance on MRI which depends on the degree of hydration and the amount of calcification. MRI is best for assessing the degree of osseous, synovial, and cartilage involvement (►**Fig. 13**).[26]

Bursitis

Bursae are synovial lined sacs that fill with fluid when inflamed and can mimic a mass.[27] They are not visible on imaging unless irritated or inflamed due to trauma, infection, or arthritis. In general, bursae do not connect to the joint space, which distinguishes them from synovial cysts and normal joint recesses; however, at times, they can connect to the joint, such as the iliopsoas bursa or subcoracoid bursa.[28] On imaging, uncomplicated bursa should appear as cystic structures containing simple fluid. However, inflamed or infected bursa can have wall thickening, septations, and perilesional enhancement/vascularity (►**Fig. 14**).[28] Adventitial bursae, do not contain a synovial lining, can form in atypical locations, and are due to mechanical irritation and abrasion between tissues. They often occur in the foot and ankle but can also occur with exophytic bone tumors such as an osteochondroma.[29] A pitfall is to not overlook the underlying cause of the adventitial bursa.

Rheumatoid Nodule

Rheumatoid nodules are the most common extra-articular manifestation of rheumatoid arthritis and their presence at diagnosis can predict joint destruction.[30] These nodules occur in 30 to 40% of patients with rheumatoid arthritis and have a female-to-male predominance of 3:1.[30,31] They present as a nontender, well-circumscribed mass or masses distributed on extensor surfaces of extremities, most commonly at the olecranon, typically below 5 cm in size.[31] Skin ulceration can develop if they are at bony prominences, such as the posterior elbow. The nodules can be mobile or bound to tendon, fascia, or periosteum. Histologically, rheumatoid nodules contain three distinct zones: a central area of fibrinoid necrosis, middle layer of histiocytes, and outermost layer of granulation tissue containing chronic inflammatory

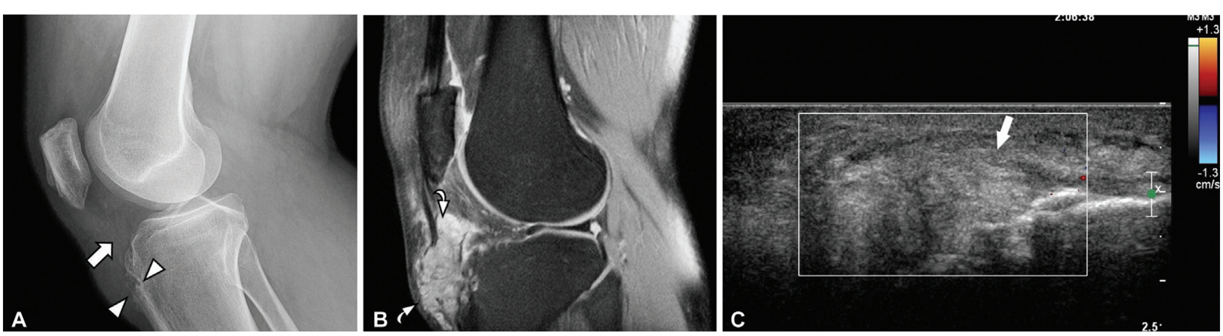

Fig. 13 A 52-year-old man with palpable anterior knee mass and gout. (**A**) Lateral knee radiograph shows increased soft tissue density (*arrow*) in Hoffa's fat and bony erosions (*arrowheads*) at the tibial tuberosity. (**B**) Sagittal short-tau inversion recovery (STIR) magnetic resonance (MR) image shows an irregular, hyperintense lobulated mass (*curved arrow*), consistent with gouty tophi. (**C**) Ultrasound image shows a hyperechoic mass (*arrow*) without vascularity.

Fig. 14 A 73-year-old woman with right hip pain and swelling. Axial short-tau inversion recovery (STIR) magnetic resonance (MR) image shows a large greater trochanteric bursa (*arrow*) with layering debris.

cells and fibrous tissue.[32] Rheumatoid nodules have heterogeneous echogenicity on US with variable vascularity. On MR, the lesions are isointense to muscle on T1, and T2 hypo-/hyperintense depending on the amount of granulation tissue (►**Fig. 15**).[32] There is a varied enhancement pattern on MRI, including solid internal enhancement.[32] The location and history of rheumatoid arthritis are helpful in making the diagnosis.

Amyloid Arthropathy

Amyloid arthropathy is soft tissue deposition of amyloid protein in the tendons and ligaments of large joints, particularly the shoulder. There are many causes of amyloidosis, however, dialysis is the most common cause for amyloid arthropathy.[33] It presents with capsular soft tissue thickening and bony erosions, and findings of arthritis, such as joint effusions and bursitis, are also common. Amyloid deposition is characteristically low signal on T2 and T1 sequences, without internal enhancement (►**Fig. 16**).[33] In addition, it has an apple green birefringence appearance under polarized light after staining with Congo red.[33] In severe disease, there can be substantial soft tissue thickening and bony erosions may appear as an invasive malignancy. Evaluation for characteristic appearance of amyloid deposition and other imaging evidence for arthritis, as well as a correlation with a history of dialysis, can help differentiate it from a tumor.[34]

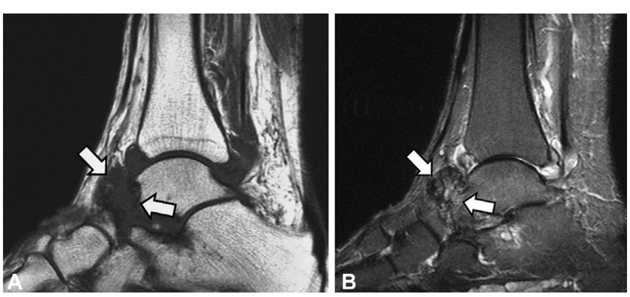

Fig. 15 A 51-year-old man with history of rheumatoid arthritis and ankle mass. Sagittal (**A**) T1-weighted and (**B**) short-tau inversion recovery (STIR) magnetic resonance (MR) images show a predominantly hypointense mass (*arrows*) in the talonavicular joint eroding into the talar head consistent with a rheumatoid nodule.

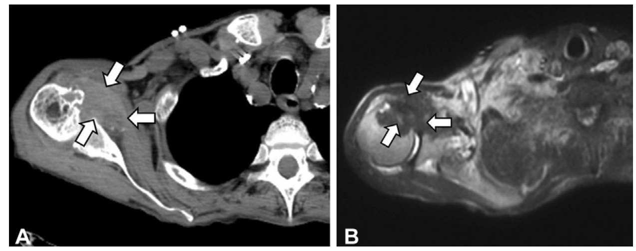

Fig. 16 A 72-year-old man with end-stage renal disease on dialysis presents with shoulder swelling and pain. (**A**) Axial noncontrast computed tomography (CT) and (**B**) axial T2-weighted magnetic resonance (MR) images through the glenohumeral joint show a soft tissue mass (*arrows*) arising from the right humeral head with bony erosions. Biopsy of the masses showed apple green birefringence after staining with Congo red, diagnostic of amyloid deposition.

Intramuscular Sarcoid Granuloma

Sarcoidosis is a multisystem granulomatous disorder characterized by the accumulation of T lymphocytes, mononuclear phagocytic cells, and noncaseating granulomas in various organs, especially the lungs.[35] Musculoskeletal involvement is seen in 20% of patients with sarcoidosis and can involve joints, bone, and muscle.[35] Intramuscular sarcoid is seen in $< 2\%$ of patients but can be a diagnostic dilemma, presenting as soft tissue granulomas that can mimic lymphadenopathy or a sarcoma.[35] The intramuscular sarcoid triad consists of muscular granulomas, myositis, and myopathy.[36] Sarcoid granulomas appear as well-demarcated heterogeneous nodules with variable internal vascularity on US and enhancement on postcontrast MRI (►**Fig. 17**).

Synovial and Ganglion Cyst

Cystic lesions in soft tissues are extremely common and are typically synovial or ganglion cysts. However, there is inconsistent use of the terms "synovial" and "ganglion" cyst in clinical practice and the literature. Luckily, differentiating between the two is often clinically irrelevant and may not be possible on imaging. Synovial cysts represent herniation of synovial tissue into surrounding soft tissues; thus, they connect to the joint or tendon sheath. Unlike synovial cysts, ganglion cysts do not communicate with the joint space and lack a cellular lining.[37] Ganglion cysts often exist next to a joint or tendon sheath and are believed to form from repetitive stress.[38] Ganglion cysts are characterized by dense connective tissue filled with gelatinous fluid rich in hyaluronic acid and other mucopolysaccharides. Both synovial and ganglion cysts are nonneoplastic and can be left alone if nonsymptomatic. On US, both types of cysts appear as anechoic lesions with increase through transmission and

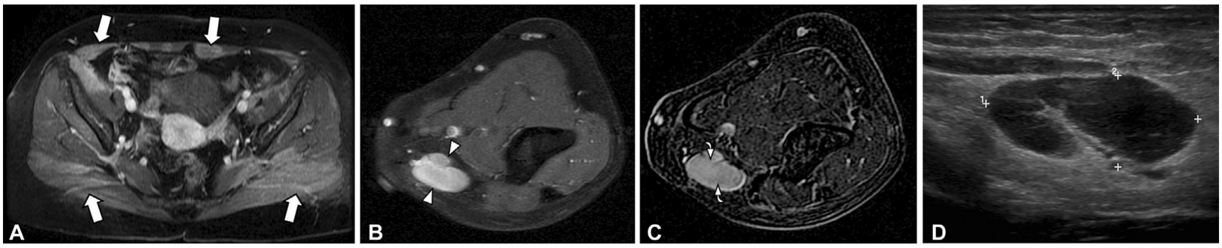

Fig. 17 A 38-year-old female with sarcoidosis, lower extremity weakness, and elbow mass. (**A**) Axial T1 fat-suppressed postcontrast magnetic resonance (MR) image shows nonspecific patchy enhancement of bilateral gluteal and rectus muscles (*arrows*) which can be seen with sarcoid myopathy. (**B**) Axial T2 fat-suppressed MR image of the elbow in the same patient reveals a T2 hyperintense nodule (*arrowheads*) with solid enhancement on the (**C**) postcontrast axial subtraction image of the elbow (*curved arrows*) consistent with sarcoid granuloma. (**D**) Ultrasound image shows a heterogeneous hypoechoic mass with internal septation.

should have a thin or imperceptible peripheral rim. On MRI, both types of cysts should demonstrate low signal intensity on T1W images, high signal intensity on T2W images, and can have rim enhancement (►**Fig. 18**).[38] These cysts should lack solid internal enhancement; however, multiseptated ganglia can appear to have enhancement. Moreover, longstanding ganglia can cause pressure erosions in the adjacent bone, mimicking an aggressive process.[38] Two additional pitfalls deserve mention. First, synovial or ganglion cysts can mimic intramuscular myxomas, especially if there is internal enhancement.[38] Second, necrotic neoplasms can mimic a synovial or ganglion cyst but neoplasms typically have thicker walls and perilesional vascularity.

Epidermoid and Sebaceous Cysts

Epidermoid cyst is a common cutaneous lesion possessing a thin layer of squamous epithelium containing keratin and lipids. It forms after migration of epidermal components into the dermis, and are commonly found in the scalp, face, trunk, upper back, and groin.[39] In the extremities, they are believed to be due to traumatic implantation of epidermal tissue. However, intracranial epidermoid cysts are likely due to an embryogenetic event. Similarly, a sebaceous cyst is also a cutaneous cystic lesion, but results from obstruction of the hair follicle in a sebaceous gland and will also demonstrate connection to the skin surface.[40] Sebaceous cysts are much less common than epidermoid cysts and differentiation between the two on imaging can be hard. In general, most cutaneous cystic lesions are epidermoid and not sebaceous cysts. On sonography, both epidermoid and sebaceous cysts are hypoechoic and can have a lamellar sonographic pattern.[39,40] When epidermal cysts rupture, they can show color Doppler signal mimicking vascularization in a solid mass.[1] On MRI, epidermoid cysts have a well-circumscribed border, low signal on T1W images, high signal on T2W images, and should have no internal enhancement (►**Fig. 19**).[41]

Infection

Soft Tissue Abscess

An abscess is a focal collection of pus in any body part with a peripheral capsule created by macrophages, fibrin, and granulation tissue from infection by a pyogenic bacterium or other pathogen.[42] In patients with acute signs of localized or systemic infection, the diagnosis can be easy; however, for patients who are poor historians or with atypical symptoms, the diagnosis can be difficult. The most common causative organisms are *Staphylococcus aureus*, streptococcus, *Serratia marcescens*, and *Pseudomonas aeruginosa*.[42] MRI is the best imaging modality and should be performed with intravenous contrast whenever possible (►**Fig. 20**). An abscess will appear as a well-circumscribed area of low T1 and high T2 signal with postcontrast rim enhancement. A peripheral rim of T1 hyperintense signal relative to the low-signal abscess cavity on precontrast T1 images is referred to as the "penumbra sign" and has a sensitivity and specificity of 54 and 98%, respectively, for the differentiation of abscess from a neoplasm.[43] Intravenous contrast improves the detection of

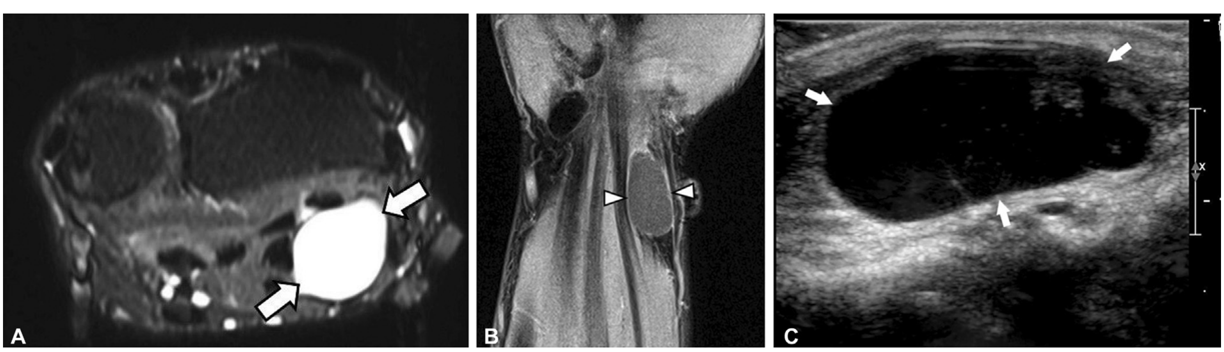

Fig. 18 A 50-year-old woman with wrist mass and hand discomfort. (**A**) Axial T2 fat-suppressed and (**B**) coronal axial T1 fat-suppressed postcontrast magnetic resonance (MR) images show a well-circumscribed T2 hyperintensity mass (*arrows*) with thin peripheral enhancement (*arrowheads*) compatible with a synovial cyst. (**C**) Ultrasound image shows an anechoic mass (*arrows*) with increase through transmission.

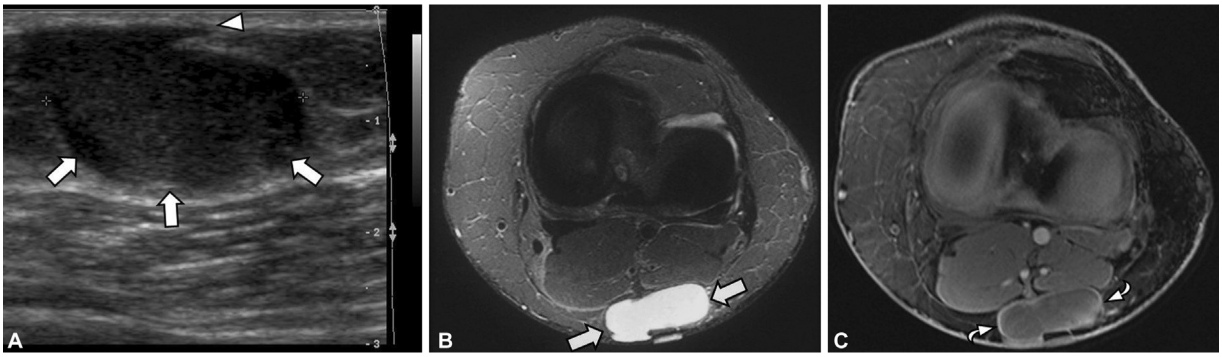

Fig. 19 A 48-year-old female with mass (*arrows*) in the popliteal fossa. (**A**) Ultrasound image demonstrates a cystic hypoechoic mass with a tract (*arrowhead*) extending to the epidermis. (**B**) Axial short-tau inversion recovery (STIR) magnetic resonance (MR) image shows a hyperintense lesion also with extension to the skin surface and thin peripheral enhancement on the (**C**) axial T1 fat-suppressed postcontrast MR image. Epidermoid cysts should have a connection to the skin surface and can have hyperechoic material differing them from a synovial cyst.

an abscess but in patients with contraindications to contrast, diffusion-weighted imaging can be helpful in determining abscess from tumor; however, this can be difficult for tumors that are highly cellular or in cases of superinfection of necrotic tumors.[44] A major pitfall is confusing an abscesses for a necrotic neoplasm or hematoma/seroma since treatment is very different between these entities. Clinical history and laboratory values of infection can be helpful, but when in doubt, percutaneous drainage/biopsy should be performed.

Cat-Scratch Disease

Cat-scratch disease typically occurs from a cat scratch or bite leading to infection from *Bartonella henselae*. Fever and regional lymphadenopathy (90%) typically develop 1 to 3 weeks after infection, with the latter occurring around the site of inoculation.[45] The most common sites of infection are the axillary and epitrochlear regions and the masses can show regions of necrosis (►**Fig. 21**).[45] Cat-scratch disease typically resolves spontaneously in immunocompetent patients, but may require antibiotics or systemic disease treatment for the immune compromised.[46] Lymphadenopathy from cat-scratch disease can mimic lymphoma. The two entities can be distinguished from each other by examining for other clinical and laboratory signs of lymphoma, any exposure to cats, and examining the distribution of lymphadenopathy.[47] In cat-scratch disease, this distribution will be regional and unilateral, while lymphoma is more likely to be systemic with diffuse and bilateral lymphadenopathy.[45] In severe cases, suppurative lymphadenopathy can also be present which may necessitate drainage.

Pyomyositis and Infectious Myositis

The term "pyomyositis" is often misused as an abscess within the muscle (►**Fig. 22**), but it specifically refers to bacterial infection of skeletal muscle from hematogenous spread that frequently leads to abscess formation.[48,49] The most common pathogen is *Staphylococcus aureus* ($>$ 75% cases).[50] Infectious myositis refers to infection of skeletal muscle, which can be due to bacteria, viruses, fungi, or parasites.[51] Since muscle is relatively resistant to infection, most cases of pyomyositis and infectious myositis are in patients with preexisting muscle damage or compromised immune systems.[48] In the early stage of pyomyositis, there can be localized muscle edema that appears hypoechoic on US. There can be muscular enlargement with low attenuation and effacement of intermuscular fat planes on CT. On MRI, there is intermediate T1 signal and high intensity on fluid-

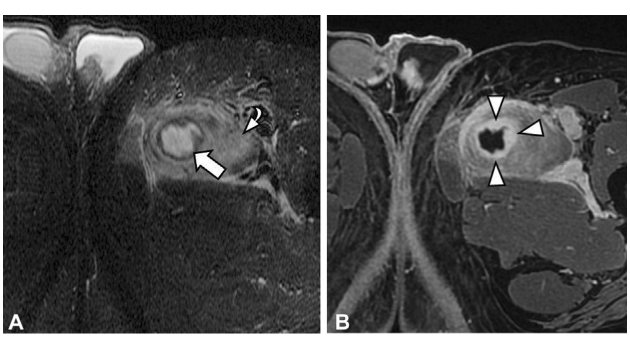

Fig. 20 A 62-year-old male with progressive thigh and buttock pain after transurethral resection of the prostate. (**A**) Axial short-tau inversion recovery (STIR) and (**B**) axial T1 fat-suppressed postcontrast magnetic resonance (MR) images show a fluid collection (*arrow*) with thick peripheral enhancement (*arrowheads*) and adjacent muscle edema (*curved arrows*) in the adductor muscles, consistent with an abscess.

Fig. 21 A 14-year-old boy with fevers and a palpable mass on the medial elbow after a cat bite. Coronal T1 postcontrast magnetic resonance (MR) images of the right (**A**) elbow and (**B**) axilla demonstrate multiple unilateral enlarged epitrochlear (*arrows*) and axillary lymph nodes (*arrowheads*), respectively. Biopsy of the lesions revealed *Bartonella henselae* infection.

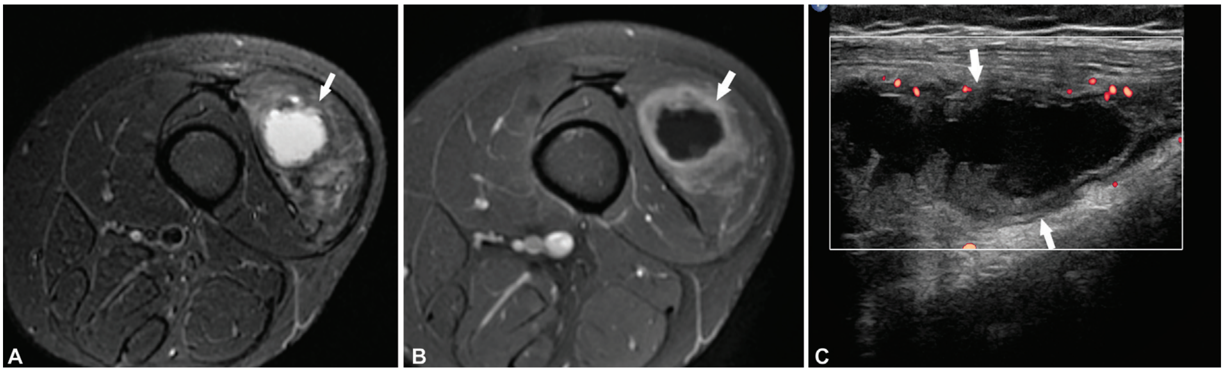

Fig. 22 A 46-year-old man with intravenous drug abuse and thigh pain and swelling. (**A**) Axial short-tau inversion recovery (STIR) and (**B**) axial T1 fat-suppressed postcontrast magnetic resonance (MR) images show a fluid collection (*arrow*) with thick peripheral enhancement *(arrows*) and adjacent muscle edema in the vastus lateralis. (**C**) Doppler ultrasound image shows a fluid collection (*arrows*) with thick peripheral rim and enhancement. Aspiration and culture revealed *Staphylococcus aureus* infection consistent with pyomyositis.

sensitive sequences with enhancement following contrast medium administration.[52] Similar to soft tissue abscess, pyomyositis and infectious myositis can be confused for a necrotic tumor.

Vascular

Pseudoaneurysm

A pseudoaneurysm can form after disruption of an arterial wall from trauma, tumor invasion, or infection.[53] Unlike a true aneurysm which represents localized dilation of an artery due to weakening of all three wall layers, a pseudoaneurysm does not involve all wall layers. Injury to the artery leads to leakage of blood and formation of a perfused sac contained by the media or adventitia or only by soft tissue surrounding the injured vessel (►**Fig. 23**).[54] Pseudoaneurysms can occur in any vessel but are most common in the radial and femoral artery from vascular access and interventional procedures.[55] A pseudoaneurysm can appear as a pulsatile mass and be mistaken for a vascular tumor especially if the patient does not recall any prior injury and the mass is asymptomatic. Biopsy can have disastrous consequences and should be avoided. Conventional angiography is the gold standard for diagnosis but is invasive and the diagnosis can be readily made on other modalities. On US, pseudoaneurysms appear as hypoechoic cystic structures adjacent to a supplying artery. There can be concentric layers of hematoma and swirling motion on Doppler imaging, "yin-yang sign." The hallmark is identifying a communicating channel (neck) between the sac and the feeding artery with "to-and-fro" Doppler waveform representing blood entering and exiting the pseudoaneurysm in relation to the cardiac cycle.[54,55] CT and MRI angiography can also be helpful in diagnosis and is better at characterizing the full extent of large pseudoaneurysms and their relation to adjacent vascular structures for pretreatment planning.[54]

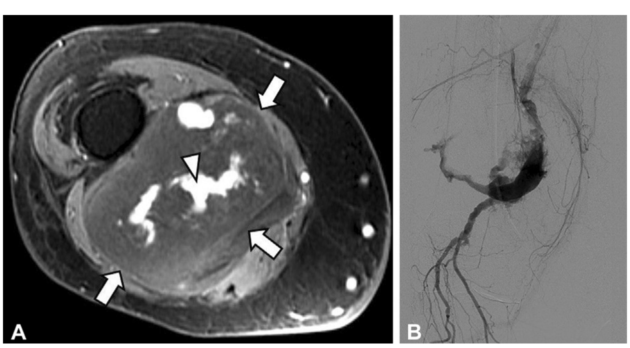

Fig. 23 A 72-year-old male with progressive leg pain and swelling. (**A**) Axial T1 postcontrast magnetic resonance (MR) image of the knee shows a large mass (*arrows*) with central tubular areas of internal enhancement (*arrowhead*). The nonenhancing component represents the thrombosed pseudoaneurysm containing the popliteal artery. (**B**) Digital subtraction angiogram shows a markedly irregular popliteal artery aneurysm with collateral vessels.

Myonecrosis

Myonecrosis is infarction of muscle and often followed by tissue liquefaction. Myonecrosis is uncommon due to the rich collateral blood flow within muscle; however, when it occurs it can cause myoglobinemia, which can lead to disseminated intravascular coagulation, acute renal failure, and death; thus, it is important to make the diagnosis early.[56] Myonecrosis can occur from trauma, compartment syndrome, exercise, heatstroke, radiation, infection, metabolic disorders, seizures, envenomation, toxins, and illicit drug use; but is most commonly seen as a complication of diabetes from occlusion of small and medium blood vessels in patients with poor glycemic control.[56,57] MRI is likely the best imaging modality and will show an intramuscular mass that is hypointense to slightly hyperintense on T1W images due to hemorrhage or protein content; and patchy hyperintensity on T2W images due to a combination of edema, necrosis, and hemorrhage. On postcontrast imaging, early myonecrosis can have internal enhancement prior to muscle liquefaction, whereas late-stage myonecrosis typically has peripheral rim enhancement as the muscle has become more necrotic. There can be foci of low signal intensity, representing either residual viable muscle or inflammatory vessels, within regions of nonenhancement which is termed the "stipple sign" (►**Fig. 24**).[56,57]

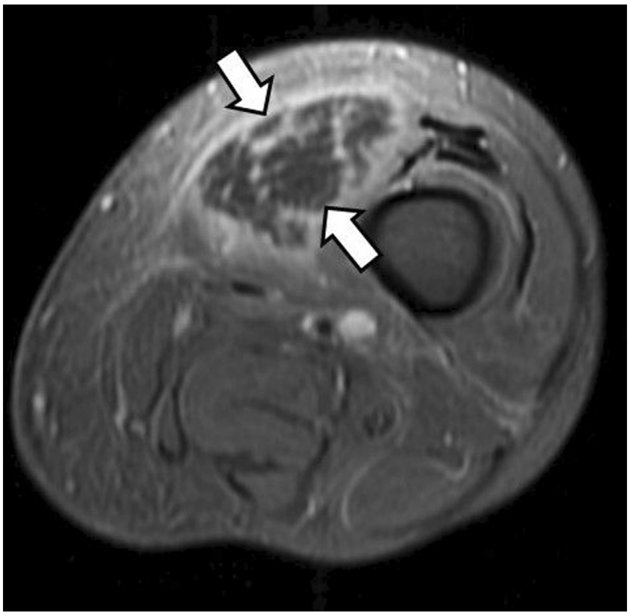

Fig. 24 A 38-year-old woman with poorly controlled diabetes now with severe left knee pain and swelling. Axial T1 fat-suppressed postcontrast magnetic resonance (MR) image shows nonenhancement in most of the vastus medialis (*arrows*). However, there are punctate foci in the region of nonenhancement, "stipple sign," representing viable muscle or inflammatory vessels. Findings are compatible with diabetic myonecrosis and can mimic pyomyositis or a necrotic tumor.

Variant Anatomy

Accessory Muscles

Accessory muscles are anatomic variants representing additional muscles that are encountered along with normal muscles. This is in distinction to anomalous muscles which are normal muscles with aberrant attachments. Most accessory muscles are asymptomatic; however, they can present as focal swelling secondary or symptoms related to compression of adjacent structures such as nerves, vessels, or tendons.[58] For instance, the anconeus epitrochlearis is an accessory muscle at the medial epicondyle of the humerus at the cubital tunnel and can cause ulnar nerve compression and neuropathy in 15% of cases.[59] Other common accessory muscles include the extensor digitorum brevis manus on the dorsum of the hand, the accessory soleus in the posterior ankle (►**Fig. 25**), and the peroneus tertius and quartus in the lateral ankle. On imaging, these accessory muscles should have the same imaging characteristics as normal muscle, distinguishing it from a neoplasm.

Conclusion

There are many nonneoplastic entities that can be mistaken for a soft tissue tumor and imaging plays a key role in the management and eventual outcome of these lesions. Radiologists and clinicians should be aware of these soft tissue tumor mimickers and recognize the determinate imaging and clinical features that distinguish them from true neoplasms. Scrutinizing the patient's clinical history and medical conditions can be extremely helpful as many conditions can be a complication of an underlying systemic disease or traumatic event, such as a pseudoaneurysm in a patient with prior vascular access procedure, or myonecrosis in a patient with poorly controlled diabetes. In cases where the lesion is indeterminate, tissue sampling or imaging follow-up should be performed. However, by applying the strategies and teaching points highlighted in this article, it may be possible to distinguish soft tissue mimickers from true neoplasms more effectively and efficiently.

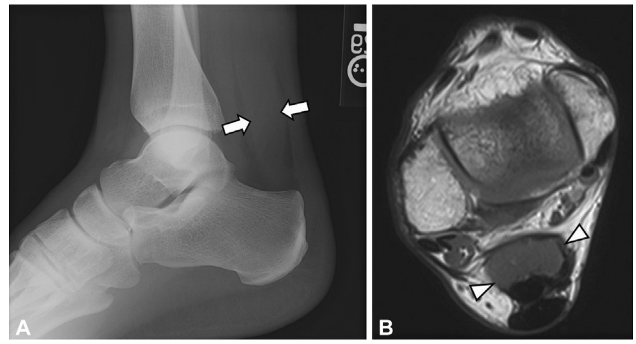

Fig. 25 A 26-year-old female with heel pain and chronic ankle swelling. (**A**) Lateral radiograph of the ankle shows soft tissue obscuring Kager's fat pad (*arrows*). (**B**) Axial T1-weighted magnetic resonance (MR) image shows an accessory soleus muscle (*arrowheads*) with the same signal intensity as skeletal muscle.

Conflict of Interest
None declared.

Acknowledgment
None.

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