# Imaging of Soft Tissue Lesions of the Foot and Ankle

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**KEYWORDS**

• Foot • Ankle • Tumor-like conditions • Tumor • MRI

The differential diagnosis of soft tissue lesions of the foot can be narrowed significantly with the aid of imaging. The cystic nature of ganglia, synovial cysts, and bursitis can be confirmed with MR imaging or sonography. Location and signal characteristics of noncystic lesions of the foot can suggest a diagnosis of Morton's neuroma, giant cell tumor of tendon sheath, and plantar fibromatosis. Synovial-based lesions of the foot and ankle can be differentiated with a variety of imaging modalities, based on the presence or absence of mineralization, lesion density, signal intensity, and enhancement pattern. Finally, knowledge of the incidence of specific neoplasms of the foot and ankle based on patient age aids radiologists in providing a limited differential diagnosis.

## TUMOR-LIKE LESIONS
### Cystic Tumor–Like Lesions

#### Ganglia

Ganglia are the most common soft tissue masses in the foot and ankle, representing more than 40% of suspected soft tissue masses.[1] Ganglia are myxoid lesions that occur around joints or tendon sheaths and often are multiloculated. They likely are caused by the coalescence of small cysts formed by myxomatous degeneration of periarticular connective tissue.[2] Ganglia often are diagnosed clinically and never imaged; however, MR imaging can be helpful if the ganglion is palpable or symptomatic because of extension along a nerve or tendon or into the tarsal tunnel.[3] Palpable lesions in the foot and ankle are most common around the tarsometatarsal joint, and clinicallyoccult ganglia are most common in the sinus tarsi and tarsal canal.[1] Classic MR imaging features include a well-defined, cystic structure that is hyperintense on fluid-sensitive sequences (**Fig. 1**). Ganglia are well defined on sonography, and can be variable in appearance, ranging from anechoic to hypoechoic, often with multiple internal septations.[4]

#### Synovial cysts

Synovial cysts are synovial-lined, juxta-articular fluid collections that can form in response to effusions associated with internal joint derangement or arthritis.[2] MR imaging of uncomplicated synovial cysts in the foot and ankle delineate fluid signal intensity foci communicating with an abnormal joint (**Fig. 2**). Complicated cysts resulting from prior hemorrhage or infection have more complex signal intensities.

#### Adventitial bursa

Adventitial bursae form when abnormal friction develops between opposing rigid structures. Adventital bursae are not uncommon in the foot and, when inflamed, the resulting adventitial bursitis may simulate a painful mass. In a study of 24 patients who had hallux valgus and hallux rigidus, Schweitzer and colleagues found a 70% incidence of adventitial bursitis subjacent to the first metatarsophalangeal joint, likely related to altered stress on the submetatarsal soft tissue.[5] MR imaging

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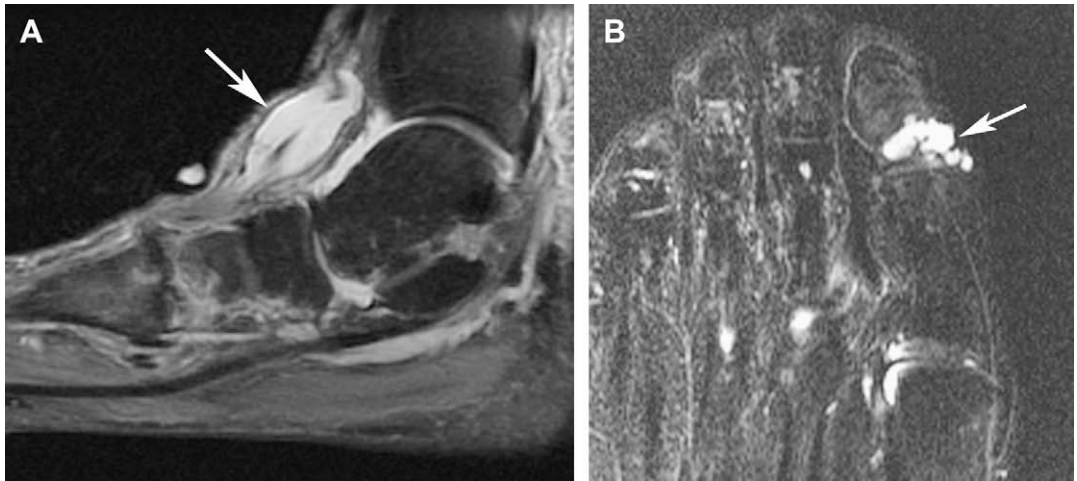
**Fig. 1.** Ganglion. (*A*) Sagittal FSE T2-weighted, fat-suppressed image through the foot demonstrates a well-circumscribed cystic focus (*arrow*) along the extensor hallucis longus tendon sheath, consistent with ganglion. Overlying soft tissue marker indicates that this was palpable. (*B*) Long-axis STIR image through the forefoot shows a multiloculated ganglion (*arrow*) adjacent to the first interphalangeal joint.

reflects the degree of active inflammation. Inactive bursitis shows little fluid and enhancement interrupting the subcutaneous fat, whereas active inflammation shows greater degrees of fluid and peripheral enhancement (**Fig. 3**).

## Noncystic Tumor–Like Lesions

### Morton's neuroma

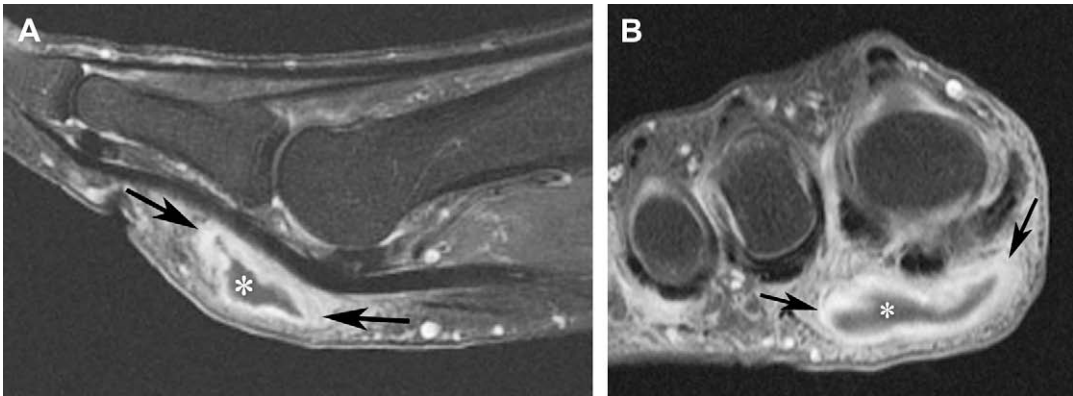Morton's neuroma, also known as interdigital neuroma, is a benign nontumorous lesion associated with neural degeneration and perineural fibrosis, most often located within the second and third interspaces.[6] Patients typically complain of pain radiating to the toes and numbness, although approximately a third of patients are asymptomatic.[7] MR imaging is accurate in diagnosing Morton's neuromas, and coronal short-axis T1-weighted imaging through the level of the metatarsophalangeal joints is the most important imaging plane.[6] MR imaging typically demonstrates a rounded intermediate soft tissue nodule in the affected interspace outlined by the adjacent fat. The relatively low signal intensity of Morton's neuroma is because this is reactive fibrosis and not a true neuroma (**Fig. 4**).[6]

### Rheumatoid nodules

Rheumatoid nodules occur in approximately 20% to 30% of rheumatoid patients, more commonly affecting women who have advanced disease.[8] Histologically, these are granulomatous foci with areas of central necrosis.[9] Nodules occur along the superficial subcutaneous tissues overlying areas susceptible to trauma, bursae, joints, tendons, or ligaments.[8] Although rheumatoid nodules are most common along the extensor surface of the upper extremity, they also can occur in the foot. MR imaging features include a nonspecific, ill-defined mass with prolonged T1 and T2 relaxation times (**Fig. 5**).[9] Diagnostic confidence can be improved if there is a clinical history of rheumatoid arthritis and active inflammatory marrow signal changes, joint effusion, and synovitis.



**Fig. 2.** Synovial cyst. Sagittal FSE proton density, fat-suppressed image shows a synovial cyst (*arrow*) extending dorsally from the degenerative talonavicular joint.

**Fig. 3.** Advential bursitis. (*A*) Sagittal and (*B*) coronal, short-axis, enhanced, T1-weighted, fat-suppressed images through the forefoot show a peripherally enhancing (*arrows*) fluid collection (*asterisk*) in the superficial plantar soft tissues adjacent to the first metatarsal head, consistent with adventitial bursitis.

### Callus

Soft tissue callus is a superficial soft tissue thickening overlying pressure points that forms in response to mechanical pressure. Calluses typically are seen within the submetatarsal soft tissues of the forefoot. Although benign and relatively common in the average adult population, calluses potentially can ulcerate and lead to deeper infection in diabetic patients. MR imaging can define the extent of the intermediate to low signal intensity calluses (**Fig. 6**), which should not be confused with more ominous pathology.[10]

### Synovial-Based Processes

### Synovial chondromatosis

Primary synovial chondromatosis is an uncommon, benign disorder in which multiple hyaline cartilage nodules are formed within a joint, tendon sheath, or bursa (**Fig. 7**).[11] Although historically believed to be metaplastic transformation of synovium into cartilage, chromosome 6 aberrations have been identified in cases of synovial chondromatosis, strongly suggesting a neoplastic process.[12,13] The knee is the most commonly involved joint (more than 50% of cases), followed by the elbow, hip, and shoulder; the foot and ankle are uncommonly involved.[2] Patients typically are in the third through fifth decades and men are affected two to four times more often than women.[2,14]

Radiographs may be unremarkable or show a synovial-based mass with or without erosions; calcifications occur in approximately 70% to 95% of cases.[11] MR imaging or MR arthrography usually shows many similar-sized bodies within the joint, tendon sheath, or bursa. The signal characteristics of the bodies depend on whether or not they are mineralized. Unmineralized bodies closely parallel imaging characteristics of hyaline
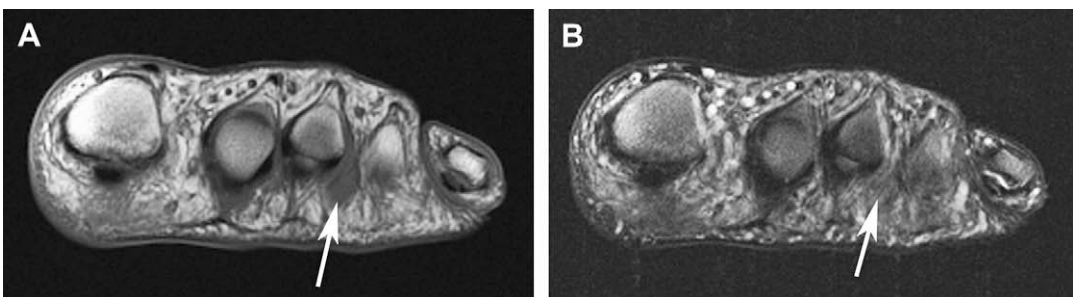


**Fig. 4.** Morton's neuroma. (*A*) Coronal, short-axis, T1-weighted image through the level of the metatarsophalangeal joints demonstrates a rounded intermediate signal soft tissue nodule (*arrow*) in the third intermetatarsal space, plantar to the transverse ligament. The subcutaneous fat serves as effective contrast to this Morton's neuroma. (*B*) This nodule (*arrow*) is less conspicuous on FSE T2-weighted image. The relatively low signal intensity of Morton's neuroma is because this is reactive fibrosis and not a true neuroma.
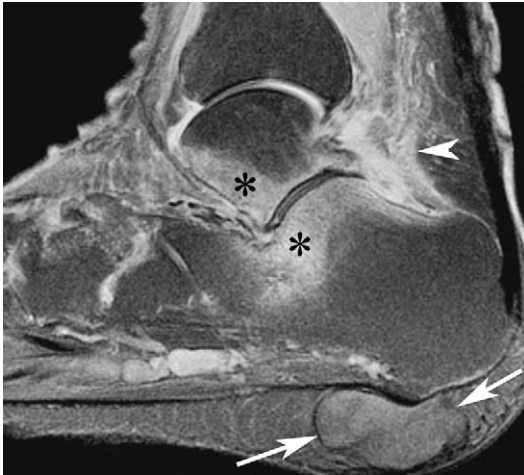
**Fig. 5.** Rheumatoid nodule. Sagittal, FSE T2-weighted fat-suppressed image shows a well-circumscribed rheumatoid nodule (*arrows*) in the plantar soft tissues of this patient who had rheumatoid arthritis. Notice the active inflammatory marrow signal changes (*asterisks*), joint effusion, and synovitis (*arrowhead*) about the subtalar joint.

cartilage, with hyperintense, lobulated signal on fluid-sensitive sequences. Mineralized osteochondral bodies can appear as signal voids resulting from dense mineralization or they may approximate fatty marrow signal intensity.[2,11]

### Pigmented villonodular synovitis

Pigmented villonodular synovitis (PVNS) is a commonly used synonym for what the World
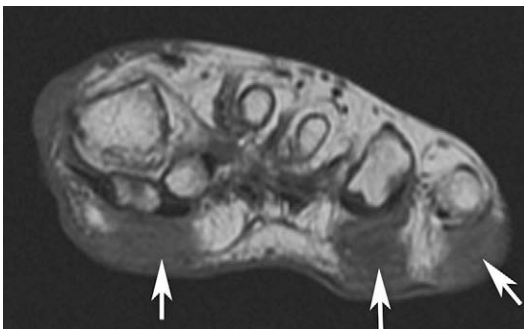


**Fig. 6.** Callus. Coronal, short-axis, T1-weighted image through the forefoot shows three foci of intermediate signal intensity (*arrows*) that replace the plantar fat pad deep to the metatarsal heads. These calluses form at pressure points in response to mechanical pressure. Notice the intrinsic muscular atrophy in this diabetic patient.

Health Organization officially terms, *diffuse-type giant cell tumor* (**Fig. 8**).[15] PVNS is a proliferation of synovium that grossly resembles a shaggy red beard and may be located intra-articularly, extra-articularly, or both. In a review of 14 cases of PVNS in the foot and ankle from the Scottish Bone Tumor Registry, the mean age of affected individuals was 26 years old with a slight female predominance.[16] Pathology involved the hindfoot in the majority of cases, followed by the mid- and forefoot.[16]

Lesions are not mineralized; however, joint effusions can be dense on conventional radiography. PVNS can result in erosions on both sides of a joint. MR imaging of PVNS commonly demonstrates hemosiderin deposition within the inflamed synovium. T1-weighted imaging typically shows mixed intermediate to low signal intensity soft tissue throughout the involved joint, persistent low signal intensity on fluid-sensitive sequences, and characteristic "blooming" (further signal loss) on gradient-echo imaging. Complete excision is the treatment of choice; however, a 14% recurrence rate has been reported.[16]

### Gout

The tophaceous form of gout is a tumor-like process that occurs most commonly as a late manifestation of the disease. Radiographic changes develop only after repeated attacks and develop in approximately 40% of patients. Focal urate deposits typically are dense on radiographs and often are associated with well-marginated erosions of the adjacent bone. Tophi are denser than skeletal muscle but not as dense as bone, with rare calcification on CT (**Fig. 9**). On CT, tophi have a mean attenuation of 160 to 170 Hounsfield units. Although lesions typically involve the metatarsophalangeal or interphalangeal joint of the great toe, tophaceous gout can result in extensive, multiple, soft tissue masses with destruction of multiple bones of the foot (**Fig. 10**).[17] Gouty tophi typically are isointense to muscle on T1-weighted sequences but can display variable signal intensity on fluid-sensitive sequences.[18] Tophi typically demonstrate variable, heterogeneous, predominantly peripheral gadolinium enhancement.

### TUMORS

In an evaluation of more than 39,000 tumor cases compiled from a referral database, Kransdorf reported the most common benign soft tissue tumors of the foot and ankle based on patient age.[19,20] In the pediatric subset, fibromatosis and granuloma annulare proved the most common benign tumors sent

**Fig. 7.** Synovial chondromatosis. (*A*) AP radiograph of the ankle shows multiple calcifications (*arrowheads*) along the lateral malleolus, fibula and medial ankle joint. Coronal T1-weighted images (*B*) pre- and (*C*) post contrast delineate the corresponding signal voids (*arrowheads*) that represent multiple osteochondral bodies in the peroneal tendon sheath and ankle joint. Intermediate signal intensity soft tissue (*asterisks*) in the tendon sheath is due to unmineralized, neoplastic chondral bodies.
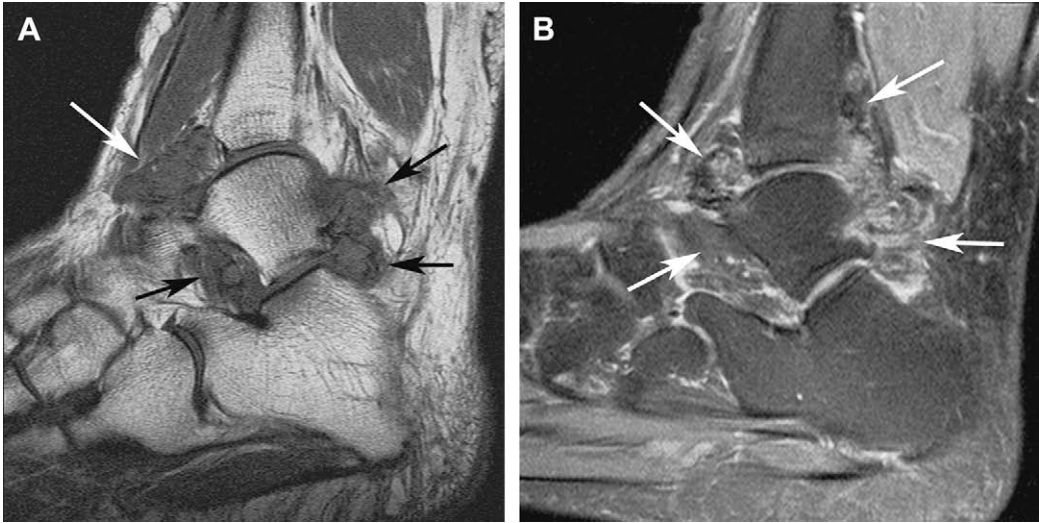
**Fig. 8.** PVNS. (*A*) Sagittal T1-weighted image through the ankle shows extensive, mixed intermediate to low signal intensity soft tissue (*arrows*) throughout the ankle joint, subtalar joint, and sinus tarsi. (*B*) FSE T2-weighted, fat-suppressed image shows persistent low signal intensity resulting from hemosiderin deposition within the extensive synovitis. Gradient-echo imaging characteristically results in further signal loss, termed blooming.

for referral; synovial sarcoma, dermatofibrosarcoma protuberans, and rhabdomyosarcoma were the most common malignant tumors of the foot and ankle. In the adult foot and ankle, fibromatosis and giant cell tumor of tendon sheath were the most common benign tumors; synovial sarcoma, malignant fibrous histiocytoma (undifferentiated pleomophic sarcoma), and leiomyosarcoma were the most common malignant tumors.
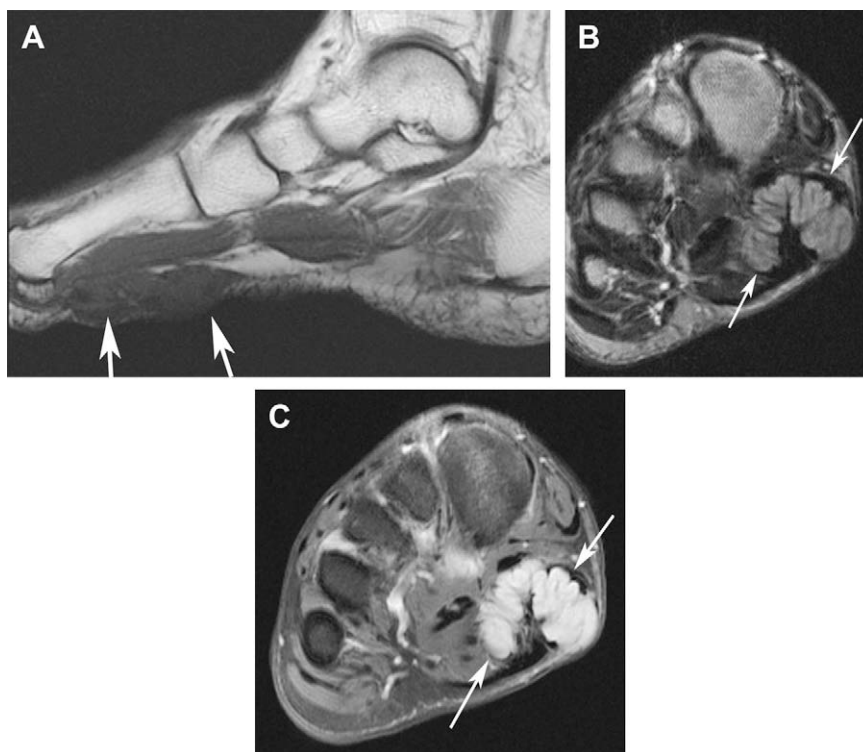
## Plantar Fibromatosis

Plantar fibromatosis is a type of superficial fibromatosis categorized under "fibroblastic/myofibroblastic tumors" by the World Health
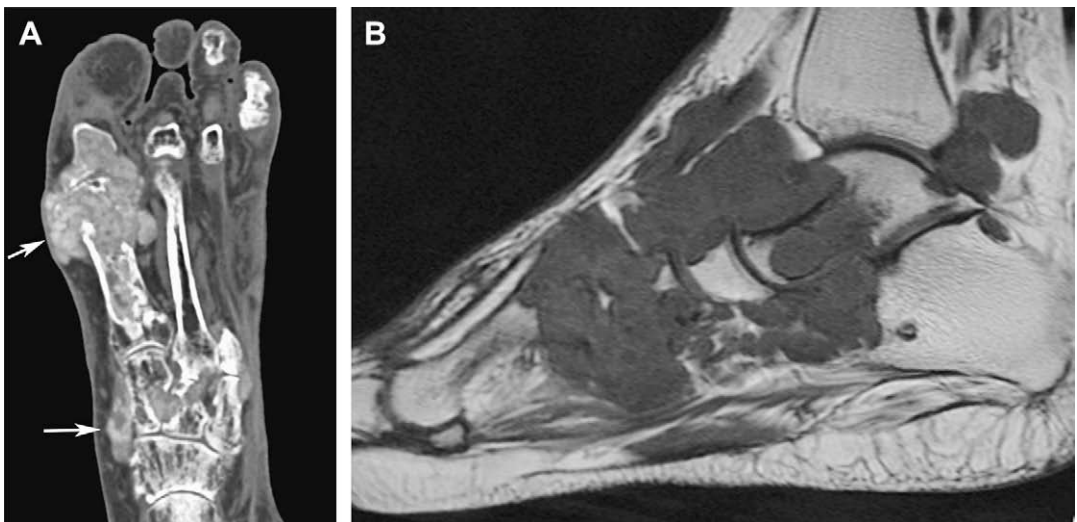


**Fig. 9.** Gout. (*A*) The tophaceous form of gout can result in extensive, multiple soft tissue masses. This long-axis, reformatted, CT image shows mineralized tophi (*arrows*) destroying the first metatarsal and the midfoot. (*B*) Sagittal T1-weighted image of multifocal gout in a different patient presents with extensive intermediate signal soft tissue masses throughout the synovial joints of the hind- and midfoot.

**Fig. 10.** Plantar fibromatosis. (*A*) Sagittal T1-weighted image displays marked thickening of the distal plantar fascia (*arrows*), which is isointense to skeletal muscle. Coronal, short-axis (*B*), FSE T2-weighted, and (*C*) enhanced, T1-weighted, fat-suppressed images show an accordion-like arrangement (*arrows*) of redundant fibromatosis along the plantar fascia.

Organization.[21] Plantar fibromatosis is a nodular fibrous proliferation arising from the plantar aponeurosis, often in non–weight-bearing regions.[22] Lesions occur more often in men, are bilateral in 20% to 50% of cases, and are more common in epileptics, diabetics, and alcoholics who have liver disease.[22,23] On sonography, plantar fibromatosis typically is a fusiform, hypoechoic, or heterogeneous mass located in the middle or distal plantar fascia.[4] On MR imaging, these infiltrative masses grow along the aponoreuosis; most are heterogeneous, isointense to slightly hyperintense to skeletal muscle on fluid-sensitive sequences, and exhibit variable enhancement (**Fig. 11**).[24]

### Giant Cell Tumor of Tendon Sheath

Giant cell tumor of tendon sheath is one of the so-called fibrohistiocytic tumors designated by the World Health Organization, in which a circumscribed proliferation of synovial-like tissue arises from the synovium of tendon sheaths.[25] This is the localized form of giant cell tumors, occurring most often in patients between ages 30 and 50 and more often in

women. On sonography, lesions typically are solid, homogeneous, hypoechoic masses with internal vascularity.[26] Giant cell tumors of tendon sheath are focal soft tissue nodules located along tendon sheaths, demonstrating decreased signal on T1- and T2-weighted sequences (similar to pigmented villondular synovitis) as a result of hemosiderin content[27] (see **Fig. 9**). Local excision is the treatment, and recurrence rates in the literature range from 0 to 30%.[25,28]

### Lipoma

Lipoma is a benign tumor comprised of mature adipocytes and is the most common mesenchymal soft tissue tumor in adults.[29] Tumors are most common in patients between ages 40 and 60, are more common in obese patients, and can be multiple in approximately 5% of patients.[29] Cytogenetic markers have been found in the majority of lipomas, including aberrations of 12q13–15.[30]

Lipomas are common benign tumors that usually are never imaged. Because of their fatty composition, lipomas are less dense than surrounding

**Fig. 11.** Giant cell tumor of tendon sheath. (*A*) Sagittal T1-weighted image shows a well-circumscribed nodule (*arrow*) along the third flexor tendon sheath that is slightly hyperintense to skeletal muscle. (*B*) Coronal, short axis, conventional T2-weighted image shows a rim of low signal intensity around the intermediate to low signal nodule (*arrow*). Signal characteristics are in keeping with pathologically proved giant cell tumor of tendon sheath.

soft tissue on radiographs. On sonography, lipomas are variable in their echogenicity but often are elliptic, well circumscribed, and have their longest dimension paralleling the skin.[4] MR imaging is diagnostic, demonstrating a soft tissue mass that is isointense to subcutaneous fat on all sequences (**Fig. 12**). A few thin septations may be present, but



**Fig. 12.** Lipoma. Sagittal T1-weighted image demonstrates a fatty mass (*arrow*) paralleling the metatarsal shaft contains a few thin septae, consistent with lipoma. Notice there are fewer septae in the lipoma relative to the plantar subcutaneous fat. Lipomas are common benign tumors that usually are never imaged.

they should be fewer in number relative to the adjacent subcutaneous fat. Displacement of muscle fibers in intramuscular lipomas could be mistaken for septations if not fully evaluated on several imaging planes.

### Soft Tissue Chondroma

Soft tissue chondroma is one of two "chondro-osseous tumors" designated by the World Health Organization.[31] Chondromas are benign extraosseous and extrasynovial soft tissue tumors composed primarily of mature hyaline cartilage, occurring in a variety of age ranges, with a slight male predominance.[31] Although most lesions occur around the fingers, soft tissue chondromas can occur around the foot and ankle. Mineralization is invariably present on radiographs. MR imaging demonstrates a soft tissue mass approximating cartilage signal intensity. If mineralization is present, this is evident by corresponding signal voids (**Fig. 13**). Lesions can become large and may be mistaken for chondrosarcoma.[32] Surgical excision typically is curative; however, up to 20% recur and malignant transformation to chondrosarcoma has been reported in rare instances.[31]

### Synovial Sarcoma

Synovial sarcoma is classified under "tumors of uncertain differentiation" by the World Health Organization.[33] These are mesenchymal, spindle-cell tumors that display epithelial differentiation and biphasic morphology, histologically resemble synovial cells (but are not actually derived from them), and have a cytogenic hallmark of t(X;18)(p11;q11).[33] Synovial sarcoma can occur in any age group but most occur in young adults and there is a male predominance.[33] Most cases of synovial sarcoma arise in the deep soft tissues around the knee; synovial sarcoma occurs less commonly in the foot and ankle. Lesions typically are lobulated soft tissue masses that can invade multiple compartments of the foot and erode into the bones (**Fig. 14**). Approximately a third of cases demonstrate mineralization on radiographs.[2] MR imaging shows fluid-fluid levels in approximately 10% to 25% of cases due to prior hemorrhage, and MR imaging also may show "triple" signal intensity resulting from a combination of cystic and solid components.[2,34] Surgical resection is the treatment. Approximately half of synovial sarcomas recur and approximately 40% metastasize to the lungs, bones, or regional lymph nodes.[33]

### Undifferentiated Pleomorphic Sarcoma

Undifferentiated high grade pleomorphic sarcoma (UPS) is categorized as a "so-called fibrohistiocytic
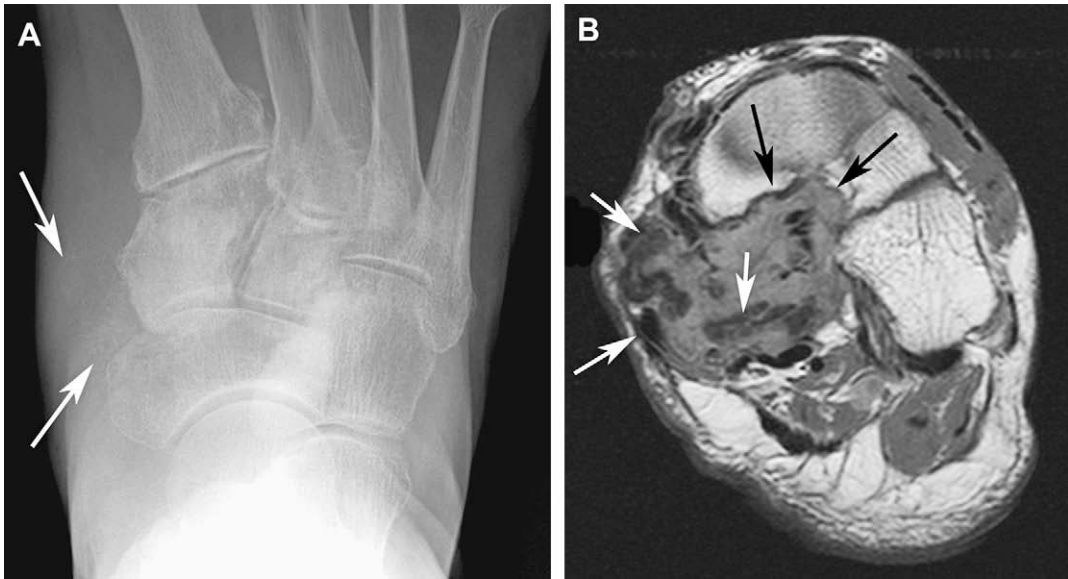
**Fig.13.** Soft tissue chondroma. (*A*) AP radiograph of the midfoot shows multiple coarse calcifications (*arrows*) within a medially located soft tissue mass. (*B*) Coronal, short-axis, T1-weighted image through the mass shows signal voids (*white arrows*) corresponding to the regions of radiographically visible mineralization. Subtle scalloping (*black arrows*) of the cuneiforms, as opposed to cortical destruction, reflects the nonaggressive nature of this tumor.
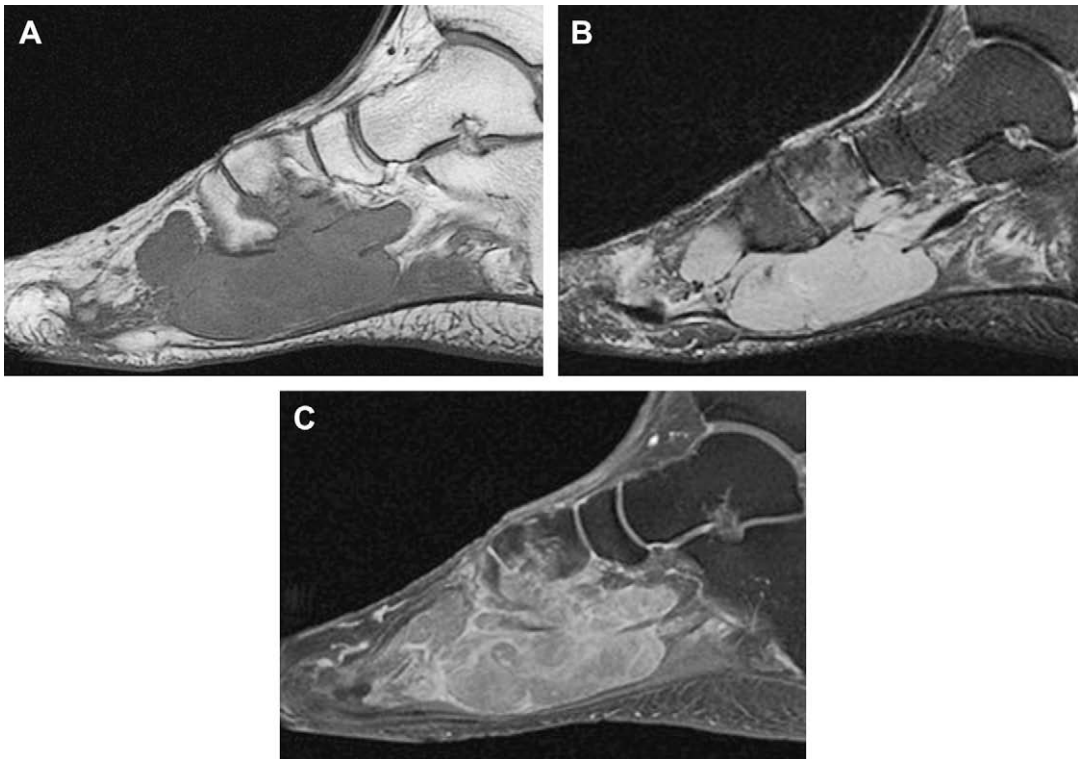


**Fig.14.** Synovial sarcoma. (*A*) T1-weighted; (*B*) FSE T2-weighted, fat-suppressed; and (*C*) enhanced, T1-weighted images show a large, lobulated soft tissue mass along the plantar aspect of the foot, which invades multiple compartments of the foot and erodes into the bones. The mass proved to be a synovial sarcoma at resection.
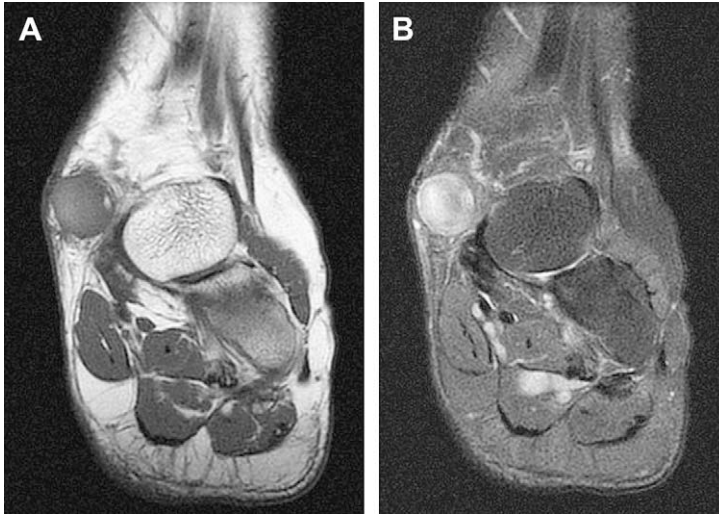
Fig. 15. Leiomyosarcoma. Coronal (*A*) T1-weighted and (*B*) FSE T2-weighted fat suppressed images through the hindfoot demonstrate a well-circumscribed, nonspecific superficial nodule medial to the talus. Resection was performed, with pathologic diagnosis of leiomyosarcoma. Patient underwent tumor resection with sural artery fasciocutaneous flap, preoperative and intraoperative adjuvant radiation therapy.

tumour" by the World Health Organization, and was previously termed malignant fibrous histiocytoma (MFH).[35] Pleomorphic (MFH-like) sarcoma represents the most common type of sarcoma in patients older than 40 years of age, and there is a slight male predominance.[35] Although approximately half of these tumors occur in the lower extremity, undifferentiated pleomorphic sarcoma is more common in the thigh than in the foot and ankle.[36] Imaging reveals nonspecific solid soft tissue masses, with the majority of tumors occurring in the deep intramuscular compartments.[36] MR imaging characteristics depend upon the variable amount of collagen, myxoid tissue, necrosis and hemorrhage.[36] Fluid-sensitive sequences often reveal hyperintense signal within the mass, although signal is variable and masses can also be hypointense to skeletal muscle. High grade pleomorphic sarcomas have a poor prognosis, with an overall 5-year survival of 50–60%.[37]

### Leiomyosarcoma

Leiomyosarcoma is a malignant smooth muscle tumor that usually occurs in middle-aged or old patients, and most often in the retroperitoneum.[38] Tumors can originate from the major blood vessels, soft tissue or dermis. Leiomyosarcomas only account for approximately 10–15% of limb sarcomas, and can occasionally be seen in the foot and ankle.[38] Radiographic mineralization is reported in approximately 15% of soft tissue lesions, and magnetic resonance imaging features are nonspecific (**Fig. 15**) with large lesions demonstrating hemorrhage, necrosis and cystic change.[39] Subcutaneous lesions are generally larger and associated with a less favorable prognosis than dermal lesions.[39] Leiomyosarcoma is

capable of both local recurrence and distant metastases, although regional lymph node involvement is rare.[38]

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