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Magnetic resonance imaging of soft-tissue tumors of the extremities: A practical approach

Chan WP. MRI of soft-tissue tumors of the extremities

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Abstract

Diagnosis of extremity soft-tissue tumors can be challenging. Characteristics of tumor margins can precisely identify locally aggressive or non-aggressive behavior for surgical planning, but cannot differentiate benign from malignant lesions. Most malignant tumors can have inhomogeneous signals on T2-weighted images. Although a uniform signal on T2-weighted images can be a reliable indication of a benign lesion, a well-defined mass with homogeneous internal signal intensity does not definitively identify a benign lesion. Some common and distinctive soft-tissue lesions can have specific characteristic clinical and imaging features allowing a diagnosis without biopsy. These are known as determinate lesions. This illustrative report presents a diagnostic guide for extremity soft-tissue tumors based on tissue signal and morphological characteristics on magnetic resonance images. It is important for clinicians to be familiar with the imaging characteristics of common determinate lesions.

Key words: Extremity; Magnetic resonance imaging; Musculoskeletal neoplasm; Sarcoma; Soft-tissue tumors

Core tip:

Chan WP. Magnetic resonance imaging of soft-tissue tumors of the extremities: A practical approach.

MAGNETIC RESONANCE IMAGING OF SOFT-TISSUE TUMORS OF THE EXTREMITIES: A PRACTICAL APPROACH

The functions of magnetic resonance imaging (MRI) in evaluation of soft-tissue tumors of the extremities include detection, characterization, local staging, and detection of recurrence and complications after therapy.

MR imaging and computed tomography (CT) scanning can be equally accurate for detecting the size and extent of a tumor. MR imaging is more accurate than CT for evaluating individual muscle involvement and therefore can be the staging procedure of choice in patients with soft-tissue sarcoma of the extremities.

MR imaging is superior to CT in detecting recurrent soft-tissue sarcomas. A nodule or mass with a mass effect on surrounding tissue is highly indicative of recurrent tumors. However, both the tumor and organizing scar (or granulation tissue) can show marked gadolinium enhancement.

MRI determinate lesions

Some common and distinctive soft-tissue lesions have specific characteristic clinical and imaging features allowing a diagnosis without biopsy[1]. These are known as determinate lesions[2]. Examples of lesions with specific signal characteristics on MR imaging are lipoma, hemangioma, ganglion and Baker cysts, peripheral nerve sheath tumor (PNST) and neurofibroma, giant cell tumor (GCT) arising from the tendon sheath, myositis ossificans, muscle tear and hematoma, abscess, myoneurosis, subungual glomus tumor, localized solitary synovitis, bursitis, tumoral calcinosis-like metastatic calcification, and aneurysm.

MRI indeterminate lesions

An indeterminate lesion is one that must be biopsied to ensure an accurate diagnosis[2]. Examples of lesions are fibroma, fibrosarcoma, leiomyoma, leiomyosarcoma, angiosarcoma (hemangiosarcoma), rhabdomyoma,

rhabdomyosarcoma, synovial sarcoma, synovioma, lymphangiosarcoma, malignant hemangiopericytoma, alveolar soft parts sarcoma, epithelioid sarcoma, and angiosarcoma. Diagnosis in a suspicious for malignancy tumor should never be left to imaging. All suspicious tumors should be biopsied.

Characteristics of tumor margins

A well-demarcated lesion or a tumor mass with a capsule can favor a benign diagnosis, whereas a less well-demarcated lesion or tumor mass with an infiltrative margin are most likely malignant. Margin characteristics can precisely identify locally aggressive or non-aggressive behavior for surgical planning, but cannot differentiate benign from malignant lesions[3]. Clinical data always play an important role in evaluating aggressiveness of tumors.

Characteristics of MRI signals

Fat, fibrous tissue, fluid or cyst, and protein can be characterized by specific signals on MR imaging. Most benign lesions have a uniform signal on T1-weighted and T2-weighted images, with the exception, for example, of neurofibromas and hemangiomas, which exhibit inhomogeneous signals on T2-weighted images. Most malignant tumors can have a uniform signal on T1-weighted images but inhomogeneous signals on T2-weighted images. Although a uniform signal on T2-weighted images can be a reliable indication of a benign lesion, a well-defined mass with homogeneous internal signal intensity does not definitively identify a benign lesion. Lack of uniformity does not reliably indicate malignancy[3]. Low-grade liposarcomas and leiomyosacroma, for example, are malignant lesions with misleading benign appearances. Soft-tissue lesions arising from trauma (*e.g.,* hematoma) can mimic malignancy.

On dynamic gadolinium-enhanced MR imaging, measurement of relaxation times cannot guide evaluation, as the T1- and T2-relaxation times of benign and malignant lesions overlap significantly[4]. Whether the time-intensity-curve (TIC) shape analysis alone can differentiate malignant

from benign soft-tissue tumors, or differentiate between tumor grades, remains controversial[5].

The aim of this illustrative report is to provide a diagnostic guide for soft-tissue tumors of the extremities based on tissue signal and morphological characteristics on MR images. Examples of common determinate lesions are illustrated, except one indeterminate lesion (malignant fibrous histocytoma) is shown as an example for comparison.

Case 1

A 55-year-old woman had had a palpable mass on her right palm for 1 year, which had recently progressively increased in size (Figure 1).

Case 2

Axial T1-weighted MR image of bilateral thighs shows a lobulated high-signal-intensity mass with uneven or focal thickening septa within the tumor on the right thigh, which can be a finding for low-grade liposarcoma (Figure 2).

Case 3

Axial, T1-weighted image, fat-saturated T2-weighted MR image, and fat saturated gadolinium-enhanced T1-weighted images of left thigh show a lobulated fat-containing mass with an enhancing nonadipose mass-like area on the left thigh, suggestive of myxoid stroma (Figure 3).

Case 4

Coronal T1-weighted imageand fat saturated T2-weighted MR image of the left calf show a heterogeneous serpiginous high-signal-intensity lesion on T2-weighted image, which is caused by dilated slow-flowing vessels with methemoglobin. Some low-signal-intensity pattern indicates fast-flow blood or hemosiderin or calcification (Figure 4).

Case 5

Coronal proton-density and axial gradient-echo images of left knee show a well-defined cystic lesion connected to the knee joint by way of a narrow neck between the semimembranosus tendon and the medial head of the gastrocnemius muscle (gm) (Figure 5).

Case 6

A 61-year-old man had a mass on his left third toe. Note the close relation of the tumor and the flexor tendon. In this case, the tumor does not extend to the bone marrow (Figure 6).

Case 7

Coronal T1-weighted image of the left forearm shows a spindle-shaped mass with isointensity relative to adjacent muscle. Because the neurovascular bundle is normally surrounded by fat, masses arising at this site maintain a rim of fat about them as they slowly enlarge. Coronal T1-weighted fat-saturated gadolinium-enhanced image shows heterogeneous enhancement of the mass. Recognition of the spindle shape of the tumor and contiguity of the tumor and adjacent nerve may suggest the diagnosis[5] (Figure 7).

Case 8

A 35-year-old man axial fat-saturated T2-weighted MR image of the right forearm shows that the mass has an area of peripheral high signal intensity of myxoid Antoni type B and a more cellular Antoni type A region of low signal intensity centrally, representing the "target sign" [5] (Figure 8).

Case 9

A 55-year-old woman axial fat-saturated T2-weighted MR image of the gluteal region shows a hyperintense mass with multiple small hypointense fascicle-like structures in the mass, representing the "fascicular sign" [5] (Figure 9).

Case 10

A 65-year-old woman axial fat-saturated gadolinium-enhanced T1-weighted MR image shows a markedly enhanced tumor mass in the subcutaneous area of the right knee. The mass has an ill-defined margin with a fascicular appearance centrally. Differentiating a benign from a malignant mass is often difficult. Imaging features suggesting malignancy can be a larger size and an infiltrative margin [6] (Figure 10).

Case 11

A 23-year-old woman complained of pain in her left thumb. A vitamin E marker was placed over the painful location as a reference point (Figure 11).

Case 12

Axial T2-weighted MR image of the knee shows a nodular mass, with a long pedicle attaching the mass to the adjacent synovium, involving the infrapatellar fat pad. Note small circular foci of low signal intensity (thin arrow), corresponding to deposition of hemosiderin. Gadolinium-enhanced T1-weighted image with fat saturation shows obvious enhancement of the lesion caused by capillary proliferation (Figure 12).

Case 13

Coronal T1-weighted and T2-weighted MR image of the knee. There is a well-defined mass within the subcutaneous of knee. On T1-weighted image, there is a hyperintensity of extracellular methemoglobin at the periphery of the hematoma (which is seen 2-7 d after injury). Intermediate signal intensity of the center is the presence of intracellular methemoglobin. Note a very thin low-signal-intensity rim at the outermost layer of the hematoma, indicating hemosiderin (Figure 13).

Case 14

Axial T1-weighted MR image of the forearm shows a soft-tissue tumor with a relatively well-defined margin. No invasion to the adjacent radius or ulna was noted. Axial T2-weighted MR image shows heterogeneous signal intensity of the tumor mass, with an area of low signal intensity, suggesting fibrosis. Axial gadolinium-enhanced T1-weighted image with fat saturation shows enhancement of the parenchymal tissue of the tumor mass, corresponding to the hypervascular part of the tumor. Histological diagnosis confirmed a storiform-pleomorphic type of malignant fibrous histiocytoma (Figure 14).

Case 15

Axial gadolinium-enhanced T1-weighted image with fat saturation shows a mass lesion within the subcutaneous fat of the buttock, with a pronounced rim of enhancement, corresponding to large amounts of granulation tissue. The unenhanced central area is a fluid-debris cavity. Note the infiltrative margin suggesting an aggressive tumor (Figure 15).

In summary, MR imaging can be helpful in evaluating soft-tissue tumors of the extremities, but it can also be misleading. The combination of signal and morphological characteristics on MR images allows radiologists to categorize many lesions as benign or malignant, although a significant proportion of the images are not specific. It is important for clinicians to be familiar with the imaging characteristics of common determinate lesions. Biopsy is needed to define the histological nature of a soft-tissue indeterminate neoplasm.

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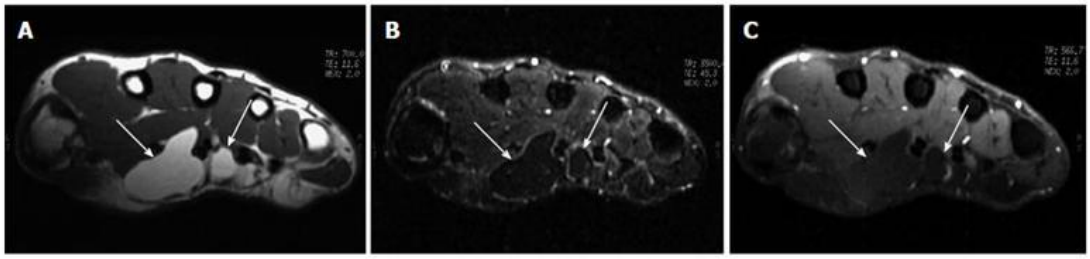

Figure 1 Lipoma of the tendon sheath. A: T1-weighted MR image of the right wrist shows a lobulated high-signal-intensity mass (arrows) located between the palmar muscles; B: Fat-saturated proton-density weighted MR image shows homogeneous low signal intensity of the tumor mass (arrows), suggestive of a fat component; C: There is no enhancement of the tumor mass (arrows) after gadolinium administration on fat-saturated T1-weighted image.

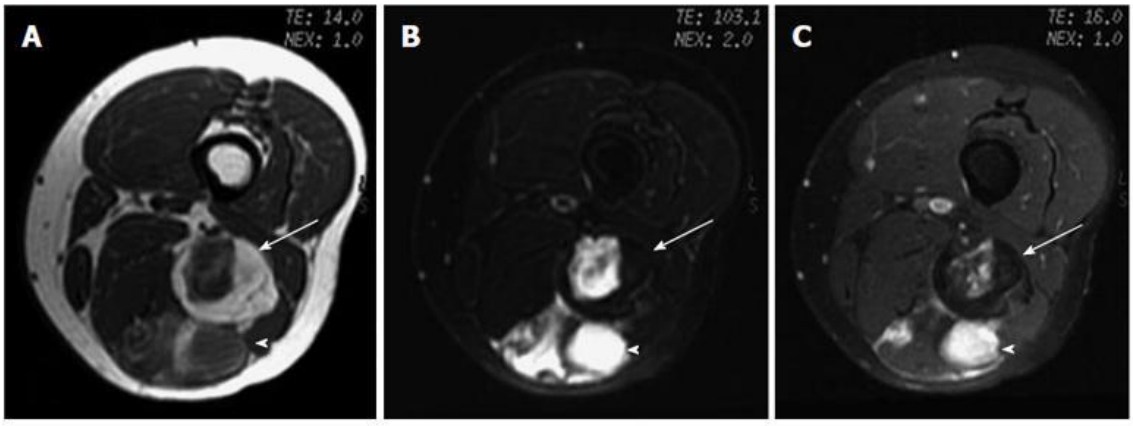

Figure 2 Low-grade liposarcoma. Axial T1-weighted MR image of bilateral thighs shows a lobulated high-signal-intensity mass with uneven or focal thickening septa (arrow) within the tumor on the right thigh, which can be a finding for low-grade liposarcoma.

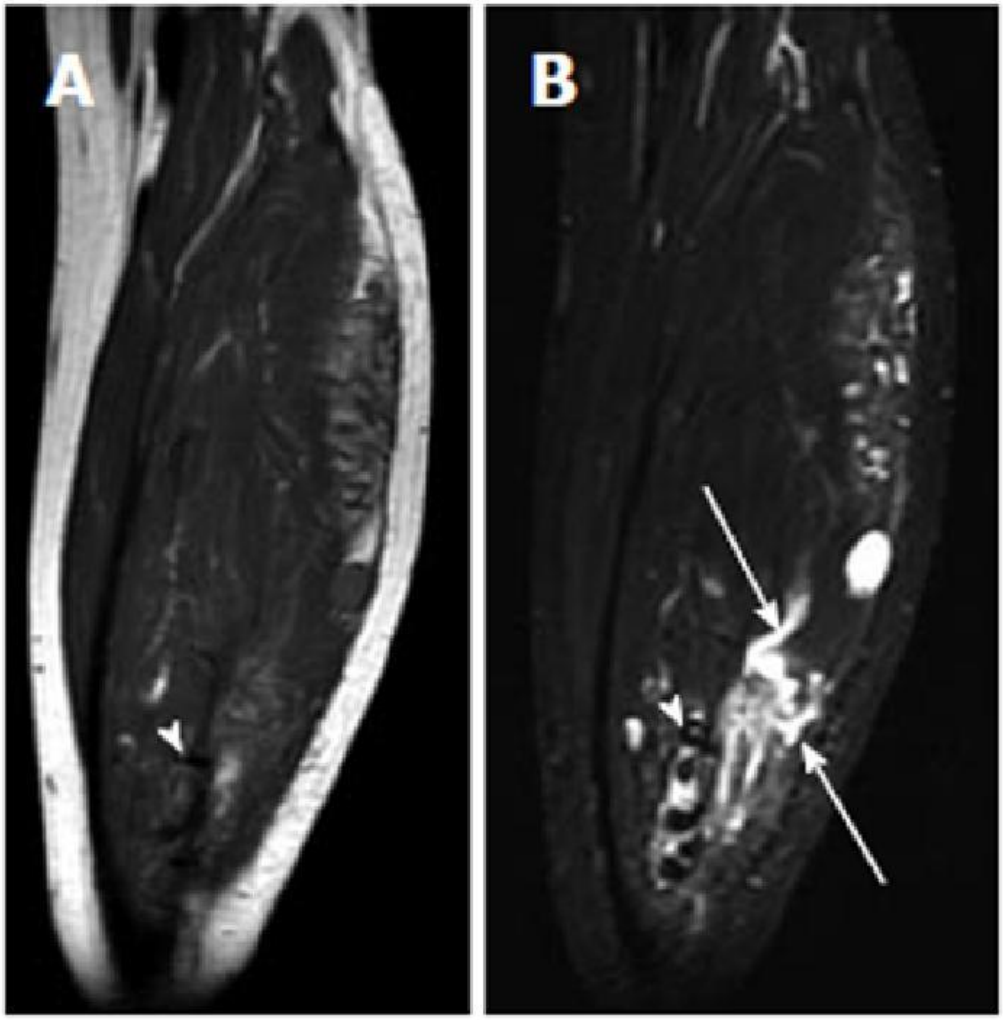

Figure 3 Myxoid liposarcoma. A: Axial; B: T1-weighted image, fat-saturated T2-weighted MR image; C: Fat saturated gadolinium-enhanced T1-weighted images of left thigh show a lobulated fat-containing mass (thin arrow) with an enhancing nonadipose mass-like area (thick arrow) on the left thigh, suggestive of myxoid stroma.

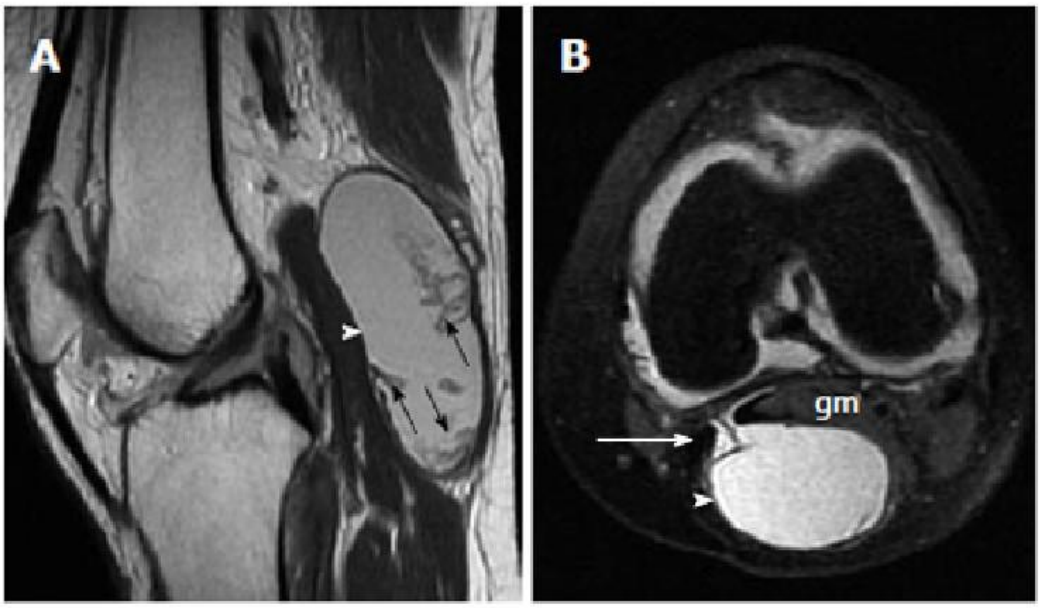

Figure 4 Cavernous hemangioma. A: Coronal T1-weighted image; B: Fat saturated T2-weighted MR image. The left calf show a heterogeneous serpiginous high-signal-intensity lesion (thin arrows) on T2-weighted image, which is caused by dilated slow-flowing vessels with methemoglobin. Some low-signal-intensity pattern (thick arrow) indicates fast-flow blood or hemosiderin or calcification.

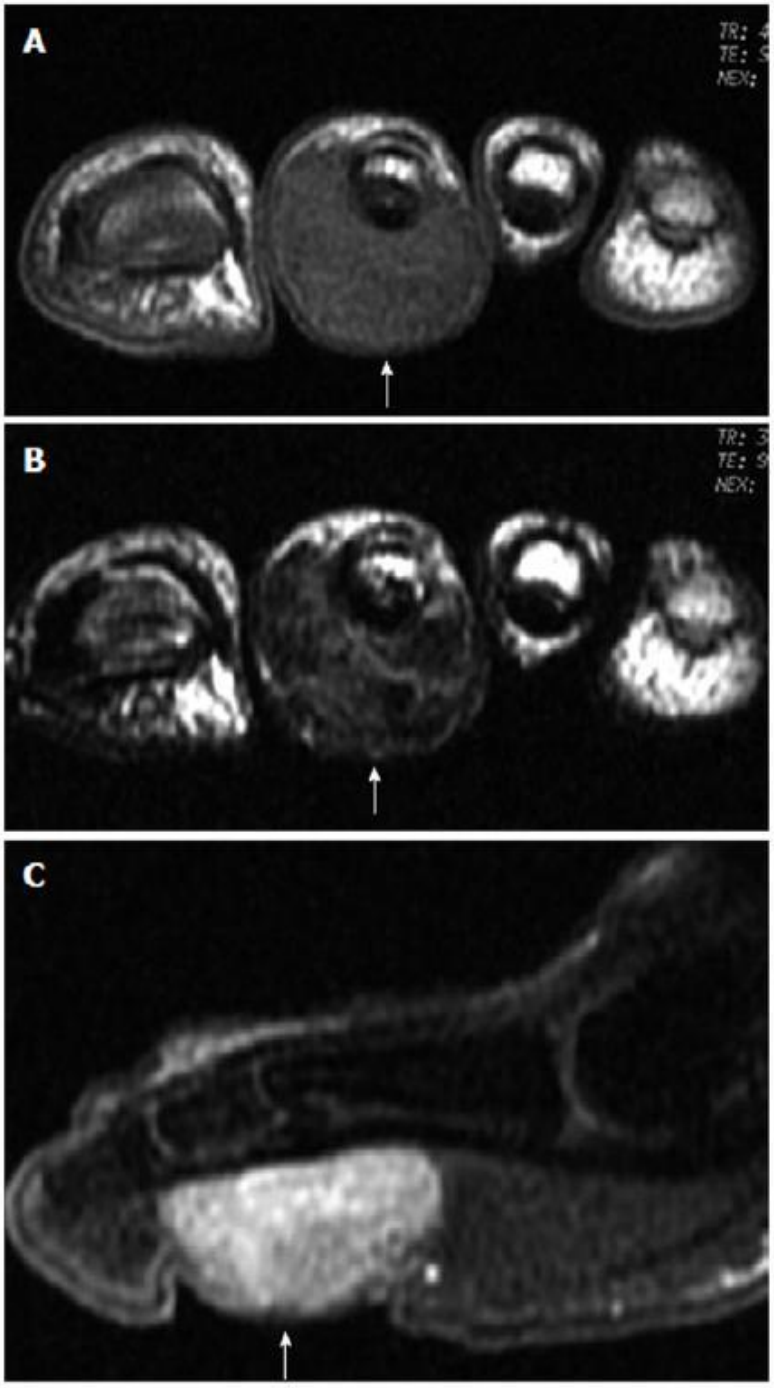

Figure 5 Baker cysts. A: Coronal proton-density B: Axial gradient-echo images; Left knee show a well-defined cystic lesion (thick arrow) connected to the knee joint by way of a narrow neck between the semimembranosus tendon (thin arrow) and the medial head of the gastrocnemius muscle (gm). Note that the Baker cyst contains debris (small arrows in A).

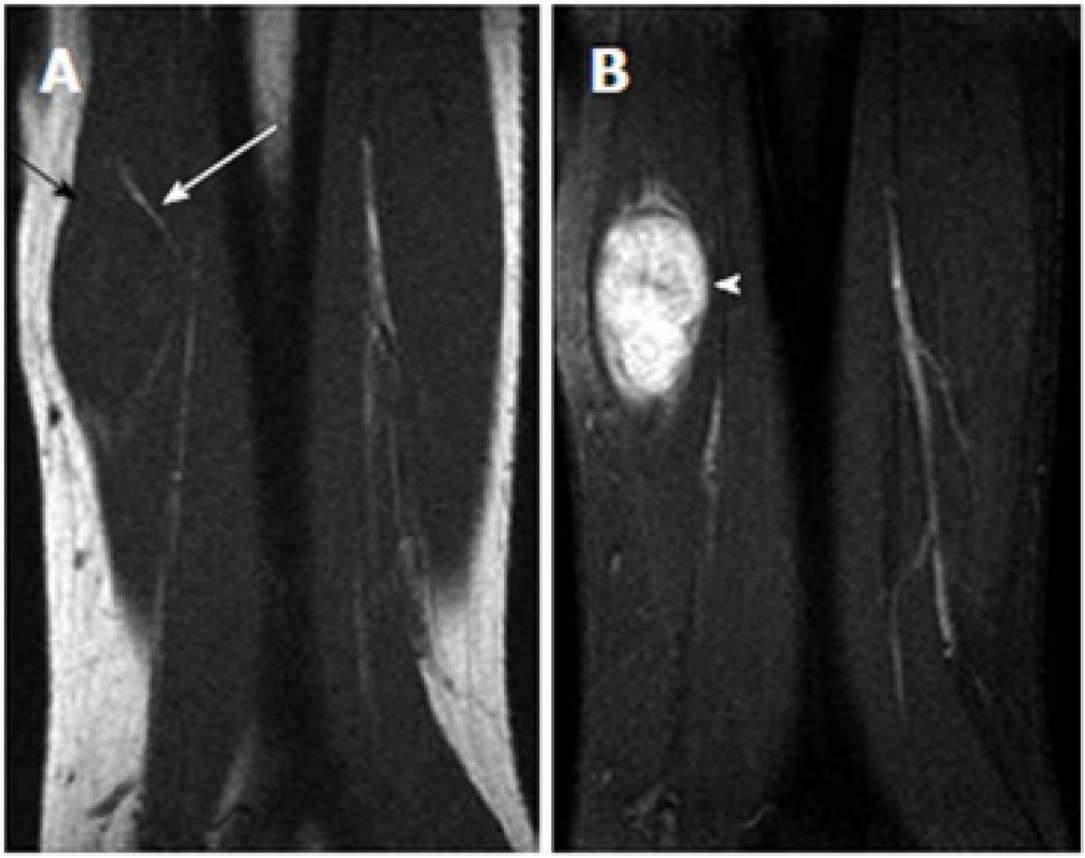

Figure 6 G iant cell tumor of the tendon sheath. A: T1-weighted image shows the tumor (arrow) on the plantar side. B: T2-weighted image shows heterogeneous low signal intensity of the tumor (arrow) due to hemosiderin deposition. C: Sagittal gadolinium-enhanced T1-weighted image with fat saturation shows obvious enhancement of the tumor mass (arrow).

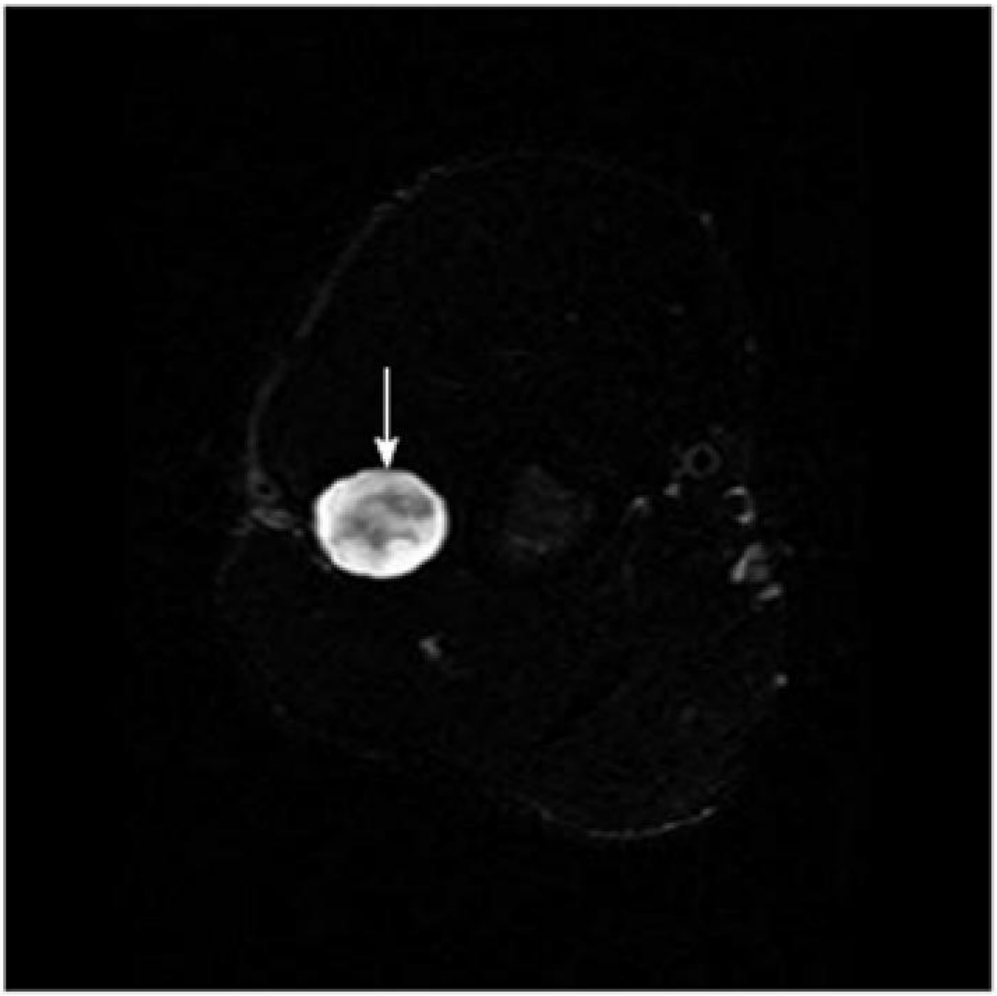

Figure 7 Neurofibroma of the left ulnar nerve (split-fat sign) in a 58-year-old man. A: Coronal T1-weighted image of the left forearm shows a spindle-shaped mass with isointensity relative to adjacent muscle. Note the presence of the split-fat sign (arrows). Because the neurovascular bundle is normally surrounded by fat, masses arising at this site maintain a rim of fat about them as they slowly enlarge. B: Coronal T1-weighted fat-saturated gadolinium-enhanced image shows heterogeneous enhancement of the mass. Recognition of the spindle shape of the tumor and contiguity of the tumor and adjacent nerve may suggest the diagnosis[5].

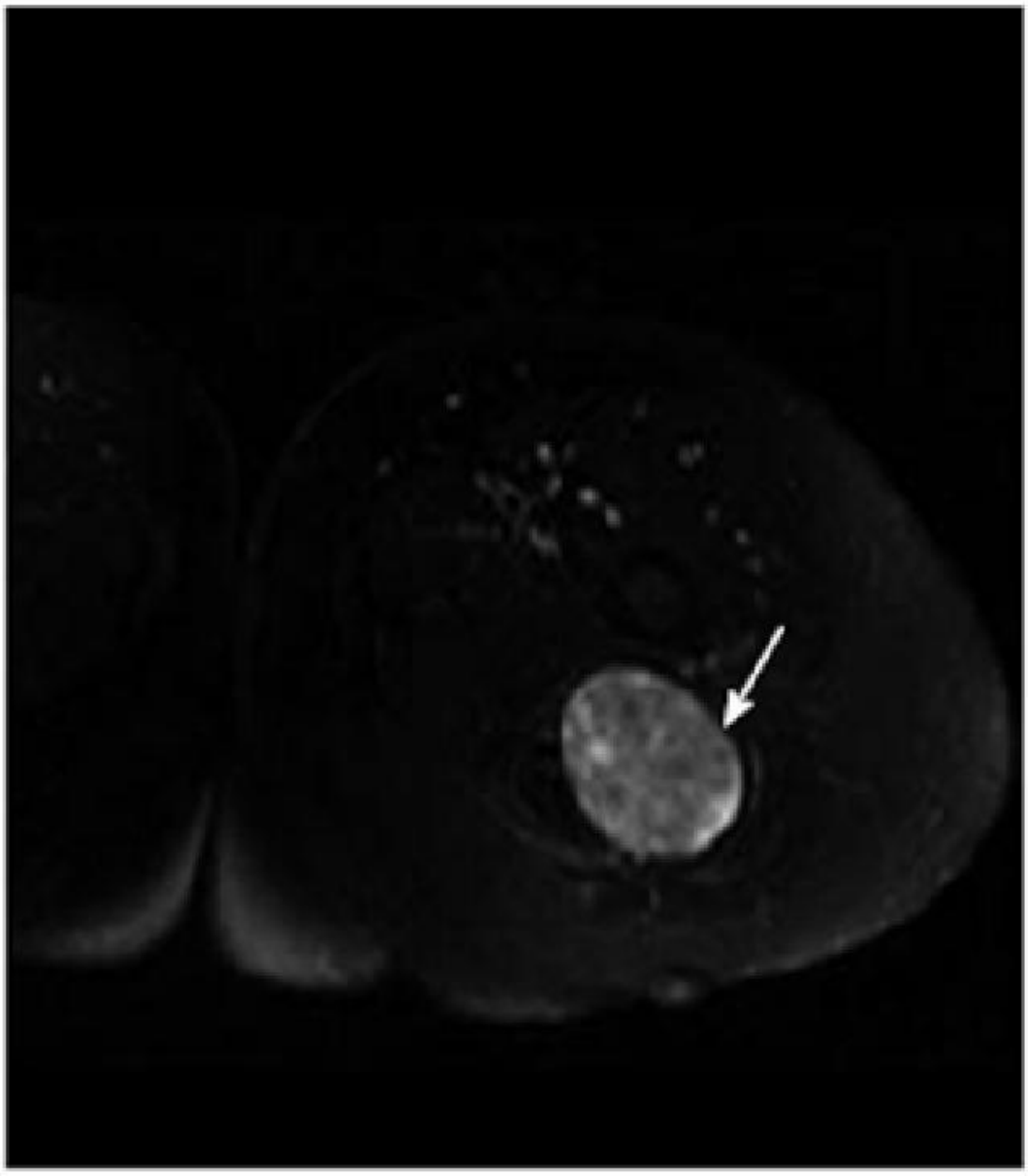

Figure 8 Neurofibroma of the right radial nerve (target sign) in a 35-year-old man. High signal intensity of myxoid Antoni type B (arrow).

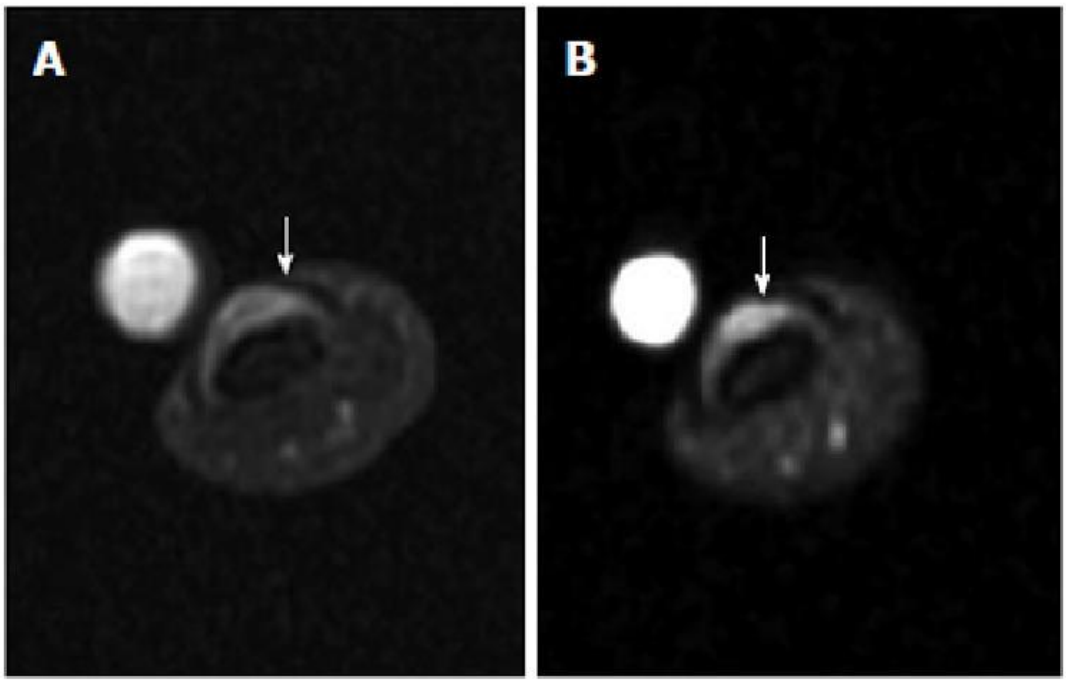

Figure 9 Neurofibroma of the left sciatic nerve (fascicular sign) in a 55-year-old woman. A hyperintense mass (arrow) with multiple small hypointense fascicle-like structures in the mass, representing the "fascicular sign".

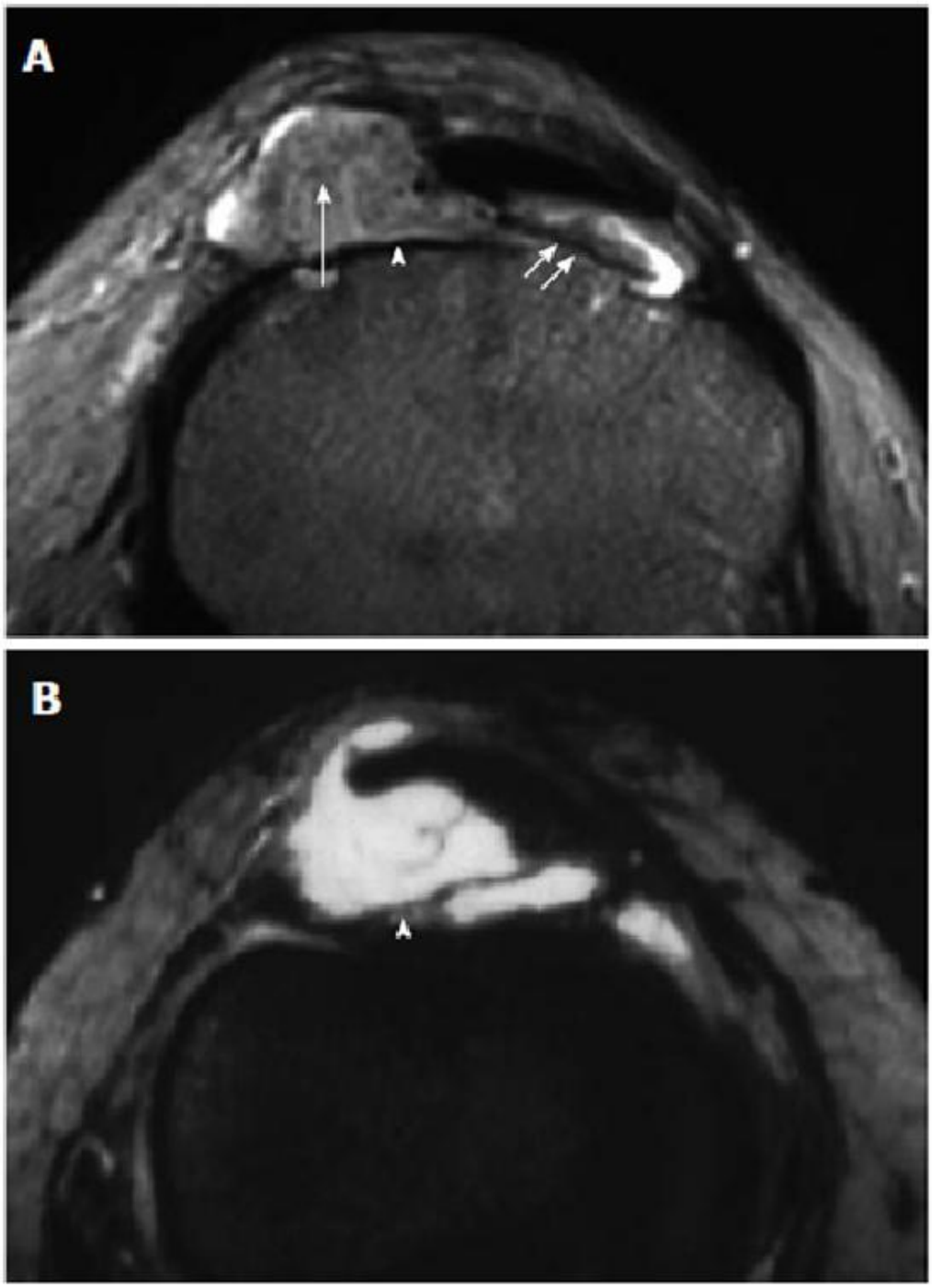

Figure 10 Malignant peripheral nerve sheath tumor involving the subcutis of the right knee in a 65-year-old woman. Tumor mass (thick arrow) in the subcutaneous area of the right knee; the mass has an ill-defined margin (thin arrows) with a fascicular appearance centrally.

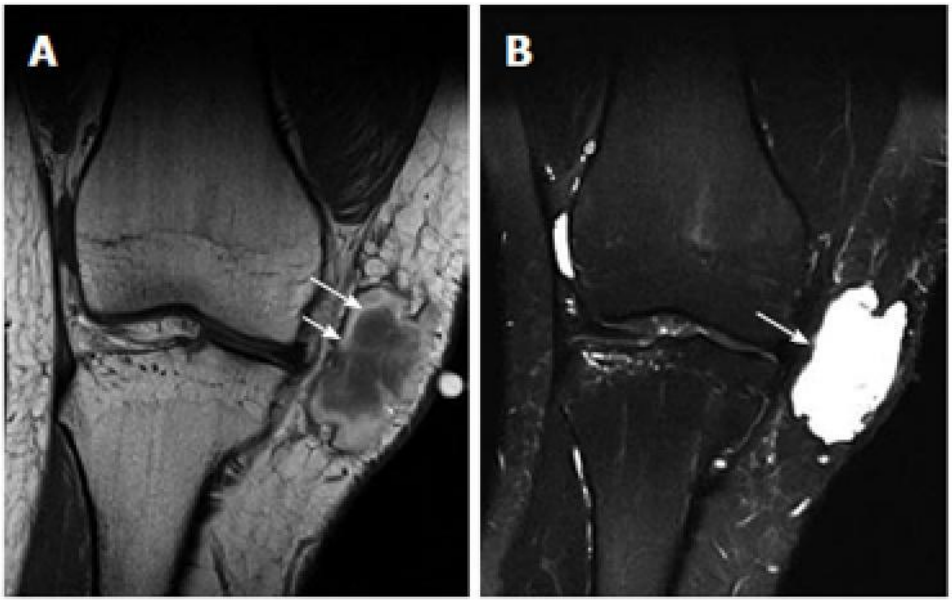

Figure 11 Subungual glomus tumor. A: Coronal proton-density-weighted MR image of the left thumb shows a small subungual tumor (arrow). B: Fat-saturated gadolinium-enhanced T1-weighted image shows obvious enhancement of the tumor (arrow).

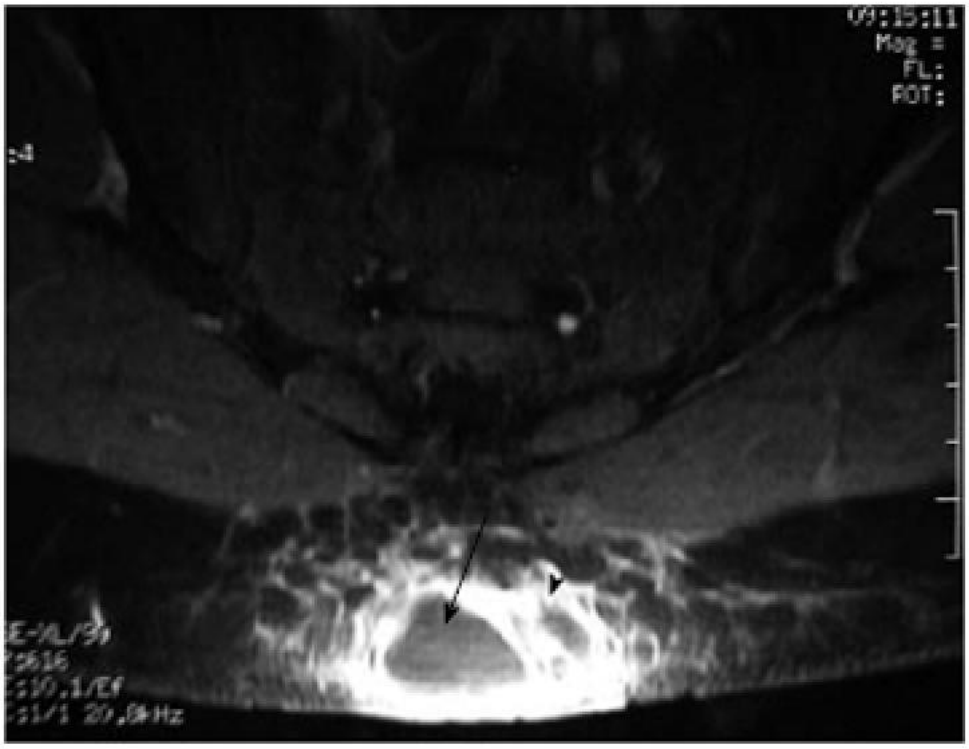

Figure 12 Localized nodular synovitis (solitary PVNS). A: Axial T2-weighted MR image of the knee shows a nodular mass (thick arrow), with a long pedicle (double short arrows) attaching the mass to the adjacent synovium, involving the infrapatellar fat pad. Note small circular foci of low signal intensity (thin arrow), corresponding to deposition of hemosiderin. B: Gadolinium-enhanced T1-weighted image with fat saturation shows obvious enhancement of the lesion (arrow) caused by capillary proliferation. (Photo courtesy of Dr. Guo-Shu Huang).

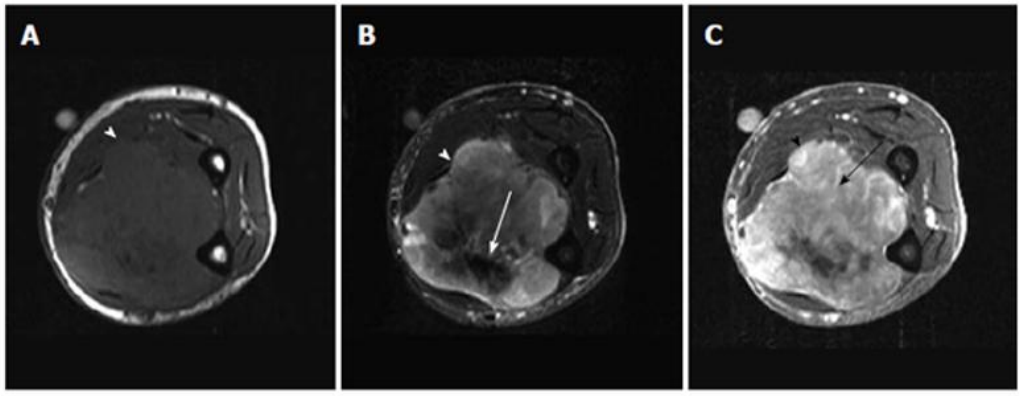

Figure 13 Early subacute hematoma. A: Coronal T1-weighted; B: T2-weighted MR image of the knee. On T1-weighted image, there is a hyperintensity of extracellular methemoglobin at the periphery (thin arrow) of the hematoma (which is seen 2-7 d after injury). Note a very thin low-signal-intensity rim at the outermost layer of the hematoma, indicating hemosiderin (thick arrow). B: Coronal T2-weighted MR image show overall hyperintensity of the hematoma (arrow), exception made for a very thin low-signal-intensity peripheral rim caused by hemosiderin.

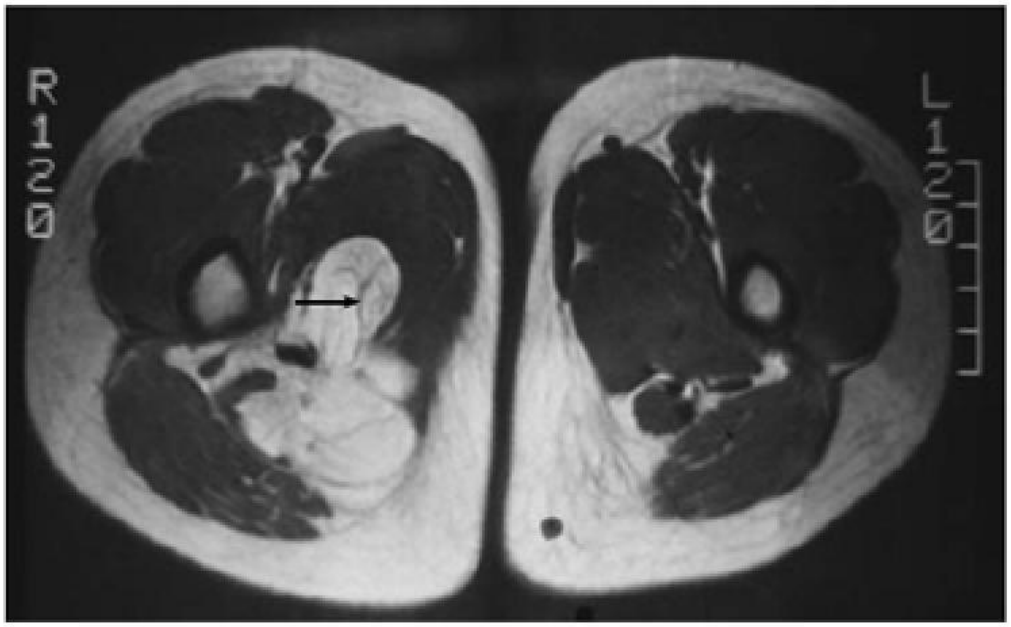

Figure 14 Malignant fibrous histocytoma. A: Axial T1-weighted MR image of the forearm shows a soft-tissue tumor (thick arrow) with a relatively well-defined margin. No invasion to the adjacent radius or ulna was noted; **B:** Axial T2-weighted MR image shows heterogeneous signal intensity of the tumor mass (thick arrow), with an area of low signal intensity (thin arrow), suggesting fibrosis; **C:** Axial gadolinium-enhanced T1-weighted image with fat saturation shows enhancement of the parenchymal tissue (thin arrow) of the tumor mass (thick arrow), corresponding to the hypervascular part of the tumor.

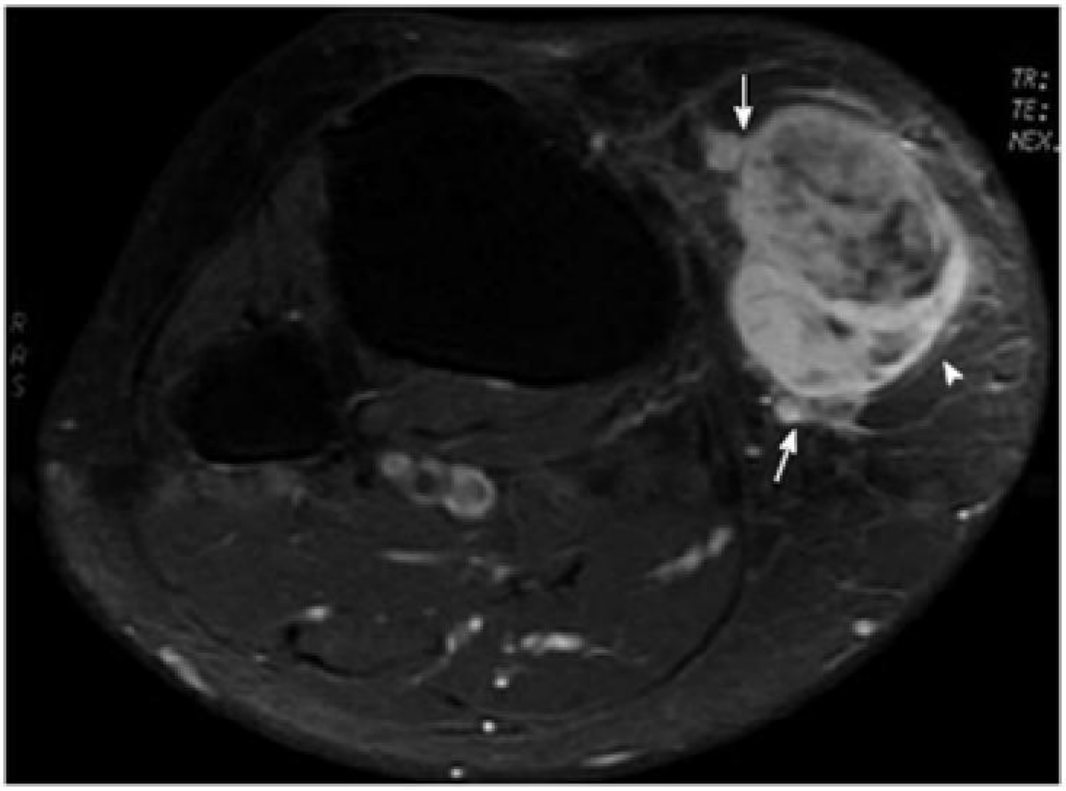

Figure 15 Abscess. Axial gadolinium-enhanced T1-weighted image with fat saturation shows a mass lesion within the subcutaneous fat of the buttock, with a pronounced rim of enhancement (thick arrow), corresponding to large amounts of granulation tissue. The unenhanced central area is a fluid-debris cavity (thin arrow).