
Distinguishing synovial sarcoma from benign and malignant mimics: MR Imaging indicators

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Synovial sarcomas (SS) are malignant soft tissue tumors thought to account for 5-10% of soft tissue sarcomas.¹⁻³ Synovial sarcomas are rare, with an estimated incidence of 2.75 in 100,000 people.⁴ However, they are the second-most prevalent soft-tissue tumors after rhabdomyosarcoma in children, adolescents, and young adults.¹

Since synovial sarcomas are so rare, many clinicians and radiologists are not familiar with their presentation and imaging appearance. For these tumors to be biopsied, it is essential that interpreting radiologists or orthopedic oncologists not deem them benign. Incorrectly assuming that an SS is a benign lesion will lead to delays in diagnosis and possibly prognosis. Conversely, mistaking a benign lesion for an SS may result in increased patient anxiety and costs due to unnecessary procedures and imaging tests.

The aim of this article is to describe the key magnetic resonance imaging

(MRI) features of SS, as well as to describe those of benign and malignant tumors that are often confused with SS (Table 1).

In one study, 84% of synovial sarcoma patients were between 10 and 50 years old.⁵ Males and females seem to be equally affected.⁶ Ninety percent of SS occur in the lower extremities often near joints, and in the trunk wall, but the disease can be found anywhere in the body⁹ with rare reports of intra-articular SS.¹⁰ Synovial sarcomas are high-grade (II/III).¹¹ There are three common histologic types.¹² The monophasic type is most common and made up of only of spindle cells.¹² The biphasic type consists of spindle cells and epithelial cells.¹² Finally, the undifferentiated type is made up of cells resembling those of small round blue cell tumors.¹²

Factors that result in a worse prognosis include large tumor size, metastases at diagnosis, trunk disease, and positive margins after surgical resection.¹³ Five-year and 10-year survival rates of SS are estimated to be about 70%, and 60% respectively.¹³ The poor survival rate of SS is likely related to local recurrence and lung metastases.¹³

Synovial sarcomas are usually first detected as painless growing masses.¹⁴ Confirmation of the presence of a mass by radiography and MRI is usually performed prior to biopsy.¹⁴ Definitive SS diagnosis is based on biopsy. The biopsied tissue is often tested for the t(X;18)(p11;q11) translocation using fluorescence in situ hybridization (FISH), for which about 90% of SS are positive.¹⁵

MRI: Benign mimickers of synovial sarcomas *Neurofibromas*

Neurofibromas are benign nerve sheath tumors²¹ and may be associated with type 1 neurofibrosis (NF1). Neurofibromas usually occur superficially anywhere on the body.^{22,23} MR imaging features that help identify neurofibromas include (1) arising along a major nerve, (2) visualization of the nerve entering and exiting the tumor, (3) the target sign (round hypointense lesion with hyperintense rim) on T2-weighted imaging (Figure 2), (4) the fascicular sign (multiple small hypointense foci scattered within a hyperintense region on T2-weighted or proton-density weighted MR images), and (5) the

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Table 1: Benign and malignant lesions confused with synovial sarcoma

Benign lesions	Malignant lesions
Neurofibroma	Lymphoma
Hemangioma	Undifferentiated pleomorphic sarcoma
Spindle cell lipoma	Extraskeletal myxoid chondrosarcoma
Pigmented villonodular synovitis (PVNS)/ Giant cell tumor of tenosynovial origin	Liposarcoma
Morel-Lavallee lesion	Epithelioid sarcoma
Synovial chondromatosis	Melanoma

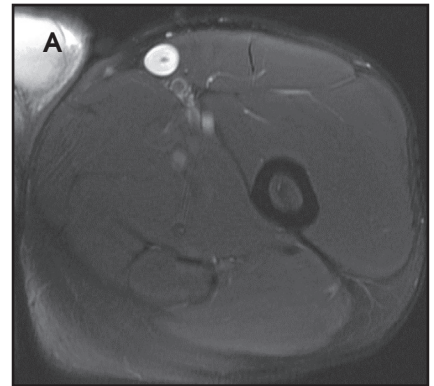


FIGURE 2. (A) Axial T2 image with fat saturation of the left thigh demonstrating a neurofibroma in the medial subcutaneous tissues. (B) Coronal STIR view of the same image.

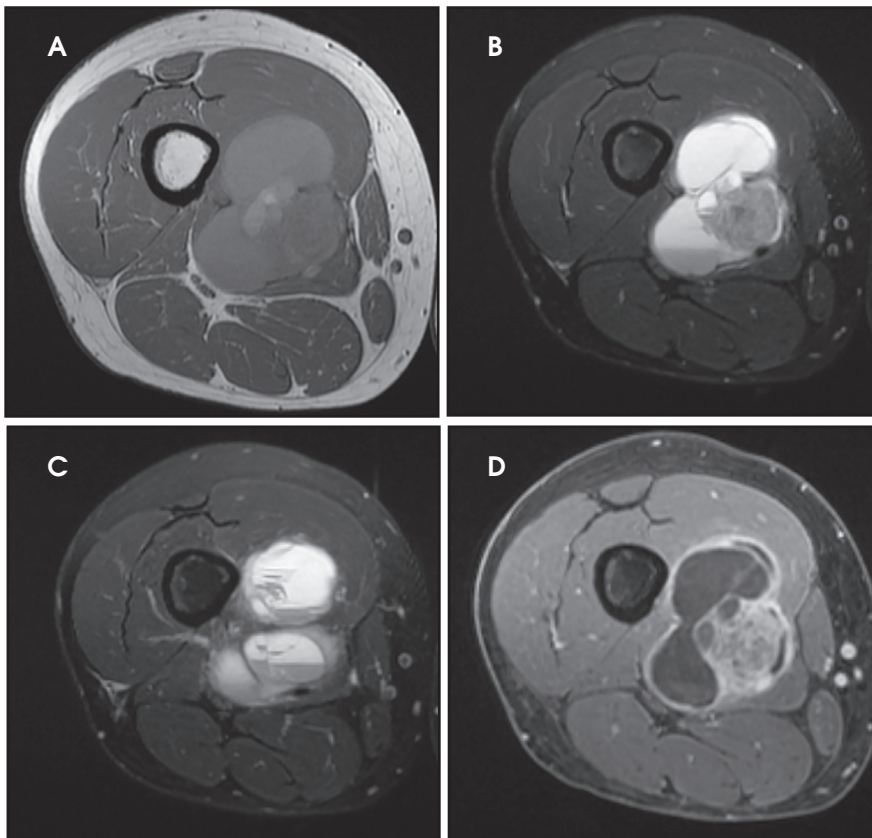


FIGURE 1. (A) Axial T1 image without fat saturation of the right thigh demonstrating a synovial sarcoma with internal areas of T1 signal. (B) Axial T2 image with fat saturation of the right thigh demonstrating a synovial sarcoma with three distinct T2 signal intensities. (C) Axial T2 image of the right thigh demonstrating a synovial sarcoma with fluid-fluid levels. (D) Axial T1 image with fat saturation, postcontrast, of the right thigh demonstrating a synovial sarcoma with heterogeneous enhancement.

split-fat sign—a rim of fat surrounding the lesion (best appreciated on T1-weighted images).^{24,25} While most neurofibromas show avid enhancement on T1 postcontrast imaging, the enhancement pattern can be variable.²⁶

Hemangiomas

Hemangiomas are an abnormal proliferation of blood vessels and are perhaps better termed venous malformations.²⁷ They are one of the most common soft-tissue tumors in children.²⁸

Hemangiomas affect females three times more often than males.²⁹ The majority of hemangiomas occur superficially, and in the head and neck region.²⁸ On MRI, hemangiomas demonstrate low to intermediate signal intensity on the T1-weighted images; however, they appear hyperintense on T2-weighted images.^{30,31} They exhibit variable enhancement on T1-weighted

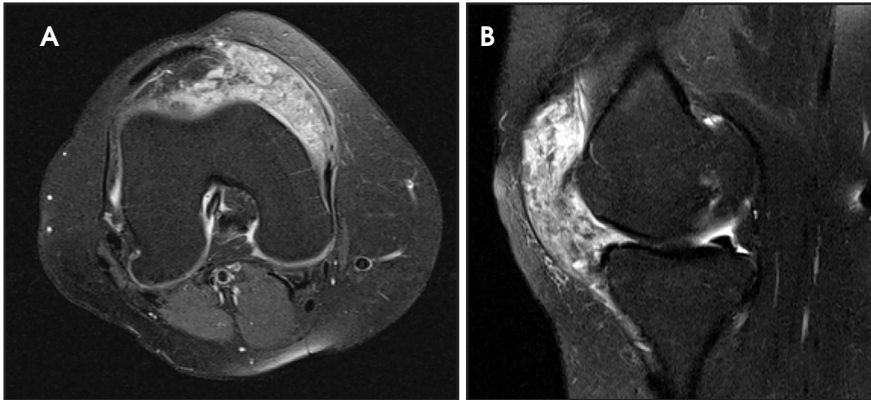


FIGURE 3. (A) Axial proton density-weighted image with fat saturation of the right knee demonstrating a synovial hemangioma in the medial joint. (B) Sagittal T2-weighted image with fat saturation demonstrating a synovial hemangioma.

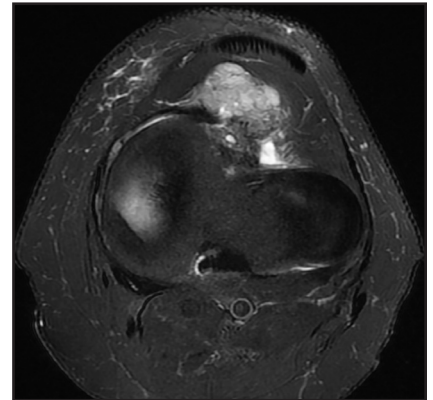


FIGURE 5. Axial T2-weighted image with fat saturation demonstrating synovial chondromatosis in left knee.

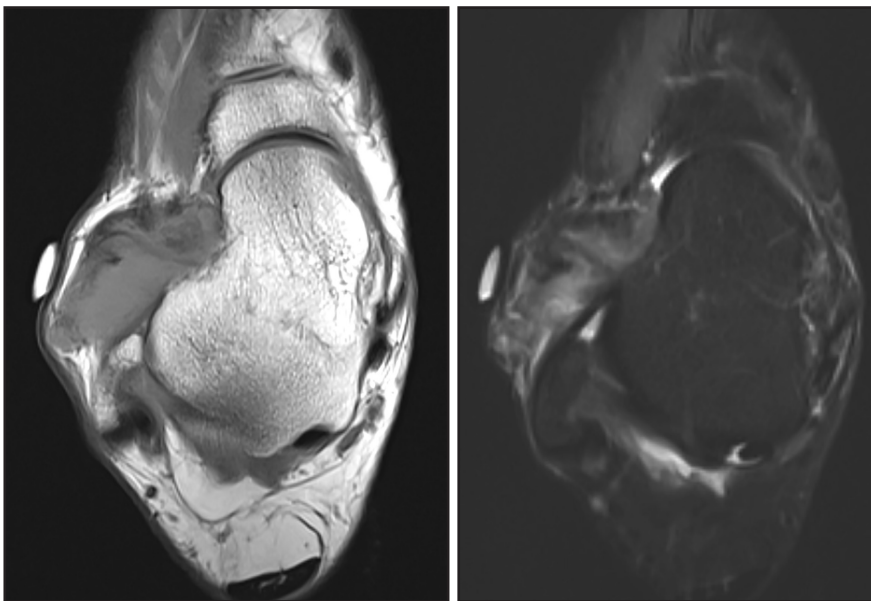


FIGURE 4. (A) Axial T1-weighted image without fat saturation showing PVNS at the lateral right ankle. (B) Axial STIR image demonstrating PVNS in the lateral right ankle.

images with contrast, depending on flow dynamics and timing of injected contrast bolus.³² Synovial hemangiomas present with the above features, and may also present with low intensity linear structures, likely due to fibrous septa or vascular channels (Figure 3), as well as fluid-fluid levels.³³ Because SS can occur intra-articularly and because SS may have fluid-fluid levels, they may be confused with synovial hemangiomas.

Spindle cell lipomas

Spindle cell lipomas are lipomas made up of lipocytes and spindle cells.³⁴ They occur most frequently in males between the ages of 45 and 65, and tend

to involve the posterior neck and shoulder.³⁵⁻³⁹ They are typically superficial and often appear in subcutaneous fat.⁴⁰ The signal intensity of the nonadipose areas of these lesions is greater than that of fat on T2-weighted sequences, and similar to that of skeletal muscle on T1-weighted sequences.⁴⁰ The nonadipose tissue displays enhancement, equal to that of nearby vessels after administration of intravenous contrast.⁴⁰

Pigmented villonodular synovitis (PVNS)/Giant Cell tumors of tenosynovial origin

PVNS is a benign and rare monoarticular disease occurring in the joints,

characterized by a proliferation of synovial cells, effusions and bone erosions.⁴¹ PVNS usually occurs between the 3rd and 5th decades of life.⁴² PVNS more often involves the knee joint of older individuals, whereas in younger patients PVNS tends to involve the hip.⁴³ The female to male ratio is estimated to be 1.35:10.⁴⁴ PVNS can be diffuse or localized.^{45, 46} PVNS shows intermediate signal on T1-weighted images (Figure 4A), low signal on T2-weighted images with areas of high signal (Figure 4B) due to inflamed synovium or joint fluid and variable enhancement on contrast-enhanced T1-weighted images.^{45, 46} PVNS has low signal on gradient-echo (GE) sequences and sometimes blooming artifacts.^{45, 46} The blooming artifacts noted on gradient-echo sequences are due to hemosiderin from chronic hemorrhage within these lesions.^{45, 46}

Morel-Lavallée lesions

Morel-Lavallée lesions occur post-traumatically and are deep subcutaneous closed degloving injuries where the skin and subcutaneous tissues are separated from the underlying fascia.⁴⁷ This injury creates a cavity that can fill with blood and necrotic fat.^{48, 49} The lesions classically occur over the greater trochanter, but can also be seen in the lumbar region, over the scapula and over the knee.^{50, 51} On MR imaging, the fluid within the cavity can exhibit varying signal intensity and can present with a

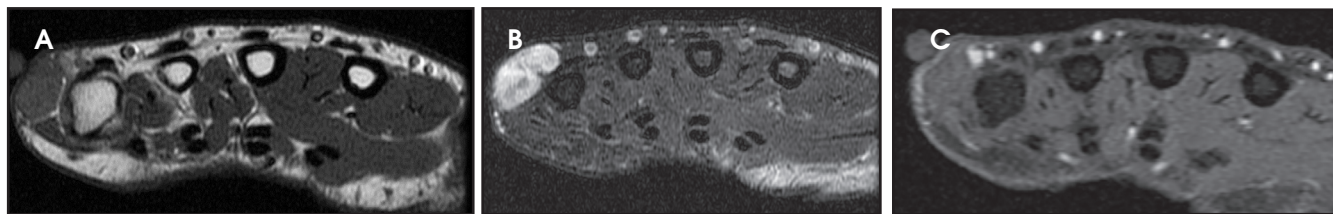


FIGURE 6. (A) Axial T1-weighted image without fat saturation demonstrating a Masson's tumor (IPEH) along the volar aspect of the left hand. (B) Axial T2-weighted image with fat saturation demonstrating a Masson's tumor (IPEH) along the volar aspect of the hand. (C) Axial T1-weighted image with fat saturation, postcontrast, demonstrating a Masson's tumor (IPEH) along the volar aspect of the hand.

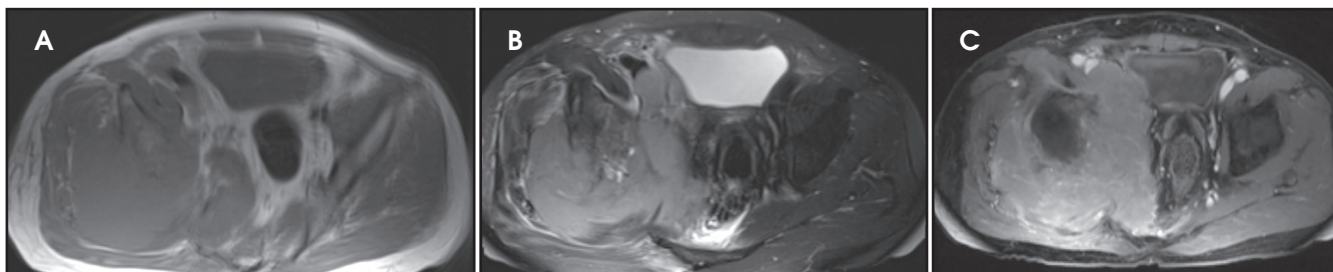


FIGURE 7. (A) Axial T1-weighted image without fat saturation demonstrating lymphoma of the right ilium with pelvic lymphadenopathy. (B) Axial T2-weighted image with fat saturation demonstrating lymphoma of the right ilium with pelvic lymphadenopathy. (C) Axial T1-weighted MR image with fat saturation, postcontrast, demonstrating lymphoma of the right ilium with pelvic lymphadenopathy.

fluid-fluid levels.⁵⁰ If the lesion is in the characteristic location with a history of trauma and has the classical appearance, then no differential diagnosis should exist. If not, the lesion can be mistaken for sarcoma.^{50,52} If the provided clinical history is equivocal, then short-term follow-up imaging could be used to ensure resolution/change in size of the lesion.

Synovial chondromatosis

Synovial chondromatosis is a benign disorder that involves the formation of cartilaginous nodules in the synovium of joints, tendon sheaths, and lining of the adjacent extraarticular bursae.⁵³ These nodules can become detached and exist as bodies in the joint space.⁵³ Synovial chondromatosis occurs in large joints such as the hip, elbow, knee (Figure 5) and shoulder joint.⁵⁴ The disorder can appear at any age, but is most prevalent in the 4th and 5th decades of life.⁵⁴ Males are more affected than females in a ratio of 2-4:1.^{55,56} The appearance of synovial chondromatosis on MRI depends on the presence of synovial proliferation, formation of loose bodies, and degree of mineralization.⁵⁷ Synovial chondromatosis is termed synovial osteochondromatosis if the intraarticular bodies are mineralized.⁵⁵

Ganglion cysts

Ganglion cysts are benign cystic masses that usually appear as unilocular or multilocular fluid signal masses adjacent to a joint or tendon sheath.⁵⁸ Women are approximately three times more likely to be affected than men.⁵⁹ Ganglion cysts are most common on the dorsal surface of the wrist. Ganglion cysts may affect people of all ages, but more commonly affect individuals between the ages of 25 and 45.⁶⁰ Very small cysts may mimic a small effusion, but the scarcity of fluid in the joint and the focal nature of the fluid should provide clues for diagnosis.⁶¹ The cysts typically have low signal intensity on T1-weighted images, but may appear hyperintense if they have high proteinaceous content or hemorrhage.⁶² Ganglion cysts typically have high signal on T2-weighted sequences⁶² and show peripheral enhancement after administration of intravenous contrast.⁶¹ Ruptured ganglion cysts are often irregularly delineated with pericapsular edema on T2-weighted sequences.⁶¹

Angioleiomyomas

Angioleiomyomas are benign smooth muscle tumors with prominent vascular components.⁶³ Angioleiomyomas are

more common in women.⁶⁴ The peak incidence occurs between the 3rd and 6th decades of life.⁶⁴ Angioleiomyomas can arise anywhere in the body, with a predilection for the lower extremities, and are painful in 60% of cases.⁶⁴ On T2-weighted MRI, the lesions exhibit mixed areas of hyperintense and isointense signal.⁶⁵⁻⁶⁷ The T2-hyperintense areas correspond to smooth muscle bundle cells and show strong enhancement with contrast.⁶⁵⁻⁶⁷ The isointense areas correspond to fibrous tissue or intravascular thrombi.⁶⁵⁻⁶⁷

Intravascular papillary endothelial hyperplasia (IPEH)/Masson's tumor

Intravascular papillary endothelial hyperplasia is a benign vascular disease characterized by a proliferation of the endothelium in blood vessels.⁶⁸ It is most common in young adults, and women are more often affected than men.⁶⁹ It occurs principally in the skin and subcutaneous soft tissues of fingers, trunk, head and neck region, and rarely in the oral region, appearing as a small superficial red to blue mass.⁷⁰ T1-weighted sequences can display homogeneous signal (Figure 6A).⁷¹ On T2-weighted images, the lesions exhibit

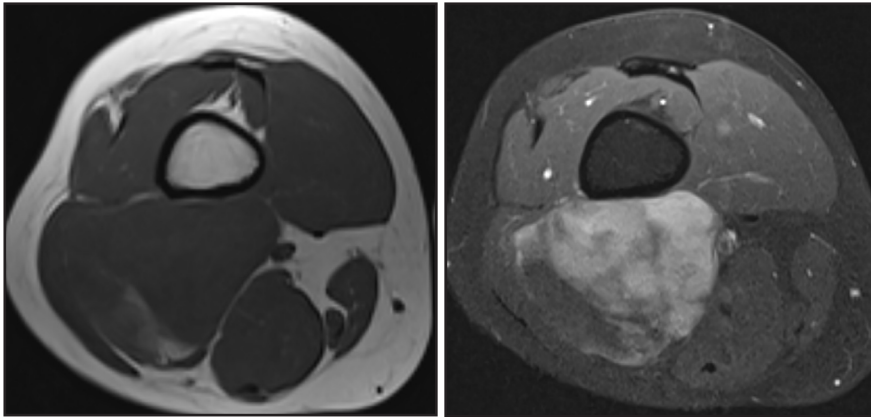


FIGURE 8. (A) Axial T1-weighted image without fat saturation showing a liposarcoma involving the posterior compartment of the thigh. (B) The same axial T1-weighted image with fat saturation postcontrast.

a heterogeneous hyperintense signal with foci of low intensity signal (Figure 6B)⁷¹ and have variable enhancement after administration of intravenous contrast (Figure 6C).

MRI: Malignant entities confused with synovial sarcoma

Lymphoma

Low-grade lymphomas such as follicular lymphoma may be mistaken for SS. Follicular lymphoma accounts for about 45% of all non-Hodgkin's lymphoma.⁷² These are low-grade lymphomas, but have the propensity to transform to a more aggressive lymphoma.⁷² Lymphomas are usually T1 isointense or hypointense (Figure 7A), T2 hyperintense (Figure 7B), and demonstrate enhancement after administration of intravenous contrast (Figure 7C).

Undifferentiated pleomorphic sarcoma (UPS) (formerly known as malignant fibrous histiocytomas)

The etiology and origin of UPS are unclear.⁷³ This tumor occurs mostly in middle to late adulthood and occurs in the proximal region of the lower extremities.⁷⁴ Undifferentiated pleomorphic sarcoma is usually low to intermediate signal intensity on T1-weighted sequences and intermediate to high on T2-weighted sequences.⁷⁵ Myxoid UPS tends to be hyperintense on T2-weighted sequences due to the high water content of its lesions.⁷⁵

Extraskeletal myxoid chondrosarcoma

Extraskeletal myxoid chondrosarcoma (EMC) is a rare subtype of chondrosarcoma.⁷⁶ The median age of diagnosis is approximately 50 years of age, with 50% of patients between the ages of 41 and 60 years.⁷⁷ Males are more commonly affected than females; the ratio is 2:1.⁷⁸ There is a predilection for involvement of the lower (62%) and upper extremities (17%).^{77,78} EMC has a characteristic chromosomal translocation, typically t(9;22)(q22;q12.2), fusing *EWSR1* to *NR4A3*, and the *EWSR1* rearrangement can be detected by fluorescent *in situ* hybridization.⁷⁹ The chromosomal translocation results in a fusion gene product responsible for alterations in cell growth and differentiation.⁷⁹ This malignant neoplasm is best evaluated by MRI, which allows for visualization of myxoid stroma and the multinodular and well-defined borders of the mass.⁸⁰ EMC tends to be isointense or hypointense on T1-weighted imaging and T2 hyperintense on T2-weighted imaging.⁷⁹

Liposarcoma

Liposarcomas originate from primitive mesenchymal cells rather than mature fat cells.⁸¹ Therefore, the presence of adipocytes is not necessary for the development of this common soft-tissue tumor.⁸¹ Liposarcoma is primarily an adult tumor, with a peak incidence between the 4th and 6th decades of life.⁸¹

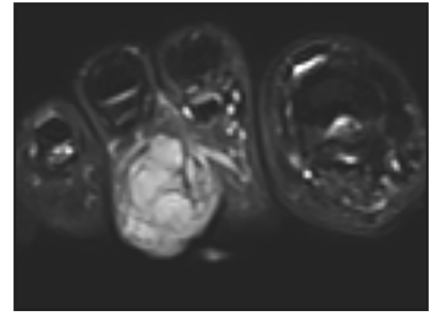


FIGURE 9. Axial STIR MR image demonstrating melanoma involving the plantar soft tissues of the foot.

Males are slightly more often affected than females.⁸¹ Liposarcomas most commonly occur in the thigh and the retroperitoneum.⁸¹ The myxoid histology is the most common feature of liposarcoma, making up 45-55% of all lesions.⁸¹ Myxoid liposarcomas lesions have low/intermediate T1 signal intensity (Figure 8A) due to the myxoid stroma and high water content of the myxomatous elements and very high T2 signal intensity (Figure 8B).⁸² The presence and relative proportion of round cells may decrease the water content of the tumor, resulting in low to intermediate T2 signal.^{83,84} Most lesions demonstrate intense enhancement after administration of intravenous contrast. Encapsulated margins and thick internal septations are often visible.⁸²

Epithelioid sarcomas

Epithelioid sarcomas are malignant tumors with unknown histogenesis.⁸⁵ It is the most common soft tissue sarcoma in the hand and wrist.⁸⁵ It occurs principally in the fingers, hands and forearms, but it can also occur in other sites, including in the musculature.⁸⁶ Regional lymphadenopathy is often present, as this tumor has a propensity to spread to the lymph nodes.⁸⁶ This tumor is prevalent in adolescents and young adults between 10 and 35 years of age.⁸⁵ Males are affected twice as often as females.⁸⁵ This tumor has variable MRI signal characteristics and should be suspected in patients with or without locally enlarged lymph nodes, as well as in patients with ulcerating cutaneous nodes.⁸⁶

Melanoma

Melanomas are tumors that arise from melanocytes.⁸⁷ Poorer prognosis is associated with a younger age of diagnosis, family history, and personal history of melanoma.⁸⁷

Melanomas tend to be isointense or hyperintense on T2-weighted images (Figure 9), and are often hyperintense on T1-weighted sequences.⁸⁸ The presence of melanin and blood products within melanomas tend to make these tumors hyperintense on T1-weighted sequences.

Conclusion

Accurate diagnosis of synovial sarcoma can impact prognosis and overall survival rates by maximizing the chances of appropriate and aggressive treatment. Although synovial sarcomas are most prevalent in children and young adults, and tend to occur in the extremities and can occur at any age and in any location in the body. We recommend all imaging studies be reviewed by a radiologist with experience in evaluating musculoskeletal tumors. A lesion should be considered a potential synovial sarcoma if it has any suspicious features. The authors recommend biopsy of all suspicious lesions and use of FISH for confirmation of the diagnosis of synovial sarcoma.

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