Characterization of Bone and Soft Tissue Tumors at MRI
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Learning Objectives
- Describe how various features of a lesion may contribute to a more specific diagnosis at MRI
- Identify characteristic MRI features of certain musculoskeletal tumors
- Recognize strengths and limitations of MRI in characterizing musculoskeletal tumors

MRI protocol
Optimal characterization of musculoskeletal tumors at MRI involves certain basic requirements. High-resolution, small-field-of-view axial T1-weighted spin-echo and fat-suppressed T2-weighted fast (turbo) spin-echo images should be obtained through the entire tumor. T1-weighted images are critical in showing the presence of fat or hemorrhage within a mass; distinguishing normal marrow and tumor; and demonstrating bone tumors against a background of fatty marrow. Fat suppression is essential in the T2-weighted images to allow evaluation of bone marrow for tumor involvement. Pre- and post-gadolinium fat-suppressed T1-weighted spin-echo images are frequently helpful, both for distinguishing cysts from solid masses and for demonstrating necrotic portions of tumor to be avoided at biopsy.

STIR images are not recommended for characterization of tumors, as many lesions show similar-appearing, very high signal on STIR images. Proton density images are of limited utility in the characterization of bone lesions, as tumor and surrounding marrow edema and marrow fat all may show similar signal, decreasing the conspicuity of the lesion (unless fat suppression is used).

Approach to characterizing soft tissue tumors at MRI
Characterization of soft tissue masses as benign or malignant often will be incorrect if one relies on traditional imaging features such as sharpness of the margin, presence of local invasion, large size, and internal homogeneity of the lesion. However, if a mass demonstrates certain characteristic imaging features, a specific diagnosis frequently can be made (e.g., cyst, ganglion, lipoma, fat necrosis, giant cell tumor of tendon sheath, hemangioma, desmoid/fibromatosis, benign nerve sheath tumor, subacute hematoma, elastofibroma). In the absence of such characteristic features, the possibility of malignancy cannot be dismissed.

A specific diagnosis can often be suggested based on one or more of the following five features:
- Chemical composition of the lesion (e.g., water, hemosiderin, methemoglobin)
- Tissue composition of the lesion (e.g., fat, collagen, myxoid matrix)
• Morphology of the lesion (e.g., serpiginous, target sign, infiltrative “tails”)
• Location of the lesion (e.g., deep to scapular tip, in an intermetatarsal space, along fascia, associated with a peripheral nerve, in a large joint space)
• Clinical circumstances of the patient (e.g., post-amputation, prolonged immobilization).

Examples of benign lesions that may be misinterpreted as sarcoma at MRI include muscle strain, myositis, myositis ossificans, rhabdomyolysis, ischemic fasciitis, parosteal lipoma, fat necrosis, and Morel-Lavallée lesion (a long-standing chronic hematoma along a subcutaneous fascial plane).

Malignant lesions that are prone to being misinterpreted at MRI as benign — clearly a much more serious error — include those sarcomas that are predominantly cystic, hemorrhagic, or myxoid. Extensive cystic change or hemorrhage within a sarcoma may overshadow the solid tumor elements present. Solid elements must be carefully sought and viewed as suspicious for tumor until proven otherwise; gadolinium-enhanced imaging (including subtraction images if enhancement is equivocal visually) is essential in this assessment.

Myxoid liposarcoma also may appear deceptively cyst-like on standard T1-weighted and T2-weighted MR images. The presence of subtle fatty streaks within the lesion often is a clue to the correct diagnosis of myxoid liposarcoma. Even more importantly, enhancement within the lesion — ranging from fine and lacy to intense and coalescent — is typically evident after contrast material administration, and is an invaluable finding to prevent misdiagnosis of myxoid liposarcoma as a ganglion or other cyst.

Another specific type of myxoid sarcoma, myxofibrosarcoma, is increasingly recognized as one of the most common fibrous sarcomas of the extremities in the elderly. This tumor has an unusual, infiltrative growth pattern along fascial and vascular planes, resulting in wispy streaks or “tails” of edema-like signal that frequently extend for considerable distances from the primary tumor. These tails of tumor enhance, and need to be brought to the attention of the treating surgeon. Due to this atypical growth pattern, even low-grade myxofibrosarcoma tends to recur relentlessly, and subsequent recurrences are of higher grade. Myxofibrosarcoma metastasizes to sites atypical for most other soft tissue sarcomas (which generally metastasize to lung), including pleura, peritoneum, adrenal glands, and bone.

The management of a soft tissue lesion will depend on the level of confidence in the diagnosis provided at MRI. If the lesion has MRI features characteristic of a specific innocuous lesion (e.g., lipoma, hemangioma, elastofibroma), clinical follow-up alone will suffice. If the lesion has typical but not pathognomonic MRI findings (e.g., hematoma, Morel-Lavallée lesion, myositis ossificans, ischemic fasciitis), close-interval imaging follow-up (such as every 2-4 months for a year) to assess for growth is a reasonable option. For all other lesions, biopsy or resection usually is the most prudent course of action.
**Approach to characterizing bone tumors at MRI**

Radiographs remain essential in the characterization of many bone lesions, and should not be neglected in the initial evaluation. Most bone tumors have sharply defined boundaries with the surrounding normal marrow at MRI; such a sharp boundary should not be misinterpreted as representing the (purely radiographic) criterion of a narrow zone of transition.

MRI may not depict calcifications unless they are large or very dense, limiting the utility of MRI in demonstrating calcified tumor matrix (such as in osteoblastoma and osteosarcoma).

On fat-suppressed T2-weighted images, hyaline cartilage lesions (enchondroma, low-grade chondrosarcoma) often can be identified due to the presence of multiple, small lobules with very high signal intensity (due to the high water content of hyaline cartilage). The distinction between enchondroma and low-grade chondrosarcoma is a common and difficult problem, however, resulting from lack of consensus on specific diagnostic criteria — both among pathologists and among radiologists.

The differential diagnosis for benign bone lesions surrounded by extensive marrow edema includes osteoid osteoma/osteoblastoma, chondroblastoma, Langerhans cell histiocytosis, and osteomyelitis. As a general (but not absolute) guideline, the greater the extent of surrounding marrow edema, the more likely the bone lesion is benign. Marrow edema may be present around malignant bone tumors, as well, in which case it constitutes the reactive zone of the tumor.

Calcific tendinitis is an important pitfall in the diagnosis of bone tumors, because it can produce erosions in subjacent bone (most commonly the humeral tuberosities or femoral trochanters) and an associated marrow edema pattern. Recognition of the overlying tendinous abnormality (at MRI and/or at radiography) will help prevent misinterpretation of the subjacent bony changes as representing a metastasis.

Lytic bone metastases generally show moderately increased signal throughout on fat-suppressed T2-weighted images, whereas blastic lesions often show such signal only in a surrounding rim ("halo"). This "halo," when present, can be particularly helpful in distinguishing between a blastic metastasis and a bone island — both of which otherwise usually show low signal on all pulse sequences.

The presence of dot-like or curvilinear flow voids (representing small, high-flow vessels) within a lytic bone lesion at MRI suggests a renal cancer primary.

Fluid-fluid (blood-fluid) levels have been reported in a wide range of bone and soft tissue tumors, benign and malignant. A bone lesion composed solely of fluid-fluid levels is consistent with an aneurysmal bone cyst. If thick septa or soft tissue nodules also are present within the lesion, other diagnoses must be considered, such as telangiectatic osteogenic sarcoma, or a secondary aneurysmal bone cyst engrafted on another bone
tumor. Gadolinium-enhanced images are useful in assessing for soft tissue elements within an otherwise cystic lesion.

References


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