Magnetic Resonance Imaging of Soft-Tissue Tumors: Determinate and Indeterminate Lesions

Derek F. Papp, A. Jay Khanna, Edward F. McCarthy, John A. Carrino, Adam J. Farber and Frank J. Frassica


This information is current as of December 29, 2007

Reprints and Permissions

Click here to order reprints or request permission to use material from this article, or locate the article citation on jbjs.org and click on the [Reprints and Permissions] link.

Publisher Information

The Journal of Bone and Joint Surgery
20 Pickering Street, Needham, MA 02492-3157
www.jbjs.org
Magnetic Resonance Imaging of Soft-Tissue Tumors: Determinate and Indeterminate Lesions

By Derek F. Papp, MD, A. Jay Khanna, MD, Edward F. McCarthy, MD, John A. Carrino, MD, MPH, Adam J. Farber, MD, and Frank J. Frassica, MD

Introduction

The evaluation of patients with soft-tissue masses must be done in a systematic fashion to prevent management errors. Although most soft-tissue masses (approximately 99%) are benign, an error in the management of a soft-tissue sarcoma can lead to limb loss or adversely affect survival. Before magnetic resonance imaging became easily available, physicians relied on the patient’s history, physical examination, conventional radiographs, and computed tomography scans for decision-making. These modalities often were insufficient for establishing a definitive diagnosis. The patient’s history alone cannot provide enough information for a diagnosis and, in fact, may be misleading. For example, lesions identified after a traumatic episode are not necessarily traumatic in origin; only half of soft-tissue sarcomas are painful at presentation, and the growth rate may not assist in the diagnosis (slow-growing lesions can be malignant or benign). Similarly, although a patient may present with systemic symptoms, the lack of systemic symptoms does not exclude malignancy. Physical examination may provide some clues that may suggest malignancy, but none are pathognomonic. Conventional radiography and computed tomography are not specific enough in differentiating benign and malignant soft-tissue masses. If one relies solely on these modalities, biopsy often is necessary for diagnosis and management. Biopsy is associated with several hazards, including neurovascular injury, hematoma formation, and delayed wound-healing.

The use of magnetic resonance imaging to identify soft-tissue lesions has markedly altered the treatment algorithm for a number of lesions. In contrast to conventional radiography and computed tomography, magnetic resonance imaging provides clear advantages in terms of diagnosis: the spatial resolution of the images is excellent; the images can be reconstructed in multiple planes; lesions can be identified more readily, and the lesion’s signal characteristics can help to narrow the differential diagnosis; areas of hemorrhage, cysts, and vascular structures are better seen; and boundaries between the lesion and unaffected bordering tissues can be evaluated readily, facilitating the planning of surgical approaches. In addition, magnetic resonance imaging used for preoperative planning can help to minimize violation and subsequent contamination of crucial neurovascular structures.

The purposes of this report were (1) to provide a diagnostic and treatment algorithm for soft-tissue lesions based on the concept of determinate and indeterminate categorization, and (2) to assist the orthopaedic surgeon in developing the skills necessary to categorize a lesion as determinate or indeterminate in nature and to be able to recognize the commonly occurring determinate lesions. With this classification system, surgeons can plan treatment for determinate lesions without a biopsy and can recommend biopsy for indeterminate lesions to establish a diagnosis before planning treatment.

Basics of Magnetic Resonance Imaging

The patient is positioned appropriately on the magnetic resonance imaging table and, depending on the body part being imaged, an extremity or surface coil also is used. The orientation of the magnetic field aligns the protons within the patient longitudinally with respect to the axis of the scanner. When the imaging begins, an electromagnetic radiofrequency pulse directed toward the patient realigns the protons within the patient in the transverse plane (or perpendicular to the external field for a standard spin-echo sequence). Another pulse then refocuses the protons. As the protons return to their baseline state, they emit energy. The emission of this energy (or signal) is localized to a particular area (or voxel) within the patient, and the information is processed by the system through a Fourier transformation to create the magnetic resonance image.
Types of Pulse Sequences

By emphasizing the various characteristics of the radiofrequency pulse (strength, frequency, or the time at which the signal is measured), the image can be weighted to create the different pulse sequences, each of which highlights specific tissue characteristics (Table I). T1-weighted imaging allows for excellent anatomic visualization, given its high spatial resolution. T2-weighted imaging shows abnormal changes, free extracellular water, and tissue edema. Fat suppression techniques subtract the signal produced by adipose tissue and highlight abnormal changes and tissue edema even more than do conventional T2-weighted images. A short tau inversion recovery image is a type of fat-suppressed T2-weighted image that highlights areas of increased fluid and/or edema even more than do conventional T2-weighted techniques. Gradient-echo images, which provide excellent visualization of hemorrhage or hemosiderin deposition, are the sequence of choice when imaging suspected vascular lesions, hematomas, or pigmented villonodular synovitis.

Determinate and Indeterminate Lesions

The algorithm presented relies on the physician’s ability to characterize a lesion as determinate or indeterminate. A determinate lesion is one that can be diagnosed definitively by means of the history and physical examination, and with appropriate imaging modalities such as magnetic resonance imaging or conventional radiographs—or, in simple terms, a lesion for which a diagnosis can be given without biopsy. An indeterminate lesion is one that must be biopsied to ensure an accurate diagnosis. Each individual physician has a particular degree of confidence in his or her own ability to diagnose a soft-tissue lesion that will guide the clinical management of the patient. It is important to note also that discussion with other specialists, such as musculoskeletal radiologists and pathologists, can provide much needed information and often proves to be crucial in making the correct diagnosis. A multidisciplinary approach to soft-tissue lesions is essential.

Determinate lesions include lipoma, hemangioma, ganglion and Baker cysts, hematoma, myositis ossificans, myoneerosis, neurofibroma, muscle tear, pigmented villonodular synovitis, bursitis, and aneurysm. Indeterminate lesions include the lesions that cannot be diagnosed without biopsy, such as various sarcomas (e.g., liposarcoma, synovial sarcoma, epithelioid sarcoma, and malignant fibrous histiocytoma).

**Determinate Lesions**

**Lipoma**

The lipoma is the most common of all soft-tissue tumors and is composed of mature adipose tissue. It has a characteristic firm, fatty feel and typically confers no symptoms. Nevertheless, some lipomas can cause pain through compression of adjacent neurovascular structures and, accordingly, lesions rising in the deep tissues more commonly cause symptoms than those in more superficial areas.

Lipomas have a characteristic appearance on magnetic resonance imaging corresponding to that of adipose tissue. These benign tumors appear bright on T1-weighted imaging (Fig. 1-A) and moderate to bright on T2-weighted images (Fig. 1-B). In all sequences, the lesion appears isointense compared with the subcutaneous fat. The use of fat-suppressed

<table>
<thead>
<tr>
<th>Tissue Type</th>
<th>T1-Weighted Image</th>
<th>T2-Weighted Image</th>
<th>Fat-Suppressed T2-Weighted Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cortical bone</td>
<td>Very low</td>
<td>Very low</td>
<td>Very low</td>
</tr>
<tr>
<td>Yellow marrow</td>
<td>High</td>
<td>High</td>
<td>Very low</td>
</tr>
<tr>
<td>Red marrow</td>
<td>Low/intermediate</td>
<td>Intermediate</td>
<td>Low/intermediate</td>
</tr>
<tr>
<td>Fatt</td>
<td>High</td>
<td>High</td>
<td>Very low</td>
</tr>
<tr>
<td>Fluid</td>
<td>Low</td>
<td>High</td>
<td>Very high</td>
</tr>
<tr>
<td>Muscle</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low/intermediate</td>
</tr>
<tr>
<td>Ligaments and/or tendons</td>
<td>Very low</td>
<td>Very low</td>
<td>Very low</td>
</tr>
<tr>
<td>Hemosiderin</td>
<td>Very low</td>
<td>Very low</td>
<td>Very low</td>
</tr>
<tr>
<td>Hyaline cartilage</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Physeal scar</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Labrum</td>
<td></td>
<td></td>
<td>Low</td>
</tr>
</tbody>
</table>

*Modified from: Khanna AJ, Cosgarea AJ, Mont MA, Andres BM, Domb BG, Evans PJ, Bluemke DA, Frassica FJ. Magnetic resonance imaging of the knee: current techniques and spectrum of disease. J Bone Joint Surg Am. 2001;83:128-41.†In addition to the repetition time and echo time, the degree of brightness of the fat also is related to how the sequence is acquired. For example, fat is brighter on a fast-spin-echo sequence than on a conventional spin-echo sequence (these can be made as T1-weighted, T2-weighted, or proton-density-weighted images).
T2-weighted or short tau inversion recovery images, or both, confirms the diagnosis. The diagnosis of lipoma can be made with authority when the signal intensity of the lesion matches that of subcutaneous fat on all pulse sequences, including fat-suppression pulse sequences. The image may show fibrous septations, which may not enhance with gadolinium. These lesions do not penetrate surrounding structures. When a lesion shows areas with fibrous or myxoid degeneration, the physician should consider liposarcoma in the differential diagnosis. In such cases, biopsy is warranted. Similarly, broad seps-
tations or septations with nodularity make the lesion more consistent with liposarcoma.

**Hemangioma**

Although a hemangioma is most commonly a cutaneous lesion found in children, the orthopaedic surgeon may be consulted on deep, intramuscular lesions for which physical examination findings are nonspecific. Overall, these lesions have a female predominance as high as 3:1. Fifty percent of patients describe a history of pain, which is theorized to arise as a result of the lesion causing ischemia in the surrounding soft tissues through a vascular steal phenomenon. Superficial lesions may feel soft and may increase in size when placed in a dependent position, but it may be difficult to detect this posture-related change with deep lesions.

Although conventional radiographs often show phleboliths, the magnetic resonance imaging findings typically prove diagnostic and show lipomatous tissue (most of which is contained in the margins of the lesion), vascular formations, hemosiderin deposits, and fibrosis. Overall, the lesion has a heterogeneous appearance, bright on T1-weighted images (Fig. 2-A) secondary to the adipose tissue of the lesion and bright on T2-weighted (Fig. 2-B) and short tau inversion recovery imaging, corresponding with the vascularity of the lesion. The lesion may have a serpentine appearance secondary to the multiple vessels in the lesion. Lobules and septations also are found within the lesion. Areas of high-velocity blood flow corresponding to feeding vessels appear as signal voids. Gadolinium administration results in bright enhancement of the lesion. Ultrasound can also prove useful in the diagnosis of this lesion.

**Ganglion Cyst**

Ganglion cysts that involve the dorsal or volar aspect of the wrist are one of the few types of soft-tissue lesions for which a physical examination is characteristic enough to label the lesion as determinate. These lesions need no imaging other than conventional radiography and can be treated as the patient and physician prefer. Some investigators have suggested that these lesions form when repeated stress causes mucoid degeneration of associated periarticular tissues or tendon sheaths, whereas others hypothesize that lining cells cause production of a hyaluronic-acid-rich substance, which causes the formation of a cystic lesion.

Ganglion cysts also commonly occur in the foot and ankle, although they can be associated with any tendon sheath, labrum, or capsule. Unlike a Baker cyst, a ganglion cyst does not communicate with the joint. When such a lesion is found in a location other than the wrist, additional imaging should be performed. On magnetic resonance imaging, the lesion appears smooth and round or oval, and it may have septations. The wall of the cyst is well-circumscribed and forms a distinct border against the adjacent tissues. Although the septations may enhance with gadolinium administration, the lesion itself should not. The lesion appears with a signal intensity similar to that of water—bright on T2-weighted imaging or short tau...
inversion recovery\(^{19,20}\) (Fig. 3-A) and dark on T1-weighted imaging (Fig. 3-B).

**Baker Cyst**

Originally described by Baker\(^{21}\), the synovial cyst (now known as the Baker cyst) forms when synovial fluid insinuates from the knee joint into communicating bursae or by causing herniation of the synovial membrane itself. This lesion occurs most commonly under the medial head of the gastrocnemius muscle. The lesion is often asymptomatic, but it can cause pain. In addition, the cyst may rupture or leak, causing resultant swelling and/or pain in the affected limb; thrombophlebitis, compartment syndrome, and claudication can occur\(^{22,23}\). The cause of the lesion is intra-articular and can include abnormalities ranging from anterior cruciate ligament damage to osteoarthritis, although meniscal tears are the most common cause\(^{24,25}\).

Ultrasound may be useful for diagnosis, but magnetic resonance imaging is the study of choice because it can delineate underlying abnormalities such as meniscal or anterior cruciate ligament tears. Magnetic resonance imaging findings of a Baker cyst are similar to those of a ganglion cyst. The Baker cyst is an oval, well-defined mass found posterior to the knee joint. The fluid appears dark on T1-weighted images and bright on T2-weighted and short tau inversion recovery imaging (Figs. 4-A and 4-B). The signal intensity of the lesion matches that of joint fluid on all pulse sequences.

**Hematoma**

Although most patients with a hematoma do not present to an orthopaedist, it is important to keep this lesion in the differential diagnosis of soft-tissue lesions. The patient often relates a history of trauma, and residual ecchymosis can sometimes be seen during the physical examination. When a history of trauma is not present, it is important to ask the patient about systemic anticoagulation or clotting deficiencies because these conditions can be associated with chronic expanding hematomas\(^{26}\). Most such lesions will resolve on their own, but the natural history of the lesion may also follow two other courses: the hematoma may begin to calcify on the periphery (eventually becoming myositis ossificans) or it may continue to expand, which may be related to continual irritation caused by hemosiderin breakdown products. In such instances, the lesion does not heal, and it chronically expands secondary to continued capillary bleeding\(^{27,28}\). Continued expansion of the lesion may cause compression of neurovascular structures or pressure erosion of nearby osseous structures\(^{27}\).

T1-weighted imaging shows a heterogeneous pattern. Areas of high signal intensity represent areas of continuing hemorrhage. Overall, the lesion is well defined and does not invade other muscle compartments (Fig. 5-A). T2-weighted images show heterogeneity (Fig. 5-B). Areas of low signal intensity, i.e., signal dropout, occur in areas of hemosiderin deposition. Areas of high signal intensity represent granulation tissue. A low-signal pseudocapsule often is seen. Fluid-fluid levels have also been described\(^{29}\). Gradient-echo imaging can be used to investigate further the areas of hemosiderin deposition\(^{26,27}\) and will show the profound signal dropout (dark areas) that is characteristically seen on gradient-echo imaging in the presence of hemosiderin or other ferromagnetic materials such as metallic implants. Gadolinium-
**Magnetic Resonance Imaging of Soft-Tissue Tumors: Determinate and Indeterminate Lesions**

**Fig. 5-A**
Hematoma. Sagittal axial T1-weighted image (Fig. 5-A) and sagittal fat-suppressed T2-weighted image (Fig. 5-B) of the leg showing a mass lesion in the anterior compartment (arrow in Fig. 5-B). The T1-weighted image shows areas of hyperintensity (arrowheads), reflecting methemoglobin. The high-signal-intensity areas on the fat-suppressed T2-weighted image are related to soft-tissue edema and hemorrhage. Clinical correlation is especially helpful for the diagnosis of hematoma, and attention should be given to the presence or absence of coagulopathy, history of surgery, or other trauma.

**Fig. 5-B**

**Fig. 6-A**
Myositis ossificans. Axial T1-weighted image (Fig. 6-A) and axial short tau inversion recovery image (Fig. 6-B) showing a lesion (arrows) with an associated rim of bright T1 signal that may reflect subtle expansion of the surrounding fascia or peripheral methemoglobin. The lesion appears isointense to slightly hypointense compared with muscle on T1-weighted images and has a moderate, increased signal on the short tau inversion recovery images with foci of bright signal that likely reflect fluid components. The location adjacent to the anterior femoral cortex is characteristic. If only the lesion rim enhances, then it is unlikely to represent a neoplasm, and early myositis ossificans is more likely.
enhanced images can be used to confirm the identity of the lesion. When there is no enhancement with gadolinium contrast, the lesion can be considered determinate. Although Liu et al.\textsuperscript{26} reported cases of gadolinium enhancement of chronic hematomas, the increased chance of malignancy makes diagnosis uncertain, and these lesions cannot be considered determinate\textsuperscript{26,30}.

**Myositis Ossificans**

Some injuries progress from a simple hematoma to myositis ossificans. The exact mechanism for this progression is unknown, although it develops most often during the third decade of life\textsuperscript{31,32}. The most commonly affected muscles are the quadriceps and brachialis\textsuperscript{31,32}. It is thought that these lesions occur more commonly after severe injuries. Diagnosis of this lesion can often be made with conventional radiography. The lesion appears in the pattern of mature, lamellar bone and is well defined\textsuperscript{33}. For early lesions, when calcification is absent, magnetic resonance imaging provides an additional imaging option. On T1-weighted imaging, the lesion most often resides in the same compartment as the traumatized muscle, and the lesion is isointense or slightly hypointense relative to skeletal muscle. In some instances, the lesion may be subtle, so that it may be recognized only by alteration of the fascial planes\textsuperscript{32} (Fig. 6-A). On T2-weighted and short tau inversion recovery imaging, the lesion appears hyperintense compared with muscle (Fig. 6-B). Surrounding edema may or may not be present. The periphery of the lesion may have decreased signal intensity, showing the zonal pattern of growth; when this pattern is recognized, it is diagnostic.

**Myonecrosis (Diabetic and Idiopathic)**

Myonecrosis may present as a soft-tissue lesion. This condition is associated most commonly with diabetes, but other predisposing factors include alcohol consumption. Diabetic myonecrosis can even occur as the initial event in a patient’s history, although most patients have severe neuropathy or other more severe sequelae in the disease process\textsuperscript{34,35}. This painful lesion develops quickly with or without a history of trauma. It is thought that the lesion develops secondary to endothelial damage from diabetic microangiopathy, combined with activated coagulation factors and the continued presence of fibrin degradation products\textsuperscript{36}. The only laboratory abnormality associated with the disease is an elevated creatinine serum kinase, but even this finding is not always present\textsuperscript{34,35}.

Biopsy should be avoided because these patients are at high risk for wound-healing complications\textsuperscript{38}. Magnetic resonance imaging is the diagnostic modality of choice. Swelling of the muscle occurs and can be visualized best on T1-weighted imaging, although fascial layers and muscle fiber
Neurofibroma. Sagittal T1-weighted image (Fig. 8-A) and coronal short tau inversion recovery image (Fig. 8-B) of the ankle showing a well-circumscribed mass (arrows) in the plantar aspect of the foot that is hypointense compared with muscle on the T1-weighted image. The short tau inversion recovery image shows the typical “target” sign in which the periphery of the lesion is bright and the center is dark.

Rectus femoris muscle tear. Axial T1-weighted image (Fig. 9-A) and axial short tau inversion recovery image (Fig. 9-B) of the distal part of the thigh showing the lesion (arrows) as a focal contour deformity with swelling of the muscle belly. Short tau inversion recovery imaging shows associated muscle edema, reflecting an acute or subacute tear.
patterns are maintained (Fig. 7-A). T2-weighted imaging shows the lesion more clearly, with diffuse hyperintensity. The overall picture is mixed, with areas of necrosis and muscle regeneration (Fig. 7-B). The lack of invasion of surrounding structures differentiates this lesion from sarcomas. Gadolinium contrast may be used, with enhancing areas corresponding to healing or viable tissue, whereas nonenhancing areas correspond to loci of tissue necrosis.[35,37]

Neurofibroma
Patients with a history of neurofibromatosis Type 1 present with soft-tissue neurofibromas that can be mistaken for sarcomas. These patients often do not have any associated neurologic deficit.[39] The masses occur superficially and in the deep tissues, and they may or may not cause pain. Because patients with neurofibromatosis Type 1 are at high risk for malignancy, magnetic resonance imaging can be useful in determining the nature of the lesion and in ruling out dedifferentiation of the lesion into a neurofibrosarcoma.

On T1-weighted imaging, the lesion appears darker than skeletal muscle and often has a nodular appearance (Fig. 8-A). T2-weighted imaging shows areas of high signal intensity (corresponding with myxoid areas) and areas of low signal intensity (corresponding with compressed nerve fibers) (Fig. 8-B). Commonly, a target sign is seen, with an area of low signal intensity within a larger, high-signal-intensity area.[40,41] It should be noted that continued observation with serial magnetic resonance imaging can rule out dedifferentiation to neurofibrosarcoma.

Muscle Tear
A patient with a muscle tear often can recall the exact moment when the injury occurred. There is a feeling of sudden weakness, and a snapping sound may or may not be heard. The muscle in question often swells and becomes quite tender. Other signs, including ecchymosis and edema, occur, although none is specific for muscle tear. Over time, the swelling subsides, but the patient may be left with a lump, i.e., soft-tissue fullness, in the area that corresponds to scarring from the previous lesion and may be mistaken for a soft-tissue tumor.[42,43]

Although this presentation is the most common one, it should be noted that muscle tears can also occur insidiously. One series of muscle tears presenting as soft-tissue masses showed that six of seven occurred without a traumatic event and that only 50% caused pain.[44]

Magnetic resonance imaging is the best imaging modality for making the diagnosis of a muscle tear. T1-weighted imaging shows the ruptured muscle or the formation of scar, or both. Care should be taken to evaluate the course of the involved muscle in the axial, coronal, and sagittal planes and to confirm that the morphology of the injury suggests the presence of a muscle tear. Most frequently, the deformity is clear, and there is no evidence of invasion of the surrounding structures (Fig. 9-A). The time relative to the injury dictates the muscle’s appearance on T2-weighted imaging. Acute injuries show hyperintense lesions with surrounding edema (Fig. 9-B). Chronic injuries show low to intermediate signal intensity.
Pigmented Villonodular Synovitis

Another lesion that might be mistaken for a soft-tissue mass, pigmented villonodular synovitis, occurs infrequently, but it can be diagnosed with magnetic resonance imaging. Patients typically complain of pain in or around the involved joint, with associated swelling. Warmth and effusion of the joint also may occur. The most common location is the knee, followed by the hip, ankle, and elbow. The disease has two different forms: one that affects the entire joint in a diffuse pattern and another that presents in a nodular form. The nodular form is more easily resected, but treatment for either form should be attempted because secondary arthritis will develop if the abnormal tissue is not excised.

Conventional radiographs show a joint effusion with joint erosion after continued disease, although most of the joint space is maintained. Narrowing of the joint occurs concentrically. The lesion has a characteristic appearance on magnetic resonance imaging: low signal intensity on both T1-weighted and T2-weighted imaging secondary to the high hemosiderin content of the lesion (Figs. 10-A and 10-B). Gradient-echo images, which are particularly sensitive to ferromagnetic materials such as hemosiderin, show profound signal dropout in patients with pigmented villonodular synovitis and may help to differentiate this lesion from synovial chondromatosis. Thus, the lesion can be described as “blooming” from the joint capsule. Although gradient-echo and fast-field-echo imaging may show hemosiderin content better than T1-weighted or T2-weighted imaging does, hemosiderin deposition may not occur if the lesion is imaged too early, i.e., before maturation. If a mass is noted, it is usually indicative of nodular disease.

Bursitis

When a mass develops near a joint, the physician should consider bursitis among the potential diagnoses. The inflamed bursa can present acutely, subacutely, or chronically; the last presentation may mimic a tumor. The cause of the bursitis may vary, but most commonly it is associated with trauma, infection, gout, or rheumatoid arthritis. Similarly, the affected area varies, and almost any joint can be involved. The most common locations include the prepatellar area and the greater trochanter. In these locations, the physician can make the diagnosis without magnetic resonance imaging. Magnetic resonance imaging is most useful in assisting the physician to make the diagnosis of bursitis in other locations (e.g., about the olecranon, ankle, and pes anserinus insertion). On T1-weighted imaging, the inflamed bursa appears as an oval or cystic structure that is hypointense compared with muscle (Fig. 11-A). T2-weighted imaging shows the high signal intensity common to all fluid-filled lesions (Fig. 11-B), and the periphery of the lesion may also appear bright. Gadolinium enhancement occurs in infectious or inflammatory cases (e.g., rheumatoid arthritis or gout).
Aneurysm and/or Pseudoaneurysm

Although the formation of an aneurysm or pseudoaneurysm in an extremity is uncommon, it may mimic a malignant soft-tissue lesion. The most common cause of such a lesion is trauma, although there are other causes (e.g., congenital disease, atherosclerosis, and mycotic aneurysms). The incidence approaches its peak in individuals who are sixty-five years of age or older, and men are affected more often than women. The formation of a pseudoaneurysm occurs more commonly than does a true aneurysm in the extremities, and aneurysms rarely form below the knee.

Popliteal artery aneurysms, the most common aneurysm in the lower extremity, can affect nearby neurovascular structures. Symptoms such as paresthesias or painful claudication secondary to compression of adjacent neurovascular structures can occur, although the mass itself may be non-painful. Palpation of the lesion often reveals a pulse.

On both T1-weighted and T2-weighted imaging, the size of the associated vessel is at least 50% larger than that of neighboring sections (Fig. 12). With gadolinium enhancement, the aneurysm appears bright (as does the entire vessel). Mural thrombus may or may not exist and has imaging characteristics similar to those of a hematoma.

Indeterminate Lesions and Biopsy Techniques

When the physician cannot reach a diagnosis on the basis of the patient history, physical examination, and advanced imaging, the lesion is considered indeterminate and possibly malignant. Lesions that are hypointense compared with muscle on T1-weighted imaging and hyperintense on T2-weighted imaging are suspicious for soft-tissue sarcomas. Similarly, certain elements of the physical examination, such as a size of >5 cm, a firm mass, subfascial location, and a mat-like lesion adherent to neighboring tissues, are characteristic of soft-tissue sarcomas. Although suggestive of malignancy, these characteristics are not diagnostic.

If the lesion is indeterminate, a tissue sample must be obtained for diagnosis. Given the consequences of misdiagnosis or failure to diagnose a soft-tissue lesion, the importance of obtaining a biopsy cannot be overemphasized. The three primary techniques include open biopsy, core needle biopsy, and excisional biopsy.

The standard in obtaining diagnostic samples of tissue is the open biopsy technique. The technique allows direct visualization of the lesion. Frozen sections obtained at the time of the procedure ensure that the surgeon has obtained a diagnostic section of tissue. When performing an open biopsy, the surgeon must meticulously plan the approach because subsequent procedures will require excision of the tract of the biopsy. Transverse incisions must be avoided, and care should be taken to avoid exposing (and thus contaminating) neurovascular structures during the procedure. At all times, meticulous hemostasis must be maintained to prevent hematoma formation. Hematomas that track under subcutaneous tissue or through intermuscular spaces carry tumor cells and may contaminate these areas.

The core needle biopsy, especially when performed at centers that specialize in musculoskeletal tumors, is an alternative to open biopsy. Some investigators have questioned the sensitivity of core biopsy alone, but numerous studies have shown that it provides an accurate diagnosis in >80% of cases. The numerous advantages of core needle biopsy include decreased patient morbidity, less subcutaneous hematoma formation, and avoidance of the need for open biopsy. The procedure often is performed on an outpatient basis and without the use of general anesthesia. Advanced techniques such as cytogenetic studies and electron microscopy also can be used with this technique. When available, core needle biopsy is preferred to open biopsy. In general, excisional biopsy should be avoided, but when used, it should be reserved for lesions measuring <2 cm or lesions for which the surgeon already has a definitive diagnosis. It should not be used for large lesions or lesions that do not have a diagnosis because the consequences of inadequate resection are severe. If excisional biopsy must be repeated, the revision procedure becomes markedly more difficult than the index procedure because of the disruption of soft-tissue planes and because hematoma formation contaminates the wound bed. In addition, repeat excision results in lower rates of successful tumor removal.
Corresponding author:
A. Jay Khanna, MD  
c/o Elaine P. Henze, BJ, ELS, Medical Editor, Department of Ortho-

References


The Journal of Bone & Joint Surgery - JBJS.org  
VOLUME 89-A · SUPPLEMENT 3 · 2007

Magnetic Resonance Imaging of Soft-Tissue Tumors: Determine and Indeterminate Lesions

paedic Surgery, Johns Hopkins Bayview Medical Center, 4940 Eastern Avenue, #A672, Baltimore, MD 21224-2780. E-mail address: chenze1@jhmi.edu


