Magnetic Resonance Imaging of Malignant Soft Tissue Neoplasms in the Adult

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KEYWORDS

- Soft tissue tumor • Malignant • MR imaging
- Soft tissue neoplasm

Soft tissue sarcomas are estimated to represent 1% of malignant tumors.[1–3] The incidence of soft tissue sarcoma is estimated at 2.7 per 100,000[4] and increases significantly with age. In patients who are 80 years and older, the incidence is 8 per 100,000.[5] Magnetic resonance (MR) imaging is the favored modality for evaluation of soft tissue tumors and tumorlike conditions. Although advances in thin-section computed tomography (CT) have recently allowed detailed multiplanar reconstructions, MR imaging allows superior contrast resolution without radiation exposure.

Intravenous contrast administration may be useful for evaluation of malignant soft tissue tumors. Contrast may allow distinction of small tumor nodules (usually in the periphery) in a predominantly cystic lesion or a spontaneous hematoma. Malignant lesions may show increased vascularity at the periphery and high interstitial pressure at their center leading to a high rim to center differential enhancement ratio.[6] Negative features regarding the use of intravenous contrast include increased cost and length of time of the examination. Severe reactions to gadolinium and nephrogenic systemic fibrosis are rare but can occur.

Dynamic enhancement with gadolinium has been used in an attempt to differentiate benign from malignant soft tissue lesions.[7–9] High soft tissue vascularity and perfusion result in an increased rate of enhancement. Malignant lesions usually reveal greater enhancement and an increased rate of enhancement.[10] One difficulty with dynamic contrast-enhanced imaging is a significant overlap between the rate of enhancement of benign and malignant lesions.[11] We do not routinely perform dynamic enhancement sequences at our institutions and we believe significant overlap limits differentiation of benign from malignant solid soft tissue masses with otherwise nonspecific features.

Although MR imaging is excellent at delineating soft tissue lesions, a correct histologic diagnosis based on imaging studies alone is seen in only 25% to 30% of cases.[12–14] However, we believe that this percentage continues to increase and ultimately will approach the 75% to 90% range.[15] Most lesions are nonspecific with intermediate T1 and intermediate to high T2 signal; however, a specific diagnosis can be obtained in many instances by evaluating lesion signal intensity, location, growth pattern, and other unique intrinsic

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Radiol Clin N Am 49 (2011) 1219–1234
doi:10.1016/j.rcl.2011.07.006
0033-8389/11/$ – see front matter

characteristics of the lesion. Unless a specific diagnosis can be determined, the lesion should be considered indeterminate, and an appropriate biopsy path should be discussed with the orthopedic oncologist or treating surgeon. A poorly selected biopsy path may violate compartments needed for reconstruction and necessitate amputation for definitive treatment.[16,17]

Some investigators have proposed that criteria such as tumor margins, homogenous versus heterogeneous signal intensity, and lesion size can distinguish a benign from a malignant lesion in more than 90% of cases.[12] Other reports note that malignant lesions can appear smoothly marginated and homogenous and MR imaging appearance cannot accurately separate benign and malignant processes.[9,13,14,18–20] Malignancies tend to grow pushing against adjacent structures and forming a pseudocapsule as they enlarge. The pseudocapsule consists of compressed fibrous connective tissue, normal tissue, vascularization, and inflammatory reaction. Malignant lesions tend to respect anatomic compartments and fascial borders until late in their course.[21] Heterogeneous signal may represent mixed tissue types, necrosis, or hemorrhage within the lesion. Only a minority (5%) of benign soft tissue tumors are larger than 5 cm in diameter, and about 1% of benign lesions are deep.[5,22] In general, irregular margins, heterogeneous signal, and large size are indicators of a malignant lesion. Unless a specific diagnosis can be determined, a lesion should be considered indeterminate and biopsy performed.

An intracompartmental lesion is one that has not crossed any natural anatomic boundaries such as cortical bone, articular cartilage, joint capsule, major fascial plane, tendon, or ligament. Identifying invasion of other compartments is important for tumor staging and is often apparent on MR imaging. Aggressive lesions more readily invade surrounding tissues and cross anatomic boundaries. Vascular channels and poorly planned biopsy paths may contribute to invasion of adjacent compartments.

Lesion location is important for restricting the differential diagnosis. MR imaging with its excellent soft tissue contrast is the most valuable modality for determining location. Potential lesion locations include intramuscular, intermuscular, subcutaneous, and intra-articular/periarticular locations. A multifocal or an extensive lesion also limits diagnostic considerations to include angiomatous lesions, neurofibromatosis (NF), fibromatosis, lipomatosis, myxoma (Mazabraud syndrome), metastases, or lymphoma.

Lesions discussed in the following sections are included because of their frequency or their specific location or unique imaging characteristics that allow for a specific diagnosis or a limited differential diagnosis. For the common but nonspecific lesions, a reasonable differential diagnosis requires knowledge of lesion prevalence, anatomic distribution, and age range. Lesions that predominantly affect pediatric patients (see the article by Navarro and colleagues elsewhere in this issue for further exploration), benign soft tissue tumors (see the article by Walker and colleagues elsewhere in this issue for further exploration), and tumorlike conditions (see the article by Stacy and colleagues elsewhere in this issue for further exploration) are discussed in separate articles within this issue.

DERMATOFIBROSARCOMA PROTUBERANS

Dermatofibrosarcoma protuberans (DFSP) (**Fig. 1**) constitutes approximately 6% of soft tissue sarcomas.[23] This lesion is an intermediate-grade malignancy, but fibrosarcomatous transformation representing a higher-grade component may occur in 17% to 20% of cases.[24–26] DFSP most commonly occurs in the third to fifth decades of life with occasional reports of pediatric involvement.[27,28] Men are affected more frequently than women.[29] The lesion presents as a slowly growing reddish brown to bluish superficial skin nodule. Large lesions may become painful. Surgery with an excision margin of greater than 3 cm is associated with a local recurrence rate of 20%.[30] Head and neck tumors have a higher local recurrence rate (50%–75%). The incidence of metastasis is approximately 5%.[31] The trunk is affected in up to 50% of cases followed in frequency by the proximal upper and lower extremities (35%–40%) and the head and neck (14%).[29,32] Lesions may be multiple with small nodules coalescing to form a plaque.[29] MR imaging demonstrates a lesion involving the skin and subcutaneous adipose tissue causing a focal protuberance of the skin with a lobular or nodular architecture. Involvement of the underlying muscle is uncommon. The signal characteristics of the lesion are nonspecific, with signal similar to skeletal muscle on T1-weighted (T1W) images and similar to or greater than fat on T2-weighted (T2W) sequences. Fat-suppressed T2W sequences or short tau inversion recovery images typically demonstrate high signal intensity. Moderate enhancement is seen after intravenous gadolinium administration. The lesion may show heterogeneous signal if hemorrhage or necrosis is present. Satellite nodules in the adjacent subcutaneous tissue may be present, and linear extensions along the skin are often detected.[33]

A differential diagnosis for a subcutaneous lesion includes cutaneous malignant fibrous histiocytoma