Reviews

MRI of soft tissue tumors

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Abstract. Magnetic resonance imaging (MRI) is the only noninvasive method of defining a soft tissue tumor. The extent of the tumor and the question of involvement or noninvolvement of various adjacent tissues and structures can be determined. This information, determination of lymphatic and distant metastatic spread, is invaluable for staging and management of the disease. Whether or not the tumor type can be reliably determined, or even whether the malignant or benign nature of the tumor can be ascertained on MRI examination, is open to question. Review of the literature indicates proponents on both sides of the issue. This review illustrates the imaging features that are relevant to suggesting a histologic diagnosis, and the pitfalls that are encountered in trying to determine the malignancy or benignity of a lesion. The clinical significance of these determinations is also discussed.

Key words: MRI – Soft tissue tumors

Methods

The technical considerations in tailoring a magnetic resonance (MR) examination for both the initial diagnosis and follow-up of soft tissue tumors include selection of pulse sequence, coil, scan plane, and contrast administration.

The goal in pulse sequence selection is to maximize the contrast between normal and tumoral tissue. Pulse sequence selection in soft tissue neoplasm imaging (STNI) has basic and distinct differences from that in bone neoplasm imaging (BNI). In BNI, the normal tissue is usually fatty marrow, while in STNI, the normal tissue is skeletal muscle and fat. T1-weighted (T1W) spin echo fat suppression techniques (STIR) generally give the greatest contrast between normal and tumoral bone marrow. This is due to the marked hyperintensity of normal yellow marrow on T1 imaging, the suppression of the fatty marrow signal, and the additive T1 and T2 effects seen in fat suppression techniques.

Maximizing contrast between normal and tumoral soft tissue is best accomplished by spin echo technique and acquiring T1W (short TR, short TE), PDW (long TR, short TE), and T2W (long TR, long TE) images. Soft tissue neoplasms are often isointense with muscle on T1W images, but are usually hyperintense relative to muscle on PDW and T2W images. Fat is hyperintense relative to tumor on both T1W and PDW images, and both pulse sequences give excellent anatomic definition.

In most examinations, a 192 x 256 matrix and 5-mm slice thickness with 1-mm interslice gap will be adequate. A surface coil is used, except when the tumor is quite large or comparison with the opposite extremity is needed, and the body coil is then used. Sagittal, coronal, and axial scan planes are acquired for maximal anatomic detail. Contrast administration does not yet have a well-defined role, but we are currently using contrast-enhanced T1W images in evaluating patients for recurrence. It is most helpful to obtain a baseline postoperative examination, with and without contrast material, for comparison with subsequent follow-up examinations.

The major advantage of the various fast scan techniques is speed, but the advent of fast spin echo techniques negates this advantage. Fast spin echo technique with T1, PD, and T2 weighting delivers the highest resolution images in a short time with superior soft tissue contrast. Fast scan and fat suppression techniques have very little to offer in soft tissue neoplasm imaging.

Discussion

Review of the literature reveals conflicting points of view concerning histologic identification of soft tissue tumors.
by MRI. Some proponents claim that MRI is the technique of choice for identification [8] and characterization of soft tissue masses, and that the nature of the lesion with respect to benign versus malignant can be determined in most cases [2]. Other authors report individual cases that can be determined by signal characteristics [3, 11, 14, 20, 28], and by location: for example, a lesion within the lumen of a vein with signal characteristics of a cellular tumor was correctly diagnosed as a leiomyosarcoma [23]. Secondary signs, such as muscle atrophy in nerve sheath tumors [24], are also helpful. On the other hand, some authors report that MRI is incapable of reliably distinguishing between benign and malignant soft tissue masses [12, 13, 21].

In order to determine the feasibility of reliable MRI diagnosis of soft tissue tumors, we considered the following features:

- Size of the lesion
- Margination
- Involvement of adjacent structures
- Signal homogeneity
- Tissue characterization

It would be expected that a benign tumor would be small, well encapsulated with smooth margination, not involve any adjacent structures, and show signal homogeneity. On the other hand, a malignant tumor would be expected to be large, with irregular margination, possibly invade adjacent structures, and show signal inhomogeneity because of tissue necrosis and hemorrhage. The signal intensities on the various pulse sequences could be expected to provide a clue as to the tissue type.

These expectations are only partially met. The size criteria in the adult held true in our material. In one large series, there were no malignant tumors under the size of 3 cm diameter [2]. Care, however, must be exercised in pediatric patients. In one infant, a smooth, well-circumscribed homogeneous tumor of 1.5 cm diameter proved to be an embryonal rhabdomyosarcoma (Fig. 1). The margination of the lesions also varied. A benign tumor, as expected, may present with a smooth margin. However, a malignant tumor may also present with an apparently smooth margin (Fig. 2). It is also imperative that all images in all sequences be carefully examined for margination, since irregularity may be visible in only one segment on one particular sequence. Benign tumors as well as malignant tumors can present with irregular margins (Figs. 3, 4) [17, 27].

Several different tumors, benign and malignant, may have somewhat similar appearances with respect to margin and homogeneity (Figs. 5, 6) [6, 10, 18, 19]. Involvement of adjacent structures with invasion of muscles, fascial planes, and compartments, may range from subtle to obvious. Care should be taken when bony cortex is involved without medullary signal intensity changes. The lesion may either destroy or erode bone (Fig. 7), and the MRI examination may not show sufficient detail to distinguish between the two. Invasion through muscle planes may be subtle and only seen on one particular section and on only one of the pulse sequences (Fig. 8). The tumor may grossly invade the subcutaneous tissue (Fig. 9). This may show the linear reticular pattern of subcutaneous lymphedema. If a large lymph node is present in the subcutaneous tissues, thickened lymphatic channels adjacent to the node may be seen [5]. An advanced tumor may penetrate its compartment, the subcutaneous tissues, and the skin to form a fungating mass (Fig. 10).

An inhomogeneous signal intensity within the tumor may represent mixed tissue, necrosis, or hemorrhage. A homogeneous appearance may be expected in a benign tumor, but a malignant tumor may also show this finding (Fig. 11). Benign tumors and conditions can also appear inhomogeneous and even invasive (Fig. 12) [7]. As might be expected, malignant tumors may show inhomogeneous signal intensity (Fig. 13). However, all sequences must be inspected, since a false homogeneity may be seen on only one.

The signal intensities on the various pulse sequences define the tissue types. Most tumors, however, are cellular and will give signal characteristics similar to water, precluding histologic diagnosis on this basis [25]. The signal characteristics of the various tissues are summarized in Table 1. Tumors that contain fat can be readily discerned, although their benign or malignant nature cannot always be determined. A benign lipoma need not have a homogeneous appearance on all pulse sequences since these tumors often contain fibrous septa (Fig. 14) and sometimes ossification. A benign intramuscular lipoma characteristically infiltrates muscle planes. A liposarcoma may have fatty and cellular areas, depending on cellular differentiation (e.g., lipoblastic versus myxoid) [4, 15, 26], but is not expected to have thin, low signal intensity septa [26]. A hemangioma shows inhomogeneous high signal on T1W images due to fibrous fatty septa. The signal characteristics of blood are a complex matter, but in general, high signal intensity may be seen on both T1W and T2W images in the subacute stage. A hematoma may be confused with a tumor, since a mass may be palpated and complex signal characteristics seen (Fig. 15). A hemosiderin-laden tumor, such as pigmented villonodular synovitis, would show low signal intensity on both T1W and T2W images [22]. A plain

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<th>Table 1. Signal characteristics on MRI of various tissues</th>
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VH, Very high; H, high; I, intermediate; L, low; VL, very low
* T2-weighted gradient echo techniques are best for detecting calcifications because they are much more sensitive to magnetic field inhomogeneities from the magnetic susceptibility heterogeneity caused by calcifications within an image voxel.