MRI Of Locally Recurrent Soft Tissue Tumors Of The Musculoskeletal System

C Costelloe, A Yasko, W Murphy, R Kumar, V Lewis, P Lin, R Stafford, J Madewell

Citation

Abstract
The typical MR appearance of recurrent soft tissue tumors is a mass demonstrating increased T2 signal intensity (SI) and internal enhancement. Lack of growth, diminution in T2 SI and decreasing enhancement can distinguish nodular post-therapeutic changes from tumor. Predictable variants from the normal appearance of recurrent tumor include low T2 SI in fibrous tumors, rim enhancement in chondroid tumors and fat signal in recurrent lower grade lipomatous tumors.

INTRODUCTION
Magnetic resonance imaging (MRI) is commonly used to evaluate for recurrent soft tissue tumors by virtue of excellent soft tissue contrast resolution. Recurrent tumor usually presents as a mass that exhibits increased signal intensity on T2 – weighted images and demonstrates internal enhancement after administration of intravenous contrast. These imaging characteristics can help differentiate tumor from post-therapeutic soft tissue alterations. Radiation therapy does not typically produce a mass and post-operative fluid collections demonstrate no internal enhancement. Nodular granulation tissue/scar may enhance internally but is expected to remain stable or decrease in size on follow-up examinations.

Variations in the imaging characteristics of recurrent tumors can often be predicted on the basis of the histology of the primary tumor. Fibrous tumors may demonstrate low T2 signal intensity, chondroid tumors may exhibit rim enhancement and lipomatous neoplasms may produce recurrent masses composed primarily of fat. Knowledge of typical imaging characteristics and common variants aids in the identification of recurrent tumor.

TYPICAL MR APPEARANCE OF RECURRENT SOFT TISSUE NEOPLASMS
MRI provides several advantages over other imaging modalities in evaluation for recurrent tumor in the soft tissues. Exquisite soft tissue contrast resolution better facilitates evaluation of the extent of disease and proximity of vital structures (such as neurovascular bundles), in comparison to CT [1]. MRI can allow detection of smaller recurrent nodules in comparison to CT [2] and better delineation of an early postoperative site than ultrasound [3]. MRI can be used as the primary imaging modality in the evaluation for recurrent tumor or can be used as an adjunct to ultrasound. The typical MR appearance of a recurrent soft tissue neoplasm is a mass lesion [4] demonstrating high T2 SI and internal enhancement after administration of intravenous contrast [5] (Fig. 1).

Figure 1 Typical MR Appearance of Recurrent Soft Tissue Tumors – Dermatofibrosarcoma Protuberans

(a) Recurrent dermatofibrosarcoma protuberans of the left foot on axial MRI images obtained 9 years after resection. A discrete nodule is visible within the dorsal subcutaneous tissues at the level of the 2nd metatarsal. The recurrent tumor is isointense to muscle on the T1-weighted image.
(b) The nodule demonstrates high T2 signal intensity on the fat saturated T2-weighted image.

(c) Homogeneous enhancement is visualized on the fat saturated T1-weighted image obtained after administration of intravenous gadolinium contrast. These signal characteristics are common to the majority of recurrent soft tissue neoplasms.

MR APPEARANCE OF POST-THERAPEUTIC SOFT TISSUE CHANGES

Common treatment modalities that produce alterations in soft tissue are radiation and surgery. Photon radiation produces MR signal changes in the soft tissues that can increase in magnitude for up to 12-18 months after the conclusion of therapy [6]. Typical radiation-induced changes include muscular, fascial and subcutaneous edema with preservation of soft tissue architecture (Fig. 2). The preservation of normal muscular and fascial architecture is a strong indication of lack of recurrence [7].

Figure 2 Radiation Change – Small Cell Sarcoma

(a) Small cell sarcoma of the left thigh presents as a mass demonstrating high signal intensity on an axial fat saturated T2-weighted MR image obtained prior to therapy.

(b) A combination of chemotherapy and radiation therapy decreases the mass to a small nubbin of low T2 signal intensity (arrow) on a similar examination obtained 15 weeks later. The radiation has resulted in an area of mildly increased T2 signal intensity representing muscular, fascial and subcutaneous edema. The linear margin of the radiation field is demonstrated laterally (arrowheads). The architecture of the soft tissues is preserved. Resection of the residual tumor was performed after completion of therapy (not shown).

Nodular areas of increased T2 signal intensity in the early
postoperative period can pose a diagnostic dilemma. Differential diagnosis includes residual or recurrent tumor, postoperative fluid collections and nodular scar/granulation tissue. Administration of intravenous contrast allows differentiation between cystic and solid masses, which is helpful for identifying seromas (Fig. 3).

Figure 3 Evolution of Scar

Figure 6
(a) Postoperative baseline axial T2-weighted MR image obtained 18 weeks after resection of a malignant fibrous histiocytoma of the right calf reveals a nodular area of high T2 signal intensity. Differential considerations are recurrent tumor and nodular scar/granulation tissue.

Figure 7
(b) A similar examination obtained 10 months after surgery demonstrates that the area is less rounded in appearance and T2 signal has decreased (arrow), as is common with scar formation.

Figure 8
(c) Retraction of the scar tissue is best demonstrated on the fat saturated T1-weighted image obtained after administration of intravenous contrast. The scar demonstrates only mild enhancement.

Post-operative fluid collections demonstrate rim enhancement, typically resolve within 3-18 months [8] (though some may remain stable for years), and are not expected to increase in size without further therapeutic intervention [9].

Recurrent tumor nodules and early scar typically enhance after administration of intravenous contrast. When viewed
on follow-up examinations, recurrent tumor is expected to increase in size, while enhancing postoperative changes are expected to remain stable or decrease in size. Scar tissue also has a tendency to decrease in T2 signal intensity [10] and enhancement [11] with time. Follow-up examinations are necessary to document stability or decrease in nodularity of the resection site (Fig. 3).

**TYPICAL VARIATIONS IN THE MR APPEARANCE OF RECURRENT PRIMARY SOFT TISSUE TUMORS**

The imaging characteristics of several recurrent tumor types vary predictably from the norm, reflecting the histology of the primary tumor. Neoplasms that produce a large amount of collagen, such as fibrous tumors (desmoid fibromatosis), may exhibit low T2 signal intensity. Use of intravenous contrast can greatly increase the conspicuity of these lesions on T1-weighted sequences, particularly when combined with the use of fat suppression (Fig. 4).

**Figure 9**
(a) Recurrent desmoid fibroma on axial MR images obtained 30 months after resection. The recurrent nodule is isointense to muscle on the T1-weighted image. No fat surrounds the tumor. The reader is invited to estimate the size and location of this virtually imperceptible nodule.

(b) The tumor is predominately low in signal intensity on the fat saturated T2-weighted image, causing the nodule to blend deceptively with the surrounding tissues.

(c) The value of intravenous contrast is demonstrated on this fat saturated T1-weighted image. Intense enhancement is typical of recurrent desmoid fibroma and reveals the otherwise inconspicuous tumor.

Recurrent soft tissue neoplasms may produce little or no internal enhancement, as is typical of the avascular matrix of chondrosarcomas. The paucity of internal enhancement upon recurrence can be more profound than in the primary tumor,
resulting in tumor nodules that mimic postoperative seromas (Fig. 5). Knowledge of this variation and the histology of the primary tumor can promote early biopsy rather than continued routine follow-up.

Figure 5 Avascular Variant - Recurrent Chondrosarcoma

**Figure 12**
(a) Recurrent high-grade chondrosarcoma of the right iliac bone on axial MR images obtained 6 months after resection. Chondrosarcoma is often lower in signal intensity than muscle on T1-weighted images (arrow).

Another group of tumors that vary predictably from the norm are adipose tumors, such as atypical lipomatous tumors (ALT), and low-grade liposarcomas. These neoplasms are composed predominately of fat (high T1 SI, suppression with fat saturation techniques), and contain thicker and/or more numerous septae than simple lipomas [12]. Detection of recurrence can be challenging due to high fat content within the nodule. Non-fat saturated T1-weighted sequences often best demonstrate an expanding area of fat producing mass effect on adjacent structures. The mass effect can be subtle when the recurrence is early and comparison to previous examinations can be essential for identifying recurrent tumor (Fig. 6).

Figure 6 Recurrent Adipose Neoplasm – Atypical Lipomatous Tumor

**Figure 13**
(b) The recurrent nodule demonstrates high T2 signal intensity and a lobulated border.

**Figure 14**
(c) Enhancement is primarily at the rim of the lesion on the fat saturated T1-weighted image, mimicking a postoperative seroma. This appearance should be viewed with suspicion in patients with a history of chondrosarcoma. Biopsy confirmed the diagnosis of recurrent tumor.
Figure 15
(a) Pre-operative axial MR image of an atypical lipomatous tumor of the left shoulder girdle displays a mass composed primarily of high signal-intensity fat (arrowheads). The lesion contains numerous thin septae.

Figure 16
(b) A recurrent nodule is evident on a follow-up axial T1-weighted image obtained 20 months after resection (arrow). The recurrence displays homogeneous, high signal intensity fat. Mass effect with displacement of the latissimus dorsi muscle identifies this finding as recurrent tumor, distinguishing it from normal fat.

SUMMARY
The most common appearance of recurrent soft tissue tumors on MRI is a mass lesion demonstrating high signal intensity on T2-weighted images and internal enhancement after administration of intravenous contrast. Familiarity with the appearance and behavior of post-therapeutic change, the typical appearance of recurrent tumors and knowledge of common variants aids in the early detection of recurrent soft tissue neoplasms.

CORRESPONDENCE TO
Colleen M. Costelloe, M.D. Phone: 713-563-1260 Fax: 713-563-6626 ccostelloe@di.mdacc.tmc.edu

References
Author Information

Colleen M. Costelloe, M.D.
Division of Diagnostic Imaging, University of Texas M.D. Anderson Cancer Center

Alan W. Yasko, M.D.
Feinberg School of Medicine, Department of Orthopaedic Surgery, Northwestern University

William A. Murphy, M.D.
Division of Diagnostic Imaging, University of Texas M.D. Anderson Cancer Center

Rajendra Kumar, M.D.
Division of Diagnostic Imaging, University of Texas M.D. Anderson Cancer Center

Valerae O. Lewis, M.D.
Department of Orthopaedic Oncology, University of Texas M.D. Anderson Cancer Center

Patrick P. Lin, M.D.
Department of Orthopaedic Oncology, University of Texas M.D. Anderson Cancer Center

R. Jason Stafford, Ph.D.
Division of Imaging Physics, University of Texas M.D. Anderson Cancer Center

John E. Madewell, M.D.
Division of Diagnostic Imaging, University of Texas M.D. Anderson Cancer Center