American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Soft-Tissue Masses**

Variant 1: **Soft-tissue mass. Clinically suspect superficial lipoma. Initial imaging study**.

Radiologic Procedure	Rating	Comments	RRL*
X-ray area of interest	9		Varies
US area of interest	7		O
MRI area of interest without IV contrast	6		O
MRI area of interest without and with IV contrast	5	If any suggestion of complexity.	O
CT area of interest without IV contrast	4		Varies
CT area of interest with IV contrast	1		Varies
CT area of interest without and with IV contrast	1		Varies
Tc-99m bone scan area of interest	1		☢ ☢ ☢
FDG-PET/CT area of interest	1		☢ ☢ ☢ ☢
X-ray arthrography area of interest	1		Varies
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 2: **Soft-tissue mass. Nonspecific clinical assessment. Initial imaging study.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray area of interest	9		Varies
MRI area of interest without IV contrast	1		O
MRI area of interest without and with IV contrast	1		O
US area of interest	1		O
CT area of interest without IV contrast	1		Varies
CT area of interest with IV contrast	1		Varies
CT area of interest without and with IV contrast	1		Varies
Tc-99m bone scan area of interest	1		☢ ☢ ☢
FDG-PET/CT area of interest	1		☢ ☢ ☢ ☢
X-ray arthrography area of interest	1		Varies
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition: **Soft-tissue Masses**

Variant 3: **Juxta-articular soft-tissue mass. Clinically suspect ganglion or popliteal cyst. Initial imaging study.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray area of interest	9		Varies
MRI area of interest without IV contrast	7		O
MRI area of interest without and with IV contrast	6	If the mass is around a joint, contrast is less important.	O
US area of interest	6		O
CT area of interest without IV contrast	1		Varies
CT area of interest with IV contrast	1		Varies
CT area of interest without and with IV contrast	1		Varies
Tc-99m bone scan area of interest	1		☢ ☢ ☢
FDG-PET/CT area of interest	1		☢ ☢ ☢ ☢
X-ray arthrography area of interest	1		Varies
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Variant 4: **Soft-tissue mass. Nondiagnostic radiologic evaluation. Next study.**

Radiologic Procedure	Rating	Comments	RRL*
MRI area of interest without IV contrast	9		O
MRI area of interest without and with IV contrast	8		O
US area of interest	5		O
CT area of interest without IV contrast	4		Varies
CT area of interest with IV contrast	1		Varies
CT area of interest without and with IV contrast	1		Varies
Tc-99m bone scan area of interest	1		☢ ☢ ☢
FDG-PET/CT area of interest	1		☢ ☢ ☢ ☢
X-ray arthrography area of interest	1		Varies
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Clinical Condition: **Soft-tissue Masses**

Variant 5: **Soft-tissue mass. Prominent calcification on radiologic evaluation. Next study.**

Radiologic Procedure	Rating	Comments	RRL*
MRI area of interest without and with IV contrast	9		O
MRI area of interest without IV contrast	8		O
CT area of interest without IV contrast	5		Varies
US area of interest	1		O
CT area of interest with IV contrast	1		Varies
CT area of interest without and with IV contrast	1		Varies
Tc-99m bone scan area of interest	1		☢ ☢ ☢
FDG-PET/CT area of interest	1		☢ ☢ ☢ ☢
X-ray arthrography area of interest	1		Varies
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Variant 6: **Patient presenting with spontaneous hemorrhage, with palpable mass. Nondiagnostic radiographic evaluation. Next study.**

Radiologic Procedure	Rating	Comments	RRL*
MRI area of interest without and with IV contrast	9		O
MRI area of interest without IV contrast	7		O
CT area of interest without and with IV contrast	4		Varies
US area of interest	3		O
CT area of interest without IV contrast	2		Varies
CT area of interest with IV contrast	2		Varies
Tc-99m bone scan area of interest	1		☢ ☢ ☢
FDG-PET/CT area of interest	1		☢ ☢ ☢ ☢
X-ray arthrography area of interest	1		Varies
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Clinical Condition: **Soft-tissue Masses**

Variant 7: **Patient presenting with spontaneous hemorrhage, without palpable mass. Nondiagnostic radiographic evaluation. Next study.**

Radiologic Procedure	Rating	Comments	RRL*
MRI area of interest without and with IV contrast	9		O
MRI area of interest without IV contrast	7		O
CT area of interest without and with IV contrast	4		Varies
CT area of interest without IV contrast	2		Varies
CT area of interest with IV contrast	2		Varies
US area of interest	1		O
Tc-99m bone scan area of interest	1		☢ ☢ ☢
FDG-PET/CT area of interest	1		☢ ☢ ☢ ☢
X-ray arthrography area of interest	1		Varies
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

SOFT-TISSUE MASSES

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Summary of Literature Review

Introduction/Background

Imaging may be requested for patients with suspected soft-tissue masses because of a painful or painless soft-tissue abnormality palpated by the patient or physician, or because of symptoms such as pain or other complaints with no detectable mass on physical examination. The type of imaging technique initially selected varies depending on the history and physical findings as well as the suspected location of the mass. It is well known that biopsy of a presumed soft-tissue mass without an imaging workup is inadvisable.

There has been tremendous progress in imaging evaluation of soft-tissue masses over the years. With the advent of magnetic resonance imaging (MRI), lesion detection, differentiation of normal anatomic variants from true lesions, and characterization of lesions have improved because of MRI's superior soft-tissue contrast and multiple-image-plane capabilities [1-4]. Computed tomography and ultrasound (US) can be useful for problem solving by helping to characterize the nature of soft-tissue masses [2,5,6]. Also note that some lesions arising from bone (ie, osteochondroma or the soft-tissue component of a bone tumor) can present as deep soft-tissue masses clinically. In this case, radiographs can be useful.

Radiography

Radiographs are useful in the workup of a soft-tissue mass and are almost always indicated as the initial imaging study. However, they are often nonspecific when interpreted in isolation, and they may not obviate the need for more definitive cross-sectional evaluation. Most often radiographs should be considered a complementary examination, providing useful information when interpreted in conjunction with advanced modalities, including MRI and CT. If there has been a clear history of trauma and a masslike swelling develops, radiographs can be useful to track development of myositis ossificans; however, MRI or CT may still be needed to evaluate the extent of soft-tissue injury. Small but aggressive soft-tissue masses may be radiographically occult. Often the isolated radiographic finding is a "visible soft-tissue mass," and further imaging with MRI, CT, or US will be necessary.

Ultrasound

US is not frequently used as a primary imaging modality for evaluating soft-tissue masses at most institutions. However, this technique is valuable in differentiating cystic from solid lesions and has also been used to study vascularity of lesions [6-8]. US can be useful as an initial imaging study in the setting of superficial or subcutaneous lipomas. If US shows a lipomatous lesion to be internally simple and well encapsulated, further imaging may not be necessary.

Soft-tissue masses palpated around joints (especially around the knee) including lesions such as ganglia, parameniscal or paralabral cysts, and bursal collections often originate from the joint or the juxta-articular connective tissues. While soft-tissue sarcomas often occur near joints, they rarely are intra-articular or communicate with the joint; therefore, demonstration of communication with the joint is essential for establishing an appropriate differential. This can be performed using US or MRI; MRI gives the added benefit of documenting internal derangement that is often the cause of the juxta-articular lesion.

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Computed Tomography

Since the introduction of MRI, it has largely replaced CT as the technique of choice for evaluating soft-tissue masses. However, in some cases, CT may still be appropriate for evaluating soft-tissue lesions. Conditions such as suspected lipoma, calcification in soft-tissue lesions seen on routine radiographs, or suspected myositis ossificans based on clinical or radiographic data might be better evaluated with CT. Lipomas are easily characterized on both CT and MRI [2,5]. CT may be the most appropriate imaging modality for very large patients and patients with pacemakers when MRI is not feasible. In addition, large lesions located on the abdominal or chest wall, where motion artifact can create suboptimal MR imaging, may be best evaluated with CT [2,9]. A report of the Radiology Diagnostic Oncology Group on 133 soft-tissue tumors suggested that MRI and contrast-enhanced CT are comparable for determining tumor size and involvement of surrounding structures [10]. However, MRI has additional benefits in establishing a differential diagnosis of the lesion, including visualization of surrounding soft-tissue edema and vascularity as well as identification of internal fluid and fat components.

Magnetic Resonance Imaging

MRI has become the technique of choice for detecting and characterizing soft-tissue masses. Its improved soft-tissue contrast and multiple-image-plane capabilities have provided significant advantages for lesion conspicuity, characterization, and local staging [2-4,9,11-14]. Vascular structures can also be more easily identified and evaluated without the need for intravenous contrast agents [2]. Vascular structures and neurovascular involvement are more easily defined in 20% of cases compared with CT [2]. Cortical bone involvement by soft-tissue masses can be identified equally by either CT or MRI [2,4,9,10]. However, the extent of marrow involvement can be difficult to determine by CT, and there is evidence that tumor infiltration can extend beyond the apparent margin of the mass [15].

Though lesions are more easily detected with MRI, its ability to differentiate benign from malignant lesions remains controversial. Numerous studies have evaluated MR imaging features of soft-tissue lesions [1,10,13,15-23]. Reports discussing correct histologic diagnosis or differentiating benign from malignant lesions describe accuracy ranges from 24%-90%. Though imperfect, the superior soft-tissue contrast provided by fluid-sensitive MRI sequences reveals features that are useful for characterizing lesions. Malignant lesions are heterogeneous (72%-94%), larger (90% >33 mm), and more frequently involve bone and neurovascular structures [4,9,13]. The pattern of gadolinium enhancement may help identify some lesions as malignant, such as myxoid liposarcoma, and has shown utility in evaluating the aggressiveness of vascular and lipomatous masses [18,19]. Contrast is useful for identifying cystic and necrotic components of soft-tissue masses, helping to characterize lesions and identifying solid areas for biopsy. Dynamic gadolinium enhancement characteristics may be useful, but there is overlap between benign and malignant lesions [20,21]. Advanced MRI techniques such as spectroscopy and diffusion-weighted imaging have potential for differentiating benign from malignant lesions but need more refinement [5,22-26]. Even when MRI cannot characterize the type of lesion, it remains very useful for guiding percutaneous biopsy and for surgical planning.

Positron Emission Tomography

Positron emission tomography (PET) scanning has shown promise in helping differentiate benign from malignant soft-tissue lesions [27]. While some investigators have found limitations in using the average SUV_{max} (maximum standard uptake value) for differentiating between benign and malignant musculoskeletal masses, others have concluded that CT combined with PET and using fluorodeoxyglucose tracer (FDG-PET/CT) reliably differentiates aggressive soft-tissue and bone tumors from benign lesions [27,28]. These studies included a variety of lesion types, with low numbers of individual entities that could provide information regarding evaluation of specific tumor types (eg, lipoid) for malignant potential. Therefore, the role of PET scanning for evaluating soft-tissue tumors has yet to be established. It is unlikely that an SUV acquired from a PET examination could be relied upon to obviate biopsy at this point. However, information from a PET examination could be used for other purposes; for example, Benz et al [29] showed that FDG-PET can be used to determine a tumor glycolytic phenotype in sarcomas which correlates significantly with histologic grade, and PET/CT fusion images could be used to plan biopsy, targeting areas with more metabolic activity that may give higher diagnostic yield. PET scanning has been used mainly for evaluating metastatic disease and follow-up of treated lesions.

Invasive Techniques

Arthrography is rarely indicated, if at all, for evaluating soft-tissue masses. Popliteal cysts or communicating cystic lesions can be identified by introducing contrast material into the joints. However, this procedure is rarely

performed today. Still, it can be useful in determining whether the location of some soft-tissue masses is intra-articular or extra-articular, and it remains indicated when faced with this specific question. But differentiation and classification of potentially intra-articular soft-tissue tumors can usually be accomplished with standard MRI techniques [30].

Intravascular imaging techniques are generally not indicated for diagnosis and staging; however, they can be a valuable adjunct in the assessment and treatment of arteriovenous hemangiomas/malformations and other highly vascular tumors.

Once a soft-tissue mass is initially assessed with imaging and a differential diagnosis is created, image guidance is often indicated for tissue biopsy, which is addressed in other ACR Appropriateness Criteria® topics.

Summary

- As a general rule, MRI is the technique of choice for evaluating patients with suspected soft-tissue masses and pre- and post-contrast protocols are optimal in many scenarios [2,10,12,15].
- CT may be of greater value in patients who demonstrate subtle cortical bone involvement or soft-tissue calcifications on radiographs.
- An alternative technique may be required in some patients with a very large body habitus, or other factors rendering MRI unfeasible such as claustrophobia, the presence of some metallic or electrical implants or devices, or inability to remain motionless for the length of an MRI examination due to pain, Parkinson's disease, etc. CT would be selected in most of these situations.
- Focused US examination can be a valuable tool in the initial assessment of some soft-tissue lesions, especially cysts and lipomas.
- Radiographs remain an important initial imaging study and often serve as a valuable complement to MRI or CT assessment.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document.

Relative Radiation Level Designations		
Relative Radiation Level*	**Adult Effective Dose Estimate Range**	**Pediatric Effective Dose Estimate Range**
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢ ☢	0.1-1 mSv	0.03-0.3 mSv
☢ ☢ ☢	1-10 mSv	0.3-3 mSv
☢ ☢ ☢ ☢	10-30 mSv	3-10 mSv
☢ ☢ ☢ ☢ ☢	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies".		

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

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