American College of Radiology
ACR Appropriateness Criteria®
Soft Tissue Masses

Variant: 1 Superficial soft tissue mass. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
US area of interest	Usually Appropriate	O
Radiography area of interest	Usually Appropriate	Varies
US area of interest with IV contrast	Usually Not Appropriate	O
Image-guided biopsy area of interest	Usually Not Appropriate	Varies
Image-guided fine needle aspiration area of interest	Usually Not Appropriate	Varies
MRI area of interest without and with IV contrast	Usually Not Appropriate	O
MRI area of interest without IV contrast	Usually Not Appropriate	O
FDG-PET/CT area of interest	Usually Not Appropriate	☢☢☢☢
CT area of interest with IV contrast	Usually Not Appropriate	Varies
CT area of interest without and with IV contrast	Usually Not Appropriate	Varies
CT area of interest without IV contrast	Usually Not Appropriate	Varies

Variant: 2 Nonsuperficial (deep) soft tissue mass. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography area of interest	Usually Appropriate	Varies
US area of interest	May Be Appropriate	O
CT area of interest with IV contrast	May Be Appropriate	Varies
CT area of interest without and with IV contrast	May Be Appropriate	Varies
CT area of interest without IV contrast	May Be Appropriate	Varies
US area of interest with IV contrast	Usually Not Appropriate	O
Image-guided biopsy area of interest	Usually Not Appropriate	Varies
Image-guided fine needle aspiration area of interest	Usually Not Appropriate	Varies
MRI area of interest without and with IV contrast	Usually Not Appropriate	O
MRI area of interest without IV contrast	Usually Not Appropriate	O
FDG-PET/CT area of interest	Usually Not Appropriate	☢☢☢☢

Variant: 3 Soft tissue mass. Nondiagnostic radiograph and noncontrast enhanced ultrasound. Next imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
MRI area of interest without and with IV contrast	Usually Appropriate	O
MRI area of interest without IV contrast	May Be Appropriate	O
CT area of interest with IV contrast	May Be Appropriate (Disagreement)	Varies
CT area of interest without and with IV contrast	May Be Appropriate	Varies
US area of interest with IV contrast	Usually Not Appropriate	O
Image-guided biopsy area of interest	Usually Not Appropriate	Varies
Image-guided fine needle aspiration area of interest	Usually Not Appropriate	Varies
FDG-PET/CT area of interest	Usually Not Appropriate	☢☢☢☢

CT area of interest without IV contrast	Usually Not Appropriate	Varies

Variant: 4 Soft tissue mass. Nondiagnostic radiograph and noncontrast enhanced ultrasound. MRI contraindicated. Next imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
CT area of interest with IV contrast	Usually Appropriate	Varies
CT area of interest without and with IV contrast	May Be Appropriate	Varies
US area of interest with IV contrast	Usually Not Appropriate	O
Image-guided biopsy area of interest	Usually Not Appropriate	Varies
Image-guided fine needle aspiration area of interest	Usually Not Appropriate	Varies
FDG-PET/CT area of interest	Usually Not Appropriate	☢☢☢☢
CT area of interest without IV contrast	Usually Not Appropriate	Varies

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Summary of Literature Review

Introduction/Background

A variety of benign and malignant processes may present clinically as a soft tissue mass. The behavior of a mass, whether nonaggressive, indeterminant, or aggressive, can often be discerned based on history and physical examination. However, when a benign clinical diagnosis cannot be confidently provided, further characterization of a soft tissue mass with imaging is warranted [1]. Urgent imaging requests should be sought for masses that are >5 cm in diameter, deep in location, or have shown rapid growth [2]. Modern imaging techniques allow for a detailed analysis of the morphology of a soft tissue mass as well as further insight into its biologic activity, which informs the interpreter on diagnosis and appropriate next steps in management [3,4].

The purpose of this document is to identify the most appropriate imaging study(ies) to order for the assessment of a soft tissue mass based on the most frequently encountered clinical scenarios in medical practice. The rationale for the level of appropriateness granted to each study option is also described in accordance with the current literature and the consensus opinion of the members of the ACR Appropriateness Criteria Expert Panel on Musculoskeletal Imaging. This document does not address follow-up recommendations for patients with previously diagnosed masses or the appropriate approach or techniques for the imaging-guided biopsy of known masses. The former is covered by a separate ACR Appropriateness Criteria document [4], whereas the latter requires direct communication with the clinician or orthopedic oncologist supervising and coordinating patient care.

Of note, soft tissue sarcomas are rare, representing <1% of all malignancies [5]. Therefore, we must emphasize a fundamental tenet of orthopedic oncology: if a "…practitioner, or the institution, is not equipped to perform accurate diagnostic studies or definitive operative and adjunctive treatment … then it is in the patient's best interest to be referred to a treatment center before performance of

the biopsy" [6,7]. This tenet has been recently supported by a large retrospective analysis of 25,406 patients with soft tissue sarcoma of the extremities that found lower risk of positive margins and mortality in patients treated at high-volume orthopedic oncology centers (>20 soft tissue sarcoma patients annually) compared with low-volume centers [8].

Initial Imaging Definition

Initial imaging is defined as imaging at the beginning of the care episode for the medical condition defined by the variant. More than one procedure can be considered usually appropriate in the initial imaging evaluation when:

- There are procedures that are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care)

OR

- There are complementary procedures (ie, more than one procedure is ordered as a set or simultaneously wherein each procedure provides unique clinical information to effectively manage the patient's care).

Discussion of Procedures by Variant

Variant 1: Superficial soft tissue mass. Initial imaging.

The body regions covered in this clinical scenario include the neck, chest, abdomen, pelvis, humerus/upper arm, shoulder, elbow, forearm, wrist, hand, hip, femur/thigh, knee, tibia/lower leg, ankle, and foot.

Variant 1: Superficial soft tissue mass. Initial imaging.
A. Radiography Area of Interest

Initial imaging assessment of a suspected musculoskeletal soft tissue mass should almost invariably begin with radiographic evaluation and is advocated by the European Society for Medical Oncology–European Reference Network Clinical Practice Guidelines for rare adult solid cancers (ESMO-EURACAN) [9]. Although often considered unrewarding by clinicians without musculoskeletal expertise, a study of the radiographic evaluation of 454 patients with proven soft tissue masses demonstrated positive results in 62% of cases, with calcification identified in 27% of cases, bone involvement in 22% of cases, and intrinsic fat in 11% of cases [10]. Specifically, radiographic findings can be diagnostic or highly characteristic, such as in the identification of phleboliths within a hemangioma, the osteocartilaginous masses of synovial chondromatosis, or the peripherally more mature ossification of myositis ossificans, to name just a few. In addition, radiographs can be diagnostic of an unsuspected skeletal abnormality or deformity that may manifest as a soft tissue mass. Even when a specific diagnosis cannot be provided, radiographs may reveal information on the type and scope of mineralization, the presence or absence of unsuspected foreign matter, or changes within the adjacent bone. In general, radiographic findings related to a soft tissue mass can provide helpful insight in determining the next most appropriate imaging modality for further characterization. Of note, radiographs may not demonstrate an associated abnormality when a mass is small, deep-seated, nonmineralized, or in an area with complex anatomy such as the flank, paraspinal region, groin, or deep soft tissues of the hands and feet [11].

Variant 1: Superficial soft tissue mass. Initial imaging.

B. US Area of Interest

Ultrasound (US) has become increasingly recognized as an excellent triage tool for evaluation of superficial soft tissue masses [12-15]. This recognition has been further supported by a recent prospective study of 219 histologically proven masses that showed US had a sensitivity, specificity, positive predictive value, and negative predictive value of 93.3%, 97.9%, 45.2%, and 99.9%, respectively, for discriminating benign from malignant tumors in the superficial soft tissues [16]. The same group of researchers had similar results in an earlier separate retrospective analysis of 247 histologically proven masses [17]. However, although these results highlight the benefits of US in the initial assessment of superficial masses, the overall number of malignancies in both the prospective [16] and retrospective [17] studies was very small (12 patients and 11 patients, respectively). Another recent study of 42 histologically proven masses concluded that MRI performed after US does not frequently change the working diagnosis or add diagnostic value, but again, this study only included a small number of malignancies and the value of MRI for these malignancies was not separately addressed in the study [18]. Therefore, we emphasize that these studies do not have sufficient power for showing high accuracy of US in the diagnosis of malignancy. Ultimately, US is most beneficial for triage, and when US features are not clearly benign or when history and physical examination findings are otherwise concerning, further imaging is required [9,19].

Variant 1: Superficial soft tissue mass. Initial imaging.
C. US Area of Interest With IV Contrast

The use of intravenous (IV) contrast during US evaluation of soft tissue tumors may add further confidence in discriminating benign from indeterminate or malignant masses [20-22]. However, there is no literature showing that the addition of contrast provides a gain in diagnostic accuracy over standard grayscale and Doppler US features in the assessment of a soft tissue mass. Therefore, the literature does not support the use of US contrast in the initial examination of a superficial soft tissue mass.

Variant 1: Superficial soft tissue mass. Initial imaging.
D. MRI Area of Interest Without and With IV Contrast

There is insufficient literature to support the routine use of MRI without or with IV contrast as the initial examination for a soft tissue mass. The inherent limitations of this modality, most notably in the identification of mineralization, limit its use in isolation.

Variant 1: Superficial soft tissue mass. Initial imaging.
E. MRI Area of Interest Without IV Contrast

There is insufficient literature to support the routine use of MRI without IV contrast as the initial examination for a soft tissue mass. The inherent limitations of this modality, most notably in the identification of mineralization, limit its use in isolation.

Variant 1: Superficial soft tissue mass. Initial imaging.
F. CT Area of Interest With IV Contrast

CT with IV contrast does not typically play a role in the initial evaluation of a superficial soft tissue mass.

Variant 1: Superficial soft tissue mass. Initial imaging.
G. CT Area of Interest Without and With IV Contrast

CT does not typically play a role in the initial evaluation of a superficial soft tissue mass.

Variant 1: Superficial soft tissue mass. Initial imaging.
H. CT Area of Interest Without IV Contrast

CT does not typically play a role in the initial evaluation of a superficial soft tissue mass.

Variant 1: Superficial soft tissue mass. Initial imaging.
I. FDG-PET/CT Area of Interest

There is insufficient literature to support the routine use of fluorine-18-2-fluoro-2-deoxy-D-glucose (FDG)-PET/CT for the initial evaluation of a soft tissue mass.

Variant 1: Superficial soft tissue mass. Initial imaging.
J. Image-Guided Biopsy Area of Interest

The literature does not support the use of image-guided biopsy as the initial examination for a soft tissue mass. At least 20% to 25% of soft tissue masses can demonstrate features that allow for confident diagnosis based on MRI alone [23], many of which are benign and thus would not warrant biopsy. Therefore, diagnostic imaging that includes comprehensive characterization of the mass should routinely be performed before biopsy. In fact, the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology for Soft Tissue Sarcoma state that biopsy should be performed only after adequate imaging [24].

Variant 1: Superficial soft tissue mass. Initial imaging.
K. Image-Guided Fine Needle Aspiration Area of Interest

The literature does not support the use of image-guided fine needle aspiration as the initial examination for a soft tissue mass. At least 20% to 25% of soft tissue masses can demonstrate features that allow for confident diagnosis based on MRI alone [23], many of which are benign and thus would not warrant fine needle aspiration. Therefore, diagnostic imaging that includes comprehensive characterization of the mass should routinely be performed before biopsy. In fact, the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology for Soft Tissue Sarcoma state that biopsy or fine needle aspiration should be performed only after adequate imaging [24].

Variant 2: Nonsuperficial (deep) soft tissue mass. Initial imaging.

The body regions covered in this clinical scenario include the neck, chest, abdomen, pelvis, humerus/upper arm, shoulder, elbow, forearm, wrist, hand, hip, femur/thigh, knee, tibia/lower leg, ankle, and foot.

Variant 2: Nonsuperficial (deep) soft tissue mass. Initial imaging.
A. Radiography Area of Interest

Initial imaging assessment of a suspected musculoskeletal soft tissue mass should almost invariably begin with radiographic evaluation and is advocated by ESMO-EURACAN [9]. Radiographs remain the modality best suited for the initial assessment of a suspected soft tissue mass and are the initial study of choice for orthopedic oncologists [25,26]. However, radiographs have limitations and may not reveal an abnormality when a mass is small, deep-seated, nonmineralized, or in an area with complex anatomy such as the flank, paraspinal region, groin, or deep soft tissues of the hands and feet [11].

Variant 2: Nonsuperficial (deep) soft tissue mass. Initial imaging.
B. US Area of Interest

The diagnostic accuracy of US is considerably less when lesions outside the subcutaneous tissue are included. It is also less reliable for defining deep masses in large anatomical areas [27].

Although a recent prospective study of US accuracy in the characterization of 134 histologically proven deep soft tissue masses showed promising results, there were only a small number of malignancies in the study cohort, and the investigators had a high level of US expertise [28]. Therefore, US is most appropriate for superficial masses that are small (<5 cm) in size [13] but may be appropriate for deep soft tissue masses in specific settings, such as a deep mass in a thin patient.

Variant 2: Nonsuperficial (deep) soft tissue mass. Initial imaging.
C. US Area of Interest With IV Contrast

The diagnostic accuracy of US is considerably less when lesions outside the subcutaneous tissue are included. It is also less reliable for defining deep masses in large anatomical areas [27]. Although an assessment of diagnostic accuracy of US with IV contrast in the setting of a deep soft tissue mass is not available in the current literature, there is presumably no added benefit over standard grayscale and Doppler US. Therefore, the US with IV contrast is not useful for the initial assessment of deep soft tissue masses.

Variant 2: Nonsuperficial (deep) soft tissue mass. Initial imaging.
D. MRI Area of Interest Without and With IV Contrast

The current radiology, orthopedic oncology, and surgical oncology literature does not support the use of MRI without and with IV as the initial examination for a soft tissue mass.

Variant 2: Nonsuperficial (deep) soft tissue mass. Initial imaging.
E. MRI Area of Interest Without IV Contrast

The current radiology, orthopedic oncology, and surgical oncology literature does not support the use of MRI without IV contrast as the initial examination for a soft tissue mass.

Variant 2: Nonsuperficial (deep) soft tissue mass. Initial imaging.
F. CT Area of Interest With IV Contrast

CT with IV contrast does not typically play a role in the initial evaluation of a deep soft tissue mass. However, CT can be useful in areas where the osseous anatomy is complex or obscured for the distinction of ossification from calcification and the identification of characteristic patterns of mineralization [29,30]. In anatomically complex areas where radiographs would be less sensitive, CT may be beneficial as the initial or complementary imaging modality. Fortunately, the advent of virtual noncontrast reconstruction with modern dual-source CT scanners allows for acquisition of a single postcontrast scan with reconstruction of virtual noncontrast images, which can preclude the need for a separate precontrast scan phase [31].

For myositis ossificans, CT is superior to radiography in detecting the zonal pattern of mineralization, which is essential for early diagnosis [11]. In addition, CT allows for differentiation of soft tissue masses based on lesion density and can delineate vascular and bone involvement [29,30]. This differentiation may be better defined by immediately repeating the scan after contrast administration. During the assessment of cortical remodeling or invasion, the character of the interface between a soft tissue mass and the adjacent osseous cortex can usually be visualized to better advantage with CT compared to radiographs.

Variant 2: Nonsuperficial (deep) soft tissue mass. Initial imaging.
G. CT Area of Interest Without and With IV Contrast

CT without and with IV contrast does not typically play a role in the initial evaluation of a deep soft tissue mass. However, CT can be useful in areas where the osseous anatomy is complex or

obscured for the distinction of ossification from calcification and the identification of characteristic patterns of mineralization [29,30]. In anatomically complex areas where radiographs would be less sensitive, CT may be beneficial as the initial or complementary imaging modality. Fortunately, the advent of virtual noncontrast reconstruction with modern dual-source CT scanners allows for acquisition of a single postcontrast scan with reconstruction of virtual noncontrast images, which can preclude the need for a separate precontrast scan phase [31].

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Variant 2: Nonsuperficial (deep) soft tissue mass. Initial imaging.
H. CT Area of Interest Without IV Contrast

CT without IV contrast does not typically play a role in the initial evaluation of a deep soft tissue mass. However, CT can be useful in areas where the osseous anatomy is complex or obscured for the distinction of ossification from calcification and the identification of characteristic patterns of mineralization [29,30]. In anatomically complex areas where radiographs would be less sensitive, CT may be beneficial as the initial or complementary imaging modality. Fortunately, the advent of virtual noncontrast reconstruction with modern dual-source CT scanners allows for acquisition of a single postcontrast scan with reconstruction of virtual noncontrast images, which can preclude the need for a separate precontrast scan phase [31].

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Variant 2: Nonsuperficial (deep) soft tissue mass. Initial imaging.
I. FDG-PET/CT Area of Interest

FDG PET/CT does not typically play a role in the initial evaluation of a soft tissue mass. The CT component associated with PET/CT is of lower resolution compared with conventional CT and is not optimal for accurate characterization of soft tissue mineralization.

Variant 2: Nonsuperficial (deep) soft tissue mass. Initial imaging.
J. Image-Guided Biopsy Area of Interest

The literature does not support the use of image-guided biopsy as the initial examination for a soft tissue mass. At least 20% to 25% of soft tissue masses can demonstrate features that allow for confident diagnosis based on MRI alone [23], many of which are benign and thus would not warrant biopsy. Therefore, diagnostic imaging that includes comprehensive characterization of the mass should routinely be performed before biopsy. In fact, the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology for Soft Tissue Sarcoma state that biopsy should

be performed only after adequate imaging [24].

Variant 2: Nonsuperficial (deep) soft tissue mass. Initial imaging.
K. Image-Guided Fine Needle Aspiration Area of Interest

The literature does not support the use of image-guided fine needle aspiration as the initial examination for a soft tissue mass. At least 20% to 25% of soft tissue masses can demonstrate features that allow for confident diagnosis based on MRI alone [23], many of which are benign and thus would not warrant fine needle aspiration. Therefore, diagnostic imaging that includes comprehensive characterization of the mass should routinely be performed before biopsy. In fact, the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology for Soft Tissue Sarcoma state that biopsy or fine needle aspiration should be performed only after adequate imaging [24].

Variant 3: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. Next imaging study.

The body regions covered in this clinical scenario include the neck, chest, abdomen, pelvis, humerus/upper arm, shoulder, elbow, forearm, wrist, hand, hip, femur/thigh, knee, tibia/lower leg, ankle, and foot.

Of note, this variant addresses the scenario in which radiographs and/or noncontrast US have been performed but did not sufficiently characterize a soft tissue mass. In addition, this variant presumes there are no contraindications to any imaging modality. Variant 4 specifically addresses the situation of a contraindication to MRI.

Variant 3: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. Next imaging study.
A. CT Area of Interest With IV Contrast

Although CT with IV contrast lacks the specificity afforded by MRI in many cases, it does provide useful staging data [32]. In a multi-institutional study of 133 patients with primary soft tissue malignancies, Panicek et al [32] found no statistically significant difference between MRI and contrast-enhanced CT imaging in determining tumor involvement of muscle, bone, joint, or neurovascular structures. Therefore, CT with IV contrast remains an important adjunct in the evaluation of a soft tissue mass.

The advent of virtual noncontrast reconstruction with modern dual-source CT scanners allows for acquisition of a single postcontrast scan with reconstruction of virtual noncontrast images, which can preclude the need for a separate precontrast scan phase [31]. Similar to CT without IV contrast [21, 22], virtual noncontrast imaging allows distinction of ossification from calcification and identification of characteristic patterns of mineralization [29,30] and is particularly useful in assessment of mass mineralization in areas where the osseous anatomy is complex or obscured and radiographs would be less sensitive.

Variant 3: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. Next imaging study.
B. CT Area of Interest Without and With IV Contrast

The advent of virtual noncontrast reconstruction with modern dual-source CT scanners allows for acquisition of a single postcontrast scan with reconstruction of virtual noncontrast images, which can preclude the need for a separate precontrast scan phase [31]. However, a traditional CT

without and with IV contrast may be appropriate for characterization of mineralization in an anatomically complex area. Although a multi-institutional study of 133 patients with primary soft tissue malignancies by Panicek et al [32] found no statistically significant difference between MRI and contrast-enhanced CT imaging in determining tumor involvement of muscle, bone, joint, or neurovascular structures, this study did not specifically endorse the usefulness of dual-phase CT without and with IV contrast. CT with IV contrast remains an important adjunct in the evaluation of a soft tissue mass.

Variant 3: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. Next imaging study.
C. CT Area of Interest Without IV Contrast

The literature does not support the use of single-phase CT without IV contrast as the next imaging study for the evaluation of a soft tissue mass. Although a multi-institutional study of 133 patients with primary soft tissue malignancies by Panicek et al [32] found no statistically significant difference between MRI and contrast-enhanced CT imaging in determining tumor involvement of muscle, bone, joint, or neurovascular structures, this study did not endorse the usefulness of single-phase CT without IV contrast.

Variant 3: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. Next imaging study.
D. MRI Area of Interest Without and With IV Contrast

MRI without and with IV contrast is the technique of choice as the next imaging study for the evaluation of soft tissue masses. Its improved soft tissue contrast and multiplanar capability have provided significant advantages for lesion conspicuity, intrinsic tumor characterization, and local staging [3,11]. Vascular structures and neurovascular involvement are more easily defined when compared with CT.

The use of MR contrast agents improves the differentiation of benign from malignant soft tissue masses [33]. The contrast allows for better demarcation between viable tumor and muscle, edema-like reactive change, hemorrhage, and tumor necrosis, as well as providing information on tumor vascularity.

In addition to static MR contrast imaging, there are several additional modern MR techniques that provide greater insight into the character and behavior of soft tissue masses and can assist with differentiation of benign from malignant tumors. These include diffusion-weighted imaging [34-37], dynamic contrast-enhanced perfusion imaging [38,39], and MR spectroscopy [38,39]. Of note, chemical-shift imaging has not shown utility in differentiating benign from malignant soft tissue masses [40]. However, the Dixon technique will likely be increasingly recognized as beneficial for soft tissue tumor imaging through its potential to provide more homogenous fat suppression when compared to traditional T2-fat saturated imaging and better resolution than inversion recovery imaging. Furthermore, it may help decrease imaging time because the Dixon water-only and fat-only images are acquired simultaneously [41,42].

Variant 3: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. Next imaging study.
E. MRI Area of Interest Without IV Contrast

MRI without IV contrast may be beneficial as the next imaging study for the evaluation of soft tissue masses. Its improved soft tissue contrast and multiplanar capability have provided significant

advantages for lesion conspicuity, intrinsic tumor characterization, and local staging [3,11]. Vascular structures and neurovascular involvement are more easily defined when compared with CT.

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Variant 3: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. Next imaging study.
F. FDG-PET/CT Area of Interest

As a general rule, PET/CT imaging maximum standard uptake value can be useful for differentiating between benign and malignant musculoskeletal masses. When combined with anatomic data provided by CT, FDG-PET/CT can be useful in distinguishing aggressive soft tissue tumors from benign lesions [43-45]. Benz et al [46] showed that FDG-PET can be used to determine a tumor glycolytic phenotype in sarcomas, which correlates significantly with histologic grade. Fused FDG-PET/CT images can be used to plan biopsy, targeting areas with more metabolic activity that may give higher diagnostic yield. Furthermore, a meta-analysis found that FDG-PET can be a helpful tool for predicting outcome in patients with soft tissue sarcoma [47]. Lastly, FDG-PET/CT is an excellent modality to detect metastatic disease and assess treatment response [48]. Despite these benefits, FDG-PET/CT does not usually play a role as the next imaging study for the characterization of a soft tissue mass when initial radiographs or US are nondiagnostic.

Variant 3: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. Next imaging study.
G. Image-Guided Biopsy Area of Interest

The literature does not support the use of image-guided biopsy as the next step in evaluation following nondiagnostic radiographs or US of a soft tissue mass. At least 20% to 25% of soft tissue masses can demonstrate features that allow for confident diagnosis based on MRI alone [23], many of which are benign and thus would not warrant biopsy. Therefore, diagnostic imaging that includes comprehensive characterization of the mass should routinely be performed before biopsy. In fact, the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology for Soft Tissue Sarcoma state that biopsy should be performed only after adequate imaging [24].

Variant 3: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. Next imaging study.
H. Image-Guided Fine Needle Aspiration Area of Interest

The literature does not support the use of image-guided fine needle aspiration as the next step in evaluation following nondiagnostic radiographs or US of a soft tissue mass. At least 20% to 25% of soft tissue masses can demonstrate features that allow for confident diagnosis based on MRI alone [23], many of which are benign and thus would not warrant biopsy. Therefore, diagnostic imaging that includes comprehensive characterization of the mass should routinely be performed before biopsy. In fact, the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology for Soft Tissue Sarcoma state that biopsy should be performed only after adequate imaging [24].

Variant 3: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. Next imaging study.
I. US Area of Interest With IV Contrast

Although prospective studies have emerged suggesting that US is accurate in the discrimination of benign from malignant soft tissue masses, the number of malignancies in these studies was limited [16,28]. Therefore, the use of US for the final evaluation and staging of a deep soft tissue mass is not recommended.

Variant 4: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. MRI contraindicated. Next imaging study.

The body regions covered in this clinical scenario include the neck, chest, abdomen, pelvis, humerus/upper arm, shoulder, elbow, forearm, wrist, hand, hip, femur/thigh, knee, tibia/lower leg, ankle, and foot.

Variant 4: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. MRI contraindicated. Next imaging study.
A. CT Area of Interest With IV Contrast

CT has become a useful technique for the evaluation of patients who cannot undergo MRI and is the modality of choice in this scenario [29]. In the evaluation of suspected tumors, contrast imaging is especially useful in distinguishing vascularized from potentially necrotic regions of the tumor. With modern CT technology, calcification can usually be distinguished from vascular enhancement.

Of note, dual-energy CT is a relatively newer technology that has shown utility in evaluation of soft tissue masses. Using the differences in energy attenuation of soft tissue at 80 kVp and 140 kVp, this technique can allow reconstruction of virtual noncontrast CT images as well as significantly reduce metal artifact in the assessment of metal implants, improving the diagnostic value of imaging in the surrounding soft tissues [49,50]. It has also shown application in the assessment of marrow edema [51,52] and has been investigated in the distinction of marrow edema from intramedullary tumor invasion [53]. Furthermore, spectral CT is emerging as a useful tool for distinguishing benign from malignant soft tissue masses [54].

Variant 4: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. MRI contraindicated. Next imaging study.
B. CT Area of Interest Without and With IV Contrast

Dual-phase CT without and with IV contrast as the next imaging study for the evaluation of a soft tissue mass may be appropriate when MRI is contraindicated. Although single-phase CT with IV contrast is considered most appropriate in this clinical scenario given the advent of virtual noncontrast reconstruction with modern dual-source CT scanners [31], a traditional CT without and

with IV contrast can be helpful for characterization of mineralization in an anatomically complex area.

Variant 4: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. MRI contraindicated. Next imaging study.
C. CT Area of Interest Without IV Contrast

The literature does not support the use of a single-phase CT without IV contrast as the next imaging study for the evaluation of a soft tissue mass when MRI is contraindicated. However, single-phase CT with IV contrast is a useful technique for the evaluation of patients who cannot undergo MRI and is the modality of choice in this scenario [29]. In the evaluation of suspected tumors, contrast imaging is especially useful in distinguishing vascularized from potentially necrotic regions of the tumor. With modern CT technology, calcification can usually be distinguished from vascular enhancement. Therefore, CT without IV contrast is usually not beneficial.

Variant 4: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. MRI contraindicated. Next imaging study.
D. FDG-PET/CT Area of Interest

Although FDG-PET/CT is not typically used as the next imaging study for the characterization of a soft tissue mass, PET/CT imaging maximum standard uptake value can be useful for differentiating between benign and malignant musculoskeletal masses. When combined with anatomic data provided by CT, FDG-PET/CT can be useful in distinguishing aggressive soft tissue tumors from benign lesions [43-45]. Benz et al [46] showed that FDG-PET can be used to determine a tumor glycolytic phenotype in sarcomas, which correlates significantly with histologic grade. Fused FDG-PET/CT images can be used to plan biopsy, targeting areas with more metabolic activity that may give higher diagnostic yield. Furthermore, a meta-analysis found that FDG-PET can be a helpful tool for predicting outcome in patients with soft tissue sarcoma [47]. Lastly, FDG-PET/CT is an excellent modality to detect metastatic disease and assess treatment response [48]. Despite these benefits, FDG-PET/CT does not usually play a role in the initial assessment of a soft tissue mass.

Variant 4: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. MRI contraindicated. Next imaging study.
E. Image-Guided Biopsy Area of Interest

The literature does not support the use of image-guided biopsy as the next step in evaluation following nondiagnostic radiographs or US of a soft tissue mass. If MRI is contraindicated, characterization of the mass using CT with IV contrast should routinely be performed before biopsy [29]. In fact, the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology for Soft Tissue Sarcoma state that biopsy should be performed only after adequate imaging [24].

Variant 4: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. MRI contraindicated. Next imaging study.
F. Image-Guided Fine Needle Aspiration Area of Interest

The literature does not support the use of image-guided fine needle aspiration as the next step in evaluation following nondiagnostic radiographs or US of a soft tissue mass. If MRI is contraindicated, characterization of the mass using CT with IV contrast should routinely be performed before biopsy [29]. In fact, the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology for Soft Tissue Sarcoma state that biopsy should be performed

only after adequate imaging [24].

Variant 4: Soft tissue mass. Nondiagnostic radiograph and noncontrast-enhanced ultrasound. MRI contraindicated. Next imaging study.
G. US Area of Interest With IV Contrast

There is insufficient literature to support the routine use of US with IV contrast as the next imaging study for the evaluation of a soft tissue mass when MRI is contraindicated.

Summary of Highlights

- **Variant 1**: US or radiography are usually appropriate for the initial imaging of a superficial soft tissue mass.
- **Variant 2**: Radiography is usually appropriate for the initial imaging of a nonsuperficial (deep) soft tissue mass.
- **Variant 3**: MRI without and with IV contrast is usually appropriate as the next imaging study for a soft tissue mass following nondiagnostic radiographs or noncontrast-enhanced US.
- **Variant 4**: When MRI is contraindicated, CT with IV contrast is usually appropriate as the next imaging study for a soft tissue mass following nondiagnostic radiographs or noncontrast-enhanced US.

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at https://acsearch.acr.org/list. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents, please go to the ACR website at https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria.

Gender Equality and Inclusivity Clause

The ACR acknowledges the limitations in applying inclusive language when citing research studies that predates the use of the current understanding of language inclusive of diversity in sex, intersex, gender, and gender-diverse people. The data variables regarding sex and gender used in the cited literature will not be changed. However, this guideline will use the terminology and definitions as proposed by the National Institutes of Health.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit

		ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

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, because of both 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 with 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 (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."

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Disclaimer

The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

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