

Soft Tissue Tumors in Adults: ESSR-Approved Guidelines for Diagnostic Imaging

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Abstract

Soft tissue sarcomas are rare, but early, accurate diagnosis with subsequent appropriate treatment is crucial for the clinical outcome. The ESSR guidelines are intended to help radiologists in their decision-making and support discussion among clinicians who deal with patients with suspected or proven soft tissue tumors. Potentially malignant lesions recognized by ultrasound should be referred for magnetic resonance imaging (MRI), which also serves as a preoperative local staging modality, with specific technical requirements and mandatory radiological report elements. Radiography may add information about matrix calcification and osseous involvement. Indeterminate lesions, or lesions in which therapy is dependent on histology results, should be biopsied. For biopsy, we strongly recommend referral to a specialist sarcoma center, where an interdisciplinary tumor group, with a specialized pathologist, radiologist, and the surgeon are involved. In sarcoma, a CT scan of the chest is mandatory. Additional

Keywords

- ▶ soft tissue tumor
- ▶ guidelines
- ▶ diagnostic algorithm
- ▶ imaging methods
- ▶ ESSR

staging modalities are entity-specific. There are no evidence-based recommendations for routine follow-up in surgically treated sarcomas. However, we would recommend regular follow-up with intervals dependent on tumor grade, for 10 years after the initial diagnosis.

Rationale and Objective of the ESSR Guidelines

Soft tissue tumors are rare and represent a diverse group of heterogeneous entities.¹ Sarcomas account for only ~ 1% of soft tissue tumors in adults.² Early accurate diagnosis and appropriate treatment are crucial for optimum outcome.³ Therefore, regularly updated guidelines for diagnostic strategy containing both minimal requirements and recommendations for optimization are required.

The European Society of Musculoskeletal Radiology (ESSR) guidelines are not meant to be prescriptive but are intended to help radiologists in their decision management and to support discussion among clinicians who deal with suspected or proven soft tissue tumors. We are aware that variations exist between countries and that the procedure varies in a minority of patients with special entities. We wish to stress the role of specialist sarcoma treatment centers, especially in cases of uncertainty and to avoid procedures when sarcomas become evident only during surgery, resulting in intralesional resection. We strongly recommend referral to a specialist sarcoma center for biopsy in indeterminate or likely malignant tumors.

History and Clinical Features

The following information should be available for the radiologist:

History: (a) Has there been a recent trauma (caveat: many patients report trauma that may be unrelated and misleading)? (b) Is the patient anticoagulated? (c) When did the patient first notice the lesion? Is it growing, and how fast? (d) Does it change in size (e.g., dependent on position, exercise, or muscle contraction/relaxation)? (e) Is there any oncologic history (malignancy, chemotherapy, or radiotherapy)? (f) Is there history of previous surgery?

A standardized checklist, primarily filled out by the patient, and discussed with the radiologist, is considered advisable.

Clinical symptoms and palpation: (a) Is the lesion painful? (b) Is it palpable, and if so, is it hard or soft? (c) Is it movable against the skin and underlying tissue? (d) Are there skin alterations or pathologic vessels? (e) Single or multiple lesions?

Primary Imaging

Patients with palpable lumps and suspected soft tissue tumor are numerous, resulting in a high initial workload, but imag-

ing should be performed in most. Unless a lesion is clinically suspicious for malignancy (> 5 cm, deep, firm, and fixed on palpation), a reliable primary-triage image modality, in combination with clinical features, can be used to decide which patients need further work-up and who should be referred to a dedicated tumor center.

Ultrasound

In patients with a suspected soft tissue tumor, ultrasound (US) is considered the appropriate initial triage imaging modality as long as the tumor is accessible by US.⁴⁻⁶ The presence of a soft tissue tumor can be confirmed, but characterization is limited, and intra-articular and osseous involvement cannot be diagnosed reliably. US is readily available, "real time," radiation free, and cost effective but depends on the skill of the sonographer and may be challenging in obese patients. Reproducibility and reliability depend on appropriate documentation. Although US is excellent for the detection of even very small lesions, it may miss lesions in deep locations. Small areas of scar tissue can be misinterpreted as recurrence in patients who have had previous surgery.

Technical Ultrasonography Standards

Mandatory requirements: The US hardware should be quality assured, images stored in a picture archival communication system, and a written report available for each examination.

State-of-the-art scanners should be used, with high-resolution transducers (frequency dependent on the depth of the lesion) and color/power Doppler available. Extended field of view and compound imaging are desirable. If no mass is detected initially, frequency harmonic imaging for echo-poor solid masses may be useful.⁷

Who Should Perform the Initial Ultrasound?

Ideally, a board-certified radiologist (or, in the clinical setting, a radiologist with proven experience in sonographic soft tissue lesion assessment) should perform the US. We consider the radiologist (who also has access to other imaging modalities) the most suitable medical specialist for this issue. Purely cutaneous lesions can be assessed by a dermatologist, if specifically trained.

What Should Be Described on Ultrasound?

- Relation to the fascia (superficial, deep), exact anatomical location including compartmental involvement, the

relationship to/infiltration of vessels/nerves, and, if possible, joints and/or bone and crucial adjacent structures.

- Size (in three dimensions).
- Morphology: cystic, solid (intralesional echo texture, vascularization, presence or absence of necrosis, bleeding, posterior acoustic enhancement/shadowing, suspected calcifications), shape, borders/margins.

Criteria for Diagnosis of a Benign Lesion

- Simple cyst, bursa, synovial/ganglion cyst: purely cystic well-defined lesion without any solid component, anechoic, with posterior acoustic enhancement and no internal vascularity.⁸
- Superficial lipoma: homogeneous well defined, encapsulated, and compressible with no clinical concern and documented stability on US (at least 6 months follow-up).^{9,10}
- Vascular malformation with no clinical concern and stability on US (at least 6 months follow-up).¹¹
- Foreign body "granuloma" with a compatible history.¹²
- Superficial fibromatosis (e.g., palmar and plantar fibromatosis, infantile digit fibromatosis).^{13,14}
- Muscle hernia.¹⁵
- Morton neuroma.¹⁶
- Peripheral nerve sheath tumors only in case of proven neurofibromatosis for the detection and monitoring of typical neurofibromas. If painful, additional investigations should be conducted.^{11,17}

Criteria for Follow-up by Ultrasound

- Likely posttraumatic hematoma or follow-up of muscle tears (follow-up interval: depending on the size, 3–6 weeks).
- Follow-up or preoperative evaluation of soft tissue mass previously characterized by MRI, no surgery intended, or before surgery.

Criteria for Proceeding to a Subsequent MRI

- Any tumor with a reasonable chance of being malignant.¹⁸
- Location: below the superficial muscle fascia, or superficial, but obtuse contact with or crossing of the superficial fascia.^{19,20}
- Size > 5 cm.²¹
- Any clinical or sonographic doubt (i.e., cannot be positively diagnosed as benign)
- Tumor at the site of a previous excision, regardless of previous histology
- Any tumor that is not completely accessible by US

Primary MRI should be considered instead of US in the following indications:

- Clinical suspicion of malignancy: suspicious clinical examination (fixed lump, large mass), deep mass, persistent swelling after trauma, rapidly enlarging lesion (except small superficial lesions), osseous involvement, joint involvement.
- In every case of abdominal/ pelvic/ retroperitoneal/ paravertebral mass lesion detected incidentally with other

imaging modalities (alternatively, a CT scan can be performed in these cases; see later).

Primary CT should be considered instead of US when the lesion is intrathoracic or intra-abdominal (including pelvic and retroperitoneal lesions). CT after US should be considered where there are contraindications to MRI (such as pacemakers) or when MRI is not available (for other CT indications, see later).

Projection radiography serves as a complementary imaging modality to show and characterize soft tissue calcification or ossification and bone involvement,^{22,23} particularly in deep palpable lesions, para-articular lesions, and large masses. For regions with a complex anatomy (e.g., axial skeleton, head/neck, thoracic, and pelvic areas), CT is preferred over radiography.

Further Imaging

MRI

MRI is the imaging method with the best soft tissue contrast. It serves to further characterize the tumor and provide precise and reproducible local staging for therapy planning and selecting appropriate biopsy regions.²⁴

MRI should preferably be performed in a sarcoma treatment center or by a radiologist with sufficient expertise in musculoskeletal radiology (MSK) (e.g., an ESSR diploma holder or a national MSK certification holder), with the potential to provide the electronic data set to a tumor center, if necessary.

Technical MRI Requirements

The field strength of the scanner should be at least 1 T, but preferentially 1.5-T or 3-T units should be used. A cutaneous marker should be applied. The field of view should be as large as necessary to image the entire lesion, peritumoral edema, and a layer of adjacent normal tissue,²⁵ and to image non-palpable masses reliably (usually this aspect is especially important in coronal or sagittal sequences). Axial sequences with high spatial resolution are important to define tumor margins, tissue and compartment involvement, and neurovascular, bone, and joint involvement. The matrix should be optimized to achieve high in-plane spatial resolution, high signal-to-noise ratio, and a reasonable examination time (e.g., 256; if possible 384, or [in T1-weighted, T2-weighted] even 512). The slice thickness should not exceed 4 mm. In smaller tumors, 3-mm slices may be appropriate.

The tumor should be measured in three dimensions (sequences should be performed in at least two planes). At least one sequence should include an external bony landmark for measuring and operation planning.²⁶

Recommended basic protocols include T1-weighted and a fluid-sensitive, fat-saturated (FS) sequence, both parallel to the long axis of the tumor. An axial T2-weighted sequence may provide further information about the tumor matrix.^{26–28} Some authors use only axial proton-density FS or T2 FS; one of these should be performed. We recommend using intravenous gadolinium-based contrast agents, if

possible and feasible, at a routine dosage (usually, 0.1 mmol/kg body weight). In patients with renal insufficiency, the European Society of Urogenital Radiology guidelines should be taken into account.²⁹ Postcontrast sequences should be performed in two planes (routinely, the T1-weighted precontrast sequence along the long axis is repeated, and a FS T1-weighted axial sequence is performed). Subtraction images (T1-weighted pre-subtracted from T1-weighted postcontrast) help identify truly enhancing tumor areas sensitively.

Additional sequences may include dynamic contrast enhancement and diffusion-weighted sequences that can be helpful in characterizing the tumor (especially vascularization and matrix) but are not currently mandatory.^{30–32} Pretreatment dynamic MR studies are useful as a baseline for follow-up MR scans to monitor response to chemotherapy.

What Should Be Described on the MRI Report?

- Lesion location and extension²⁶
- Relation to the fascia (superficial, deep), exact anatomical location, with relationship to/infiltration of vessels/nerves, joints, and/or bone, muscles/compartments,³³ and distance to external landmark.
- Size (in three dimensions)

Lesion morphology:

- Cystic, solid (matrix signal intensity, homogeneity, vascularity, enhancement, with and without necrosis, bleeding).
- Borders, lobularity, pseudocapsule, perifocal edema, and surrounding alterations
- Multiplicity and satellite lesions, abnormal proximal lymph nodes.²⁶

Criteria for a Determinate Lesion on MRI

The following lesions may be reliably characterized on MRI: lipoma, ganglion cyst, Baker cyst, bursitis, vascular malformation, hematoma, myositis ossificans, peripheral nerve sheath tumor (neurofibromas/schwannomas), muscle tear, pigmented villonodular synovitis (PVNS), and aneurysm.³⁴

If there is any doubt about tissue characterization, the patient should be referred to a sarcoma treatment center for a second opinion.³⁵

Referral to a Sarcoma Treatment Center

Patients with soft tissue tumors should be referred regularly to a sarcoma treatment center for a primary or a secondary opinion. Soft tissue sarcomas should be managed by a multidisciplinary sarcoma team that includes an (orthopedic) tumor surgeon, musculoskeletal radiologist, oncologist, and musculoskeletal pathologist. Further members of the team would include radiotherapists, specialized physiotherapists, and so on.

Criteria for referral to a sarcoma treatment center:

- Any patient with a ≥ 5 -cm superficial tumor or with a deep-seated tumor regardless of size.³⁶
- Indeterminate US or indeterminate MRI findings, or clinical suspicion of malignancy.
- Patients should be referred *before* biopsy or surgery.

Time intervals: The patient should ideally be reviewed by the sarcoma team and biopsied, if necessary, within 2 weeks.

Criteria for Subsequent Biopsy

A biopsy (usually image guided; for excisional or non-image-guided biopsy, see later) is indicated when the lesion is either indeterminate or if there is a likelihood of the lesion being malignant. In most cases, biopsy is necessary.

Biopsy

It is essential that the biopsy be performed in the sarcoma treatment center where the patient will receive further/definitive treatment³⁶ (with the future oncologic surgeon and a specialized pathologist involved). The decision to biopsy or not should be arrived at by a multidisciplinary approach including the oncologic surgeon.

Biopsy Technique

In most patients, the method of choice is closed image-guided biopsy. In tumors ≤ 3 cm, particularly in superficial lesions, excisional biopsy may be appropriate. Rarely, for large and superficial lesions known to be homogeneous on recent imaging, non-image-guided biopsy may be appropriate.

Image-guided biopsy is minimally invasive, does not require general anesthesia or hospitalization, and has reasonable accuracy.³⁷ Therefore, when the tumor is accessible, it is preferred over open biopsy (which is also appropriate).

Image-guided biopsy can be performed by US, MRI, or CT. US is recommended, especially in superficial, smaller, and homogeneous lesions. MRI or CT are especially preferred in thoracic, abdominal, or pelvic lesions. In practice, the choice depends on local expertise and the availability of imaging modalities.

It is essential to target viable tumor areas, identified by color Doppler US,^{38,39} contrast-enhanced MRI,⁴⁰ or positron emission tomography (PET)/CT.⁴¹ Contrast-enhanced US⁴² and dynamic contrast-enhanced MRI⁴³ can help target representative areas.

The biopsy approach should be planned in collaboration with the sarcoma surgeon because the biopsy tract has to be removed en bloc at the time of surgery. Contamination of nonaffected compartments should be avoided. Core biopsy is appropriate. Fine-needle aspiration biopsy is inappropriate.⁴⁴ We recommend a biopsy needle size of at least 14G (most appropriate), and taking more than three or four samples.²⁸

Image-guided biopsy should be performed by a trained radiologist or the surgeon of the multidisciplinary tumor group in the sarcoma center after interdisciplinary discussion.

Proven Sarcoma: Further Imaging

In patients with histologically proven sarcoma, whole-body staging must be performed. When these results become available, further treatment should be planned by a multidisciplinary tumor board.

Table 1 Whole-body staging in sarcoma

Chest CT scan (unenhanced) for lung metastases	All soft tissue tumors
PET scan for osseous metastases	Alveolar soft part sarcoma ^{47,48} Angiosarcoma ⁴⁷ Leiomyosarcoma ⁴⁹ Undifferentiated pleomorphic sarcoma ⁴⁶ Dedifferentiated liposarcoma ⁴⁷
Regional MRI/CT for lymph nodes	Rhabdomyosarcoma, clear cell sarcomas, epithelioid sarcoma, angiosarcoma, synovial sarcoma ^{50,51}
Abdominal CT	Myxoid liposarcoma ⁵² Epithelioid sarcoma ⁵³ Angiosarcoma ⁵⁴ Leiomyosarcoma ⁵⁵
Brain imaging ⁵⁸	Alveolar soft part sarcoma ⁵⁶ Clear cell sarcoma, angiosarcoma ⁵⁴
MRI of the spine	Myxoid liposarcoma ⁵²

Abbreviations: CT, computed tomography; MRI, magnetic resonance imaging; PET, positron emission tomography.

Whole-Body Staging

Staging should be performed according to the updated American Joint Committee on Cancer criteria⁴⁵ that includes histologic grading according to the French Federation of Cancer Centers (considering cell differentiation, mitotic count, and tumor necrosis).

Metastatic spread of soft tissue sarcomas mainly is hematogenous, and pulmonary metastases are most common, accounting for ~ 75 to 80% of metastases. CT of the chest (native three-dimensional volume helical CT with 1-mm reconstructions) is recommended. Other sites are less commonly involved. Osseous metastases occur in ~ 10% of soft tissue sarcoma patients.⁴⁶ Higher incidences have been described for alveolar soft part sarcomas,^{47,48} angiosarcomas,⁴⁷ leiomyosarcomas,⁴⁹ undifferentiated pleomorphic sarcomas,⁴⁶ and dedifferentiated liposarcomas.⁴⁷ Eighty percent of those osseous metastases are lytic,⁴⁶ and fluorodeoxyglucose (FDG)-PET may be useful in these tumors.

Lymph node involvement is rare (~ 3% of sarcomas) and is more frequent in high-grade rhabdomyosarcoma, clear cell sarcomas, epithelioid sarcoma, angiosarcoma, and synovial

sarcoma.^{50,51} Regional MRI/CT should be considered in those tumors.

In myxoid liposarcoma,⁵² epithelioid sarcoma,⁵³ angiosarcoma,⁵⁴ and leiomyosarcoma,⁵⁵ abdominal CT should be considered. In alveolar soft part sarcoma with lung metastases,^{56,57} in clear cell sarcoma, and angiosarcoma,⁵⁴ brain imaging should be considered.⁵⁸ In myxoid liposarcoma,⁵² MRI of the spine should be considered.

The role of PET/CT and PET/MR for initial staging, therapy control, and follow-up is still regarded as controversial. It may lead to upstaging in only a minority of patients and is currently not recommended for routine use.⁵⁹

Follow-Up

To date, there are no evidence-based recommendations for routine follow-up in surgically treated sarcomas. In several European countries, follow-up is performed regularly for 10 years after the initial diagnosis.

Generally, a baseline examination 3 to 6 months postoperatively, followed by 3- to 6-month intervals up to the fifth year, and 12 months thereafter, are recommended in the American College of Radiology (ACR) appropriateness criteria.⁶⁰ The recurrence rate is known to be influenced by the tumor grade.⁶¹ As proposed by the European Society of Medical Oncology (ESMO) and national societies, we recommend follow-up intervals that depend on tumor grade: for intermediate or high-grade sarcomas, intervals of 3 to 4 months in the first 2 to 3 years, and, in low-grade sarcomas, 4 to 6 months in the first 3 years; subsequently for both, 6-month intervals up to the fifth year.⁶²⁻⁶⁴ We also recommend 12-month intervals from the fifth to tenth years. In case of symptoms/suspected recurrence, follow-up can be performed earlier.

Apart from clinical and laboratory examinations, follow-up includes imaging for local recurrence and metastatic disease. There is debate about whether imaging should be

Table 2 Example for follow-up intervals

Clinical examination, local/regional MRI, and chest CT scan (no contrast agent)	
Year after first treatment	Follow-up interval
1-3	Grading-dependent, every 3-4 mo
3-5	Every 6 mo
> 5, up to 10	Annually
Consider tissue-specific additional modalities as detailed in ► Table 1	

Abbreviations: CT, computed tomography; MRI, magnetic resonance imaging.

Adapted from Mazon and Suit.⁵⁰

Table 3 Key points

Key Points 1: General Patient Information:
- The radiologist should be informed about the patient's past medical history and clinical history/examination.
Key Points 2: Imaging Algorithm for Local Diagnosis:
- Imaging should be performed in all patients with suspected soft tissue tumors.
- Ultrasound is considered the most appropriate initial triage modality for accessible tumors to clearly determine benign lesions.
- Any tumor with a reasonable chance of being malignant or at a previous excision site requires an MRI (or, in specific cases, CT).
- MRI, as the imaging modality with best soft tissue contrast, serves for further characterization of the tumor, local staging and therapy planning, and biopsy targeting.
- Projection radiography (or, in complex regions, CT) should be performed as an additive primary modality in deep palpable lesions, para-articular lesions, and large masses to characterize soft tissue calcification or ossification and bone involvement.
Key Points 3: Ultrasound Requirements:
- Mandatory technical standards for ultrasound include quality-assured state-of-the-art scanners and transducers, archival image storage, and written examination reports.
- Radiologists with proven experience in soft tissue lesion assessment are considered most appropriate for initial ultrasound. Purely cutaneous lesions can be assessed by specifically trained dermatologists.
- Exact anatomical location, size, and morphology should be described.
- Only clearly benign, completely accessible lesions do not require further diagnostic work-up with imaging.
Key Points 4: MRI Requirements:
- Mandatory technical standards for MRI include state-of-the-art scanners (field strengths of preferentially 1.5 T or 3 T, and at least 1 T) and coils.
- Cutaneous markers should be used, and at least one anatomical landmark should be visible.
- The field of view and the matrix should be optimized for the tumor size, and the tumor extent should be measurable in three dimensions.
- Fluid-sensitive fat-saturated and T1-weighted sequences obtained in at least two planes are minimal sequence requirements.
- Intravenous contrast agent is recommended in most cases; dynamic enhancement assessment and a static postcontrast sequence with subtraction are considered beneficial.
- Exact anatomical location, size, and morphology of the lesion should be described.
- Multiplicity, satellite lesions, and abnormal proximal lymph nodes should be described.
Key Points 5: Referral to Tumor Competence Center:
- Defined by extensive expertise in the diagnosis and management of soft tissue tumors with a multidisciplinary sarcoma team that includes an orthopedic tumor surgeon, a musculoskeletal radiologist, and a musculoskeletal pathologist.
- Any patient with a ≥ 5 -cm superficial tumor, or with a deep-seated tumour, regardless of size.
- indeterminate ultrasound or MRI, or clinical suspicion of malignancy
- <i>Before</i> image-guided or excisional biopsy, or surgery.
Key Points 6: Whole-body Staging in Sarcoma:
- Staging should be performed according to the updated AJCC criteria.
- Includes chest CT without contrast.
- Depending on the histologic entity, additional modalities are recommended (Table 1).
Key Points 7: Follow-up:
- No evidence-based recommendations exist, to date.
- Examples of imaging intervals with regular follow-up over 10 y, as performed in several ESSR countries, are supplied in ►Table 2 .

Abbreviations: AJCC, American Joint Committee on Cancer; CT, computed tomography; ESSR, European Society of Musculoskeletal Radiology.

performed regularly^{18,60} or only in symptomatic cases.⁶² However, local recurrences are, especially in retroperitoneal lesions, desmoid type fibromatosis, and lesions with marked surrounding scar tissue, initially not palpable. We therefore recommend regular imaging. ► **Table 2.**

In limb sarcomas, US seems promising for exclusion of local recurrence.⁶⁵ To date, local MRI (including contrast-enhanced sequences) is considered the method of choice for local surveillance.^{24,66}

The follow-up MRI should be compared with the preoperative MRI (for morphology, site, and extent of the lesion). The MR protocol should include at least a fluid-sensitive, fat-saturated sequence (long and short axis), a T1-weighted sequence without contrast agent, and, in case of a focal mass, a T1-weighted sequence with contrast agent (with subtraction).⁶⁷ A T2-weighted sequence may add to lesion morphology assessment and thus should be included in the protocol. If available and feasible, a delayed contrast enhancement and diffusion-weighted imaging sequence may be performed.^{67,68}

In case of metallic hardware, lower field strengths are preferred, and dedicated sequences that are optimized for minimizing susceptibility artifacts should be used. In case of large metallic hardware, US, dual-energy CT or CT using modern iterative reconstruction algorithms of raw data sets, or PET/CT can be considered as alternative or additive to MRI.

Chest CT (without contrast, helical three-dimensional volume acquisition with 1-mm reconstructions) is recommended for lung metastasis surveillance in accordance with ACR criteria⁶⁰ because it is more sensitive than projection radiography.

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Notes

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References

- Fletcher CDM, Bridge JA, Hogendoorn P, Mertens F. WHO Classification of Tumours of Soft Tissue and Bone. 4th ed. Lyon, France: IARC Press; 2013
- National Cancer Institute. SEER Stat Fact Sheets: Soft tissue including heart cancer. Available at: <http://seer.cancer.gov/stat-facts/html/soft.html>. Accessed December 7, 2015
- Nakamura T, Matsumine A, Matsubara T, Asanuma K, Uchida A, Sudo A. The symptom-to-diagnosis delay in soft tissue sarcoma influence the overall survival and the development of distant metastasis. *J Surg Oncol* 2011;104(7):771–775
- Lakkaraju A, Sinha R, Garikipati R, Edward S, Robinson P. Ultrasound for initial evaluation and triage of clinically suspicious soft-tissue masses. *Clin Radiol* 2009;64(6):615–621
- Rowbotham E, Bhuvu S, Gupta H, Robinson P. Assessment of referrals into the soft tissue sarcoma service: evaluation of imaging early in the pathway process. *Sarcoma* 2012;2012:781723
- Ritchie DA. Commentary on ultrasound for initial evaluation and triage of clinically suspicious soft-tissue masses. *Clin Radiol* 2009;64(6):622–623
- Campbell R. Ultrasound of soft tissue masses. In: Allan PL, Baxter GM, Weston MJ eds. *Clinical Ultrasound*. 3rd ed. Philadelphia, PA: Churchill Livingstone/Elsevier; 2011
- Klauser AS, Tagliafico A, Allen GM, et al. Clinical indications for musculoskeletal ultrasound: a Delphi-based consensus paper of the European Society of Musculoskeletal Radiology. *Eur Radiol* 2012;22(5):1140–1148
- Inampudi P, Jacobson JA, Fessell DP, et al. Soft-tissue lipomas: accuracy of sonography in diagnosis with pathologic correlation. *Radiology* 2004;233(3):763–767
- Wagner JM, Lee KS, Rosas H, Kliewer MA. Accuracy of sonographic diagnosis of superficial masses. *J Ultrasound Med* 2013;32(8):1443–1450
- Carra BJ, Bui-Mansfield LT, O'Brien SD, Chen DC. Sonography of musculoskeletal soft-tissue masses: techniques, pearls, and pitfalls. *AJR Am J Roentgenol* 2014;202(6):1281–1290
- Horton LK, Jacobson JA, Powell A, Fessell DP, Hayes CW. Sonography and radiography of soft-tissue foreign bodies. *AJR Am J Roentgenol* 2001;176(5):1155–1159
- Griffith JF, Wong TY, Wong SM, Wong MW, Metreweli C. Sonography of plantar fibromatosis. *AJR Am J Roentgenol* 2002;179(5):1167–1172
- Vanhoenacker FM, Eyselbergs M, Van Hul E, Van Dyck P, De Schepper AM. Pseudotumoural soft tissue lesions of the hand and wrist: a pictorial review. *Insights Imaging* 2011;2(3):319–333
- Beggs I. Sonography of muscle hernias. *AJR Am J Roentgenol* 2003;180(2):395–399
- Quinn TJ, Jacobson JA, Craig JG, van Holsbeeck MT. Sonography of Morton's neuromas. *AJR Am J Roentgenol* 2000;174(6):1723–1728
- Reynolds DL Jr, Jacobson JA, Inampudi P, Jamadar DA, Ebrahim FS, Hayes CW. Sonographic characteristics of peripheral nerve sheath tumors. *AJR Am J Roentgenol* 2004;182(3):741–744
- National Comprehensive Cancer Network. NCCN Clinical Practice Guidelines in Oncology. Available at: http://www.nccn.org/professionals/physician_gls/f_guidelines_nojava.asp. Accessed December 11, 2015
- Galant J, Martí-Bonmatí L, Soler R, et al. Grading of subcutaneous soft tissue tumors by means of their relationship with the superficial fascia on MR imaging. *Skeletal Radiol* 1998;27(12):657–663
- Morel M, Taïeb S, Penel N, et al. Imaging of the most frequent superficial soft-tissue sarcomas. *Skeletal Radiol* 2011;40(3):271–284
- Datir A, James SL, Ali K, Lee J, Ahmad M, Saifuddin A. MRI of soft-tissue masses: the relationship between lesion size, depth, and diagnosis. *Clin Radiol* 2008;63(4):373–378; discussion 379–380
- Gartner L, Pearce CJ, Saifuddin A. The role of the plain radiograph in the characterisation of soft tissue tumours. *Skeletal Radiol* 2009;38(6):549–558
- De Schepper AM, Vanhoenacker F, Parizel PM, Gielen J eds. *Imaging of Soft Tissue Tumors*. Berlin, Germany: Springer-Verlag; 2006
- Verstraete KL, Lang P. Bone and soft tissue tumors: the role of contrast agents for MR imaging. *Eur J Radiol* 2000;34(3):229–246
- White LM, Wunder JS, Bell RS, et al. Histologic assessment of peritumoral edema in soft tissue sarcoma. *Int J Radiat Oncol Biol Phys* 2005;61(5):1439–1445
- Manaster BJ. Soft-tissue masses: optimal imaging protocol and reporting. *AJR Am J Roentgenol* 2013;201(3):505–514
- Dinauer PA, Brixey CJ, Moncur JT, Fanburg-Smith JC, Murphey MD. Pathologic and MR imaging features of benign fibrous soft-tissue tumors in adults. *Radiographics* 2007;27(1):173–187

- 28 Wu JS, Hochman MG. Soft-tissue tumors and tumorlike lesions: a systematic imaging approach. *Radiology* 2009;253(2):297–316
- 29 European Society of Urogenital Radiology (ESUR) Guidelines on Contrast Media. Available from: <http://www.esur.org/guidelines/>. Accessed December 11, 2015
- 30 van Rijswijk CS, Geirnaerd MJ, Hogendoorn PC, et al. Soft-tissue tumors: value of static and dynamic gadopentetate dimeglumine-enhanced MR imaging in prediction of malignancy. *Radiology* 2004;233(2):493–502
- 31 van Rijswijk CS, Kunz P, Hogendoorn PC, Taminiau AH, Doornbos J, Bloem JL. Diffusion-weighted MRI in the characterization of soft-tissue tumors. *J Magn Reson Imaging* 2002;15(3):302–307
- 32 Subhawong TK, Jacobs MA, Fayad LM. Diffusion-weighted MR imaging for characterizing musculoskeletal lesions. *Radiographics* 2014;34(5):1163–1177
- 33 Holzapfel K, Regler J, Baum T, et al. Local staging of soft-tissue sarcoma: emphasis on assessment of neurovascular encasement-value of MR imaging in 174 confirmed cases. *Radiology* 2015; 275(2):501–509
- 34 Papp DF, Khanna AJ, McCarthy EF, Carrino JA, Farber AJ, Frassica FJ. Magnetic resonance imaging of soft-tissue tumors: determinate and indeterminate lesions. *J Bone Joint Surg Am* 2007;89 (Suppl 3):103–115
- 35 Vanhoenacker FM, Van Looveren K, Trap K, et al. Grading and characterization of soft tissue tumors on magnetic resonance imaging: the value of an expert second opinion report. *Insights Imaging* 2012;3(2):131–138
- 36 Styring E, Billing V, Hartman L, et al. Simple guidelines for efficient referral of soft-tissue sarcomas: a population-based evaluation of adherence to guidelines and referral patterns. *J Bone Joint Surg Am* 2012;94(14):1291–1296
- 37 Yang J, Frassica FJ, Fayad L, Clark DP, Weber KL. Analysis of non-diagnostic results after image-guided needle biopsies of musculoskeletal lesions. *Clin Orthop Relat Res* 2010;468(11):3103–3111
- 38 Peer S, Freuis T, Loizides A, Gruber H. Ultrasound guided core needle biopsy of soft tissue tumors; a fool proof technique? *Med Ultrasound* 2011;13(3):187–194
- 39 Pohlhig F, Kirchoff C, Lenze U, et al. Percutaneous core needle biopsy versus open biopsy in diagnostics of bone and soft tissue sarcoma: a retrospective study. *Eur J Med Res* 2012;17:29
- 40 Koenig CW, Duda SH, Truebenbach J, et al. MR-guided biopsy of musculoskeletal lesions in a low-field system. *J Magn Reson Imaging* 2001;13(5):761–768
- 41 Purandare NC, Kulkarni AV, Kulkarni SS, et al. 18F-FDG PET/CT-directed biopsy: does it offer incremental benefit? *Nucl Med Commun* 2013;34(3):203–210
- 42 De Marchi A, Brach del Prever EM, Linari A, et al. Accuracy of core-needle biopsy after contrast-enhanced ultrasound in soft-tissue tumours. *Eur Radiol* 2010;20(11):2740–2748
- 43 Noebauer-Huhmann IM, Amann G, Krssak M, et al. Use of diagnostic dynamic contrast-enhanced (DCE)-MRI for targeting of soft tissue tumour biopsies at 3T: preliminary results. *Eur Radiol* 2015; 25(7):2041–2048
- 44 Yang YJ, Damron TA. Comparison of needle core biopsy and fine-needle aspiration for diagnostic accuracy in musculoskeletal lesions. *Arch Pathol Lab Med* 2004;128(7):759–764
- 45 American Joint Committee on Cancer. How are soft tissue sarcomas staged? Available from: <http://www.cancer.org/cancer/sarcoma-adultsofttissuecancer/detailedguide/sarcoma-adult-soft-tissue-cancer-staging>. Accessed December 11, 2015
- 46 Vincenzi B, Frezza AM, Schiavon G, et al. Bone metastases in soft tissue sarcoma: a survey of natural history, prognostic value and treatment options. *Clin Sarcoma Res* 2013;3(1):6
- 47 Yoshikawa H, Myoui A, Ochi T, et al. Bone metastases from soft tissue sarcomas. *Semin Musculoskelet Radiol* 1999;3(2):183–190
- 48 Sood S, Baheti AD, Shinagare AB, et al. Imaging features of primary and metastatic alveolar soft part sarcoma: single institute experience in 25 patients. *Br J Radiol* 2014; 87(1036):20130719
- 49 Gordon RW, Tirumani SH, Kurra V, et al. MRI, MDCT features, and clinical outcome of extremity leiomyosarcomas: experience in 47 patients. *Skeletal Radiol* 2014;43(5):615–622
- 50 Mazon JJ, Suit HD. Lymph nodes as sites of metastases from sarcomas of soft tissue. *Cancer* 1987;60(8):1800–1808
- 51 Sherman KL, Kinnier CV, Farina DA, et al. Examination of national lymph node evaluation practices for adult extremity soft tissue sarcoma. *J Surg Oncol* 2014;110(6):682–688
- 52 Haniball J, Sumathi VP, Kindblom LG, et al. Prognostic factors and metastatic patterns in primary myxoid/round-cell liposarcoma. *Sarcoma* 2011;2011:538085
- 53 Chase DR, Enzinger FM. Epithelioid sarcoma. Diagnosis, prognostic indicators, and treatment. *Am J Surg Pathol* 1985;9(4): 241–263
- 54 Meis-Kindblom JM, Kindblom LG. Angiosarcoma of soft tissue: a study of 80 cases. *Am J Surg Pathol* 1998;22(6):683–697
- 55 Mankin HJ, Casas-Ganem J, Kim JJ, Gebhardt MC, Hornicek FJ, Zeegen EN. Leiomyosarcoma of somatic soft tissues. *Clin Orthop Relat Res* 2004;421:225–231
- 56 Lieberman PH, Brennan MF, Kimmel M, Erlandson RA, Garin-Chesa P, Flehinger BY. Alveolar soft-part sarcoma. A clinico-pathologic study of half a century. *Cancer* 1989;63(1):1–13
- 57 Portera CA Jr, Ho V, Patel SR, et al. Alveolar soft part sarcoma: clinical course and patterns of metastasis in 70 patients treated at a single institution. *Cancer* 2001;91(3):585–591
- 58 Espat NJ, Bilsky M, Lewis JJ, Leung D, Brennan MF. Soft tissue sarcoma brain metastases. Prevalence in a cohort of 3829 patients. *Cancer* 2002;94(10):2706–2711
- 59 Roberge D, Vakilian S, Alabed YZ, Turcotte RE, Freeman CR, Hicksen M. FDG PET/CT in initial staging of adult soft-tissue sarcoma. *Sarcoma* 2012;2012:960194
- 60 National Guideline Clearinghouse. ACR Appropriateness Criteria® follow-up of malignant or aggressive musculoskeletal tumors. Available at: <https://acsearch.acr.org/docs/69428/Narrative/>. Accessed December 7, 2015
- 61 Grobmyer SR, Brennan MF. Predictive variables detailing the recurrence rate of soft tissue sarcomas. *Curr Opin Oncol* 2003; 15(4):319–326
- 62 Cancer Research UK. Follow up for soft tissue sarcoma. Available from: <http://www.cancerresearchuk.org/about-cancer/type/sarcoma/treatment/follow-up-for-soft-tissue-sarcoma>. Accessed December 11, 2015
- 63 AMSOS. Austrian Musculoskeletal Oncology Society. Available at: <http://www.amsos.at>. Accessed December 7, 2015
- 64 ESMO/European Sarcoma Network Working Group. Soft tissue and visceral sarcomas: ESMO Clinical Practice Guidelines for diagnosis, treatment and follow-up. *Ann Oncol* 2014;25(Suppl 3): iii102–iii112
- 65 Tagliafico A, Truini M, Spina B, et al. Follow-up of recurrences of limb soft tissue sarcomas in patients with localized disease: performance of ultrasound. *Eur Radiol* 2015;25(9): 2764–2770
- 66 Diana Afonso P, Kosinski AS, Spritzer CE. Following unenhanced MRI assessment for local recurrence after surgical resection of mesenchymal soft tissue tumors, do additional gadolinium-enhanced images change reader confidence or diagnosis? *Eur J Radiol* 2013;82(5):806–813
- 67 Vanel D, Shapeero LG, Tardivon A, Western A, Guinebretière JM. Dynamic contrast-enhanced MRI with subtraction of aggressive soft tissue tumors after resection. *Skeletal Radiol* 1998;27(9): 505–510
- 68 Del Grande F, Subhawong T, Weber K, Aro M, Muger C, Fayad LM. Detection of soft-tissue sarcoma recurrence: added value of functional MR imaging techniques at 3.0 T. *Radiology* 2014; 271(2):499–511