Soft tissue masses
Focus on fat-containing tumors
(Lipoma and Liposarcoma)

Elizabeth Stover,
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Gillian Lieberman, MD
Index patient: History

- 73 year old man
- Slowly enlarging mass in right thigh over 14 years
- Recently began experiencing pain and restriction of activities
Index patient: Thigh mass on MRI

Large mass in R thigh
24 x 16 x 13 cm

Location:
within adductor muscles

2 components:
solid and heterogeneous

Areas hyperintense on T1, consistent with fat

MRI coronal T1

Images from BIDMC PACS
Differential diagnosis of a soft tissue mass of the extremity

Soft tissue masses can be neoplastic (benign or malignant), infectious, inflammatory, vascular, fibrotic, or other.

Soft tissue masses can be derived from any tissue component of the extremity:
- Skeletal muscle
- Fat
- Fibrous tissue
- Blood vessels
- Cartilage
- Bone
- Peripheral nerve

Fat has distinctive characteristics on MRI and CT that allow recognition of some fat-containing masses on radiologic imaging.
Index patient: Mass on MRI

Fat is bright (hyperintense) on T1, dark (hypointense) or bright on T2 (depending on the specific sequence), and shows suppression on fat-suppressed images.
Index patient: Mass on MRI

Fat is bright (hyperintense) on T1, dark (hypointense) or bright on T2 (depending on the specific sequence), and shows suppression on fat-suppressed images.

MRI axial T1
Fat suppressed

Focal areas dark on fat suppression

Images from BIDMC PACS
Index patient: Mass on CT

Fat has Hounsfield units = -50 to -150
Usually appears dark (low attenuation);
compare to subcutaneous fat

CT without contrast

Fat density
Calcifications

Features consistent with a potentially malignant fat-containing lesion

Images from BIDMC PACS
Index patient: Diagnosis

Radiologic diagnosis:
Liposarcoma

Histologic diagnosis at excision:
Well differentiated (low grade) liposarcoma
with dedifferentiated (high grade) component

These two components accounted for the
dual appearance of the mass on the first MRI image.
Sarcoma: Overview

A sarcoma is a malignant tumor derived from mesenchyme. Sarcomas are classified based on the tissue they resemble histologically:

- Smooth muscle
- Skeletal muscle
- Fat
- Fibrous tissue
- Blood vessel
- Cartilage
- Bone*
- Peripheral nerve**

Each of these tissue types has both benign and malignant lesions.

*Soft tissue sarcomas* include all of these tissues except for bone

**Peripheral nerve tumors are not mesenchymal, but have similar behavior
## Soft tissue tumors

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Benign lesions</th>
<th>Malignant lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smooth muscle</td>
<td>Leiomyoma</td>
<td>Leiomyosarcoma</td>
</tr>
<tr>
<td>Striated muscle</td>
<td>Rhabdomyoma</td>
<td>Rhabdomyosarcoma</td>
</tr>
<tr>
<td>Fat</td>
<td>Lipoma</td>
<td>Liposarcoma</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td></td>
</tr>
<tr>
<td>Fibrous tissue</td>
<td>Fibroma</td>
<td>Fibrosarcoma</td>
</tr>
<tr>
<td></td>
<td>Elastofibroma</td>
<td>Fibromatosis (desmoid)</td>
</tr>
<tr>
<td></td>
<td>Superficial fibromatosis</td>
<td>DFSP</td>
</tr>
<tr>
<td></td>
<td>Fibrous histiocytoma</td>
<td>Malignant fibrous histiocytoma (undiff. pleomorphic sarcoma)</td>
</tr>
<tr>
<td>Cartilage/joint</td>
<td>Nodular tenosynovitis</td>
<td>Synovial sarcoma</td>
</tr>
</tbody>
</table>
# Soft tissue tumors

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<tr>
<th>Tissue</th>
<th>Benign lesions</th>
<th>Malignant lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood vessel</td>
<td>Hemangioma</td>
<td>Hemangiosarcoma</td>
</tr>
<tr>
<td></td>
<td>Lymphangioma</td>
<td>Lymphangiosarcoma</td>
</tr>
<tr>
<td></td>
<td>Glomus tumor</td>
<td>Kaposi’s sarcoma</td>
</tr>
<tr>
<td></td>
<td>Hemangiopericytoma*</td>
<td>Hemangioendothelioma</td>
</tr>
<tr>
<td>Peripheral nerve</td>
<td>Neurofibroma</td>
<td>Malignant peripheral nerve sheath tumor</td>
</tr>
<tr>
<td></td>
<td>Schwannoma</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Neuroma</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>Myxoma</td>
<td>Malignant mesenchymoma</td>
</tr>
<tr>
<td></td>
<td>Granular cell</td>
<td>Alveolar soft-part sarcoma</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Epithelioid sarcoma</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clear cell sarcoma</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Desmoplastic small cell tumor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gastrointestinal stromal tumor</td>
</tr>
</tbody>
</table>

*Can be either benign or malignant

ACS guide to soft tissue sarcoma, www.cancer.org
Up to Date: Soft tissue sarcoma
# Soft tissue tumors: benign to malignant

<table>
<thead>
<tr>
<th>WHO category</th>
<th>Locally destructive,</th>
<th>Local recurrence</th>
<th>Metastasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benign</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Intermediate (locally aggressive)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Intermediate (rarely metastasizing)</td>
<td>Yes</td>
<td>Rare</td>
<td></td>
</tr>
<tr>
<td>Malignant</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Common benign soft tissue tumors

- Lipoma (fat)
- Leiomyoma (smooth muscle)
  - Uterine leiomyomas
- Hemangioma (blood vessels)
Common soft tissue sarcomas

- Liposarcoma (fat)
- Leiomyosarcoma (smooth muscle)
- Undifferentiated pleomorphic sarcoma (unknown) (Malignant fibrous histiocytoma)
- Pediatric: Rhabdomyosarcoma (skeletal muscle)
Body sites of soft tissue sarcomas

- Lower extremity 46%
- Upper extremity 13%
- Torso 18%
- Retroperitoneum 13%
- Head and neck 9%

Different tumor types have different anatomic distributions. Liposarcoma is common in the extremity (thigh), retroperitoneum, head and neck.

The location does not always correspond to the amount of a tissue at a site. Liposarcoma is uncommon in fat of the abdomen, but may arise deep in muscle.
Soft tissue sarcomas: Statistics in USA

• ~ 10,000 will be diagnosed with and ~3,500 will die of sarcoma in 2008

• Sarcomas represent <1% of all cancers (~7% in children)

• Some tumors preferentially affect children; some affect adults.

• Overall 5 year relative survival rate: 66.7%
  By stage: 84.2% localized; 61.5% regional; 17.1% distant

Fat-containing soft tissue masses

• Some of the most common benign and malignant soft tissue tumors derive from fat.

• A variety of benign fatty (lipomatous) lesions can occur in soft tissues.

• Liposarcoma is a rare, malignant fatty tumor.
Benign lipomatous lesions of soft tissue

• Lipoma
• Lipomatosis – overgrowth of mature fat in soft tissue
• Lipomatosis of nerve
• Lipoblastoma – tumor of immature fat in children
• Spindle cell lipoma/pleomorphic lipoma
• Hibernoma
• Angiolipoma
• Myolipoma
• Chondroid lipoma
Malignant lipomatous lesions of soft tissue

• Liposarcoma
  – Well-differentiated – low grade
  – Dedifferentiated
  – Myxoid
  – Pleomorphic
  – Mixed

Each of these subtypes has different histology, behavior, and prognosis.

Note: Liposarcomas do **not** arise from lipomas.

Peterson et al, Skeletal Radiology 2003
Menu of imaging modalities for soft tissue lesions

- Plain film
- MRI
- CT
- PET and PET/CT
- Ultrasound, other

A multimodality approach is often required.
Plain film

• Advantages:
  – Initial study to assess bone vs. soft tissue lesion
  – Imaging of bone involvement and calcifications

• Disadvantages:
  – Poor evaluation of soft tissue
MRI

• Advantages:
  – Best modality for detailed imaging of soft tissue masses: excellent soft tissue contrast
  – Useful to assess extent of lesion for staging and surgical planning
  – Gadolinium can show tumor enhancement
  – Use for patients who cannot have CT contrast

• Disadvantages:
  – Some patients have contraindications to MRI
CT

• Advantages:
  – Good for evaluating bone involvement
  – Good for abdominal and retroperitoneal sarcomas
  – Best for evaluating distant (lung) metastases
    • The majority of sarcoma metastases are to the lung – rarely lymph nodes
  – May be used to guide biopsies
  – Can show calcifications
  – Use for patients with contraindications to MRI

• Disadvantages:
  – Not as detailed as MRI for soft tissue
  – Radiation exposure

Elizabeth Stover, HMS IV
Gillian Lieberman, MD
Kransdorf and Murphey, Am J Roentgenology 2000
Knapp et al, Cancer Control 2005
PET and PET/CT

• Advantages:
  – Useful for imaging tumor metabolic activity
  – May be used for biopsy guidance, staging, and assessing response to treatment or presence of residual disease

• Disadvantages:
  – FDG avidity not specific to tumors
  – Utility in soft tissue sarcoma still under study
Other modalities

- Ultrasound
  - May help distinguish cystic vs. solid masses
  - May be used to guide biopsies

- Magnetic resonance angiography
  - Can assess vascular supply of tumors
Lipoma

• Common: ~50% of all soft tissue tumors
• Upper back, neck, extremities, abdomen
• Frequently superficial location, rarely deep
• Palpable, mobile, doughy mass
• Usually asymptomatic
• Composed of mature, normal adipocytes surrounded by thin capsule
• Excision not required unless large or symptomatic. No risk of becoming malignant.
Imaging features of lipoma

- Homogenous circumscribed mass
- CT: Hounsfield units and appearance consistent with fat
- MRI: Isointense to fat in all sequences
- No enhancement (except capsule)
- MRI is very specific for diagnosis of lipoma
Companion patient 1: History

51 year old man presenting with mass in left forearm
Companion patient 1: Mass on MRI

Well-circumscribed lesion

Contained within supinator muscle

Bright on T1 = Fat

MRI sagittal T1

Homogeneous appearance

No nodularity, thick septations, or edema

Images from BIDMC PACS
Companion patient 1: Mass on MRI

MRI axial T1

Fat signal (bright on T1) becomes dark on fat suppression

MRI axial T1
Fat suppressed

Images from BIDMC PACS
Companion patient 1: Mass on MRI

MRI axial T1
Fat suppressed
Post-Gadolinium

Radiologic diagnosis: Lipoma

Mass does not enhance with contrast
Companion patient 2: History

57 year old woman presenting with enlarging posterior chest mass
Companion patient 2: Chest X-ray

Upright Chest X-ray

Note difficulty of viewing soft tissue lesions on plain film.

Can you find a soft tissue mass?
Companion patient 2: Chest X-ray

Indeterminate soft tissue mass
Companion patient 2: Mass on MRI

- MRI coronal T1 in/out of phase
- MRI axial T1 Fat suppressed

Images from BIDMC PACS
Companion patient 2: Mass on MRI

MRI axial T1 in/out of phase

Radiologic diagnosis: Lipoma

Images from BIDMC PACS
Liposarcoma

- Malignant tumor of adipose tissue
- Second most common soft tissue sarcoma
- Less frequent than lipomas by 100:1
- Usually presents as gradually enlarging, painless mass
- Majority occur in the extremities (lower>upper)
- Retroperitoneal tumors are often detected later and have a worse prognosis
- Frequent local recurrence; metastasis in ~50%
Imaging features of Liposarcoma

• CT and MRI appearance depends on histologic subtype and amount of fat
• More differentiated lesions resemble fat
• Higher grade lesions have little to no fat
• Often heterogeneous appearance
• May have thick septa and nodular areas
• May show compression of nearby structures
• May show enhancement with contrast
• May show calcifications

Peterson et al, Skeletal Radiology 2003
Companion patient 3: History

76 year old man
presenting with new mass
in left posterior chest
Companion patient 3: Mass on CT

CT without contrast

Paraspinal mass with density similar to fat

Mass extends ~18 cm in length

Images from BIDMC PACS
Companion patient 3: Mass on MRI

MRI axial T1 with gadolinium

Signal similar to fat

MRI axial T2

Multiloculated

Images from BIDMC PACS
Companion patient 3: Mass on MRI

MRI sagittal T1

MRI coronal T2

Radiologic diagnosis: Lipsarcoma

Large, heterogeneous, nodular mass
Companion patient 4: History

83 year old woman presenting with right thigh mass
Companion patient 4: Mass on CT

CT without contrast
Density of most of tumor is similar to subcutaneous fat
Heterogeneity within mass

Radiologic diagnosis:
Concerning for lipsarcoma

Images from BIDMC PACS
# Imaging features distinguishing lipoma vs. liposarcoma

<table>
<thead>
<tr>
<th>Lipoma</th>
<th>Liposarcoma</th>
</tr>
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<tbody>
<tr>
<td>Homogeneous</td>
<td>Heterogeneous</td>
</tr>
<tr>
<td>Well-circumscribed</td>
<td>Expansive, may be invasive</td>
</tr>
<tr>
<td>Round</td>
<td>Often irregular, nodular</td>
</tr>
<tr>
<td>Entire lesion resembles fat</td>
<td>Some/all non-adipose tissue</td>
</tr>
<tr>
<td>Smaller</td>
<td>Larger – can grow very large</td>
</tr>
<tr>
<td>Occasional thin septa</td>
<td>May have thick septa</td>
</tr>
<tr>
<td>Non-enhancing septa</td>
<td>May show enhancement</td>
</tr>
<tr>
<td>More often superficial location</td>
<td>More often deep location</td>
</tr>
<tr>
<td>Variable age</td>
<td>More common in older age</td>
</tr>
</tbody>
</table>

Peterson et al, Skeletal Radiology 2003  
Kransdorf et al, Radiology 2002
Applications of radiology in management of soft tissue masses

- Diagnosis
- Biopsy guidance
- Pre-surgical planning
- Post-surgical follow-up
- Radiation therapy
Imaging in diagnosis

• Imaging can be used to provide a radiologic diagnosis.

• In the case of benign lesions such as lipoma, it may help patients avoid biopsy.

• In the case of malignant or indeterminate lesions, imaging establishes a differential diagnosis and guides management.
Companion patient 5: History

56 year old woman presenting with left thigh mass
Companion patient 5: Mass on plain film

Plain film
Lower extremity
Lateral view

Soft tissue mass in left thigh

Images from BIDMC PACS
Companion patient 5: Mass on MRI

Heterogeneous mass
Nodular, with thick septa
Bright on T1, similar signal intensity to fat

MRI axial T1

Radiologic diagnosis: suspicious for liposarcoma
Pathologic diagnosis at excision: Liposarcoma
Companion patient 6: History

58 year old man
presenting with
scrotal mass,
clinically thought to
be an inguinal hernia
Companion patient 6: Mass on CT

Pelvic CT with contrast

Scrotal mass with typical location of inguinal hernia
Fat density on CT

Radiologic diagnosis:
Fat-containing inguinal hernia

Images from BIDMC PACS
Companion patient 6: Diagnosis

However, when the patient underwent attempted inguinal hernia repair, a scrotal mass was found.

Pathologic diagnosis post-surgery: **Liposarcoma**

This case illustrates that radiologic imaging is not always sufficient for diagnosis of soft tissue masses!

Radiologic imaging can usually suggest differential diagnoses, but only in a fraction of cases can provide a definitive diagnosis. Radiologic imaging cannot always reliably distinguish benign and malignant masses, and cannot always specifically identify different types of soft tissue masses.

BIDMC patient records
Kransdorf and Murphey, Am. J. Roentgenology 2000
Imaging in biopsy guidance

- CT may be used to select and guide an appropriate location for biopsy.

- Image-guided biopsy may be especially useful in heterogeneous masses.

- Core needle biopsy is the preferred approach. Biopsies must be carefully planned in conjunction with surgeons.
Companion patient 7: History

46 year old woman presenting with right thigh mass
Companion patient 7: CT guided biopsy

CT biopsy planning

CT guided core needle biopsy

Pathologic diagnosis: Myxoid liposarcoma

Images from BIDMC PACS
Imaging in surgical planning and follow-up

- Imaging is used for pre-surgical planning to assess the extent of the lesion and the involvement of other structures (vessels, nerves, muscles, bone).

- Follow-up imaging after surgery evaluates healing and monitors for disease recurrence.
Companion patient 8: History

41 year old woman presenting with palpable mass in buttocks
Companion patient 8: Mass on MRI

MRI coronal T1

MRI sagittal T1
Fat suppressed

Note: This mass does not resemble fat on MRI as much as the previous images of liposarcoma since this mass is the myxoid subtype with different histology.
Companion patient 8: Mass on MRI pre- and post-surgery

**Pre-surgery**
MRI axial T1
Fat suppressed

**Post-surgery**
MRI axial T1

Images from BIDMC PACS

Pathologic diagnosis: Myxoid liposarcoma

Mass

Area of resection; No visible residual mass
Treatment of liposarcoma

- Surgical management is the mainstay of therapy.

- Pre-operative or post-operative radiation therapy may also be used. Radiation therapy may be palliative in non-surgical candidates.

- Chemotherapy currently has a minor role but is undergoing clinical trials.

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Gillian Lieberman, MD

Take home points I

- Soft tissue sarcomas are tumors of mesenchymal tissues.
- Most soft tissue masses are benign. Soft tissue sarcomas are very rare.
- Lipomas are the most common benign soft tissue tumor. Typical presentation of lipoma is a small, mobile, soft, painless mass. Lipomas do not have malignant potential.
- Liposarcomas are rare malignant tumors of adipose tissue. Typical presentation of liposarcoma is a slowly enlarging, painless mass. Some liposarcomas may grow very large.
Take home points II

• Radiographic evaluation should include MRI as the best modality to evaluate soft tissues. CT is an alternative.

• Benign lipomas are well-circumscribed, homogeneous, fatty masses. If classic in appearance, they can be definitively diagnosed on imaging (MRI).

• Liposarcomas have several subtypes. They may appear irregular, nodular, loculated, or enhancing, and they often (but not always) contain fat.

• Imaging in soft tissue masses can be used for diagnosis, biopsy, surgical planning, and follow-up.
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