Benign soft tissue lesions with specific features: a pictorial review

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Learning objectives

To review the key magnetic resonance imaging features of various benign soft tissue tumors and tumor-like conditions, including lipoma, hemangioma, pigmented villonodular synovitis, giant cell tumor of tendon sheath, peripheral nerve sheath tumor, Morton neuroma, plantar fibromatosis, elastofibroma, desmoid, myxoma and synovial cyst.

Background

Soft tissue lesions are frequently found by radiologists in their clinical practice and include a broad range of diagnosis.

The primary goal for the imaging referral is to confirm the presence of a mass and to assess its extent in preparation for possible treatment.

Many times imaging alone is not enough to make a confident diagnosis. However, in an important subset of cases, characteristic imaging features, in conjunction with clinical history and location, can help to narrow the differential diagnosis.

MR imaging is the preferred modality for evaluating soft tissue lesions because it provides a superior soft tissue contrast, allows multiplanar image acquisition and obviates the need for iodinated contrast agents.

Some of the criteria used for predicting a benign etiology of a lesion include smooth, well-defined margins, small size, and homogeneous signal intensity, especially on T2-weighted images.

Imaging findings OR Procedure details

Lipoma

Lipoma is the most common soft-tissue tumor.

It is a benign mesenchymal neoplasm whose composition closely resembles normal fat.

The lesions may have a superficial location (Fig. 1 on page 12) or may arise deeper, within the muscles (Fig. 2 on page 12).
On **MR imaging** they are usually well-defined, lobular masses that show homogeneous signal intensity which parallels subcutaneous fat on all pulse sequences.

Thin, curvilinear septations often course through the fatty mass and may show mild enhancement after intravenous gadolinium administration.

The most important differential diagnosis for a benign lipoma is a well-differentiated liposarcoma.

Features which favor a diagnosis of well-differentiated liposarcoma are:

- great size lesions (lesions greater than 10cm);
- thick septae (> 2mm);
- nodular nonadipose areas;
- less than 75% fat in composition.

**Hemangioma**

Hemangioma, which is a localized vascular malformation, is the most frequently encountered vascular soft-tissue abnormality, comprising 7% of all benign soft-tissue tumors.

Hemangiomas usually have a superficial location but may also involve deep structures such as skeletal muscle.

The clinical manifestations of hemangiomas include bluish skin discoloration. Occasionally, pain may occur following exercise owing to shunting of blood flow away from the surrounding tissue into the lesion. Size fluctuation is common.

**MR imaging** plays a major role in diagnosing, characterizing and determining the extent of lesions. MR imaging findings are frequently diagnostic.

On T1-weighted images, the signal intensity of these lesions is usually intermediate between that of muscle and fat. There may be high-signal areas representing intralesional fat or hemorrhage (Fig. 3 on page 13a and Fig. 4 on page 14b).

On T2-weighted images, hemangioma appears as a high-signal-intensity lobulated structure, resembling a bunch of grapes (Fig. 3 on page 13b and Fig. 4 on page 14a). This appearance is due to cavernous or cystic vascular spaces containing stagnant blood. Fluid-fluid levels can also be noted within these spaces.
Punctate or reticular low-signal-intensity areas may be present. They represent fibrous tissue, fast flow circulation within a vessel or foci of calcification (Fig. 4 on page 14).

Phleboliths, which are focal dystrophic mineralizations in a thrombus, appear as circular low-signal-intensity areas on MR imaging. In these cases conventional radiography and computed tomography are helpful in making diagnosis.

Changes in the adjacent bone, including periosteal reaction, cortical and medullary changes, and overgrowth, can also be seen.

**Pigmented villonodular synovitis**

Pigmented villonodular synovitis is a member of a group of benign proliferative lesion of the synovium of the joint, bursa and tendon sheath that are usually divided according to the site of origin (intraarticular or extraarticular) and pattern of growth (localized or diffuse).

It typically affects 20-50 years old patients, with equal frequency in men and women.

The clinical manifestations are slowly progressive pain, swelling and decreased range of motion.

Pigmented villonodular synovitis is usually a monoarticular process of large joints.

In decreasing order of frequency it involves the knee (80% of cases), the hip, ankle, shoulder and elbow.

**MR imaging** reveals characteristics features of a heterogeneous, diffuse, synovially based, plaquelike thickening, often associated with nodularity.

On T1-weighted images the signal intensity of the synovial thickening is intermediate to low (Fig. 5 on page 15).

On T2-weighted images there is also predominance of low signal intensity, owing to the preferential shortening of T2 relaxation time caused by hemosiderin (Fig. 6 on page 16).

This effect is accentuated on gradient-echo images, which demonstrate an enlargement of the low-signal-intensity areas ("blooming") that is caused by magnetic susceptibility artifact (Fig. 7 on page 17).

The "blooming" effect is nearly pathognomonic of pigmented villonodular synovitis.
The degree of enhancement can vary but marked enhancement of the synovium is common.

Associated joint effusion is frequent, particularly in large joints. The effusion is generally surrounded by thickened synovial rinds of hemosiderin-laden tissue.

Additional MR findings of PVNS include bone erosions or subchondral cysts, septations, edema of adjacent bone or soft tissue and articular cartilaginous defect.

**Giant cell tumor of the tendon sheath**

Giant cell tumor of tendon sheath is a nodular form of pigmented villonodular synovitis, the histological appearance of which is identical to that of its intraarticular counterpart.

These tumors are intimately associated with the tendon sheath, and the most common location is the hand, particularly in the volar aspect of the first three fingers (80% of cases).

It usually presents as a palpable, often painless soft-tissue mass that may grow slowly.

Most patients present between the third and fifth decades of life and women are affected slightly more often than men.

**MR imaging** typically shows a well-defined mass adjacent to or enveloping a tendon.

These lesions are typically isointense or hypointense to muscle on T1- and T2-weighted images owing to abundant collagen and hemosiderin (Fig. 8 on page 18).

Some lesions may not contain enough hemosiderin to be T1- and T2- hypointense or to cause a blooming artifact on gradient-echo images.

Homogeneous enhancement is usually seen after contrast administration.

**Peripheral nerve sheath tumors**

Benign peripheral nerve sheath tumors are divided into two major categories: neurofibroma and schwannoma.

**Neurofibromas** represent about 5% of benign soft-tissue neoplasms. They most frequently affect 20-30 years old patients.
Lesions can be either superficial or deep, involving small cutaneous nerves or large major nerve trunks.

Superficial lesions are usually small and painless, whereas deeper neurofibromas are associated with neurologic symptoms.

Most lesions are solitary, but up to 10% are associated with neurofibromatosis. There are two forms of neurofibromatosis - type 1, which is commonly associated with peripheral nerve sheath tumors; and type 2 which primarily affects the central nervous system. Neurofibromas in type 1 neurofibromatosis can be divided into three types: localized, plexiform and diffuse.

**Schwannomas** represent approximately 5% of benign soft-tissue neoplasms.

20-40 years old patients are most frequently affected.

Most lesions are solitary and present as slowly growing painless masses.

Patients are usually asymptomatic unless the mass is large enough to compress the adjacent nerve.

Neurofibromas and schwannomas have similar features on **MR imaging** - they appear as a well-defined smooth - bordered fusiform mass that is aligned along the nerve.

They are low-signal intensity lesions on T1-weighted sequences (Fig. 9 on page 19a) and high-signal intensity lesions on T2-weighted sequences (Fig. 9 on page 19b), with variable contrast enhancement (Fig. 10 on page 20).

The signal on T2-weighted images can be homogeneously hyperintense or show a central hypointense region ("target sign") (Fig. 11 on page 21). The target sign is more frequently found in neurofibromas.

As the tumor enlarges, a surrounding rim of normal fat is maintained - this is the "split fat sign".

Occasionally a schwannoma can be differentiated from a neurofibroma by its location relative to the nerve - the schwannoma can be eccentric to and separable from the nerve, whereas the neurofibroma is intrinsic to it. Heterogeneous appearance with degeneration and cystic cavitation are also much more common in schwannomas than in neurofibromas.

In **type 1 neurofibromatosis** localized neurofibromas are identical to solitary lesions but they tend to be larger, multiple, and, more commonly, deep in location. Plexiform neurofibromas are pathognomonic for type 1 neurofibromatosis, usually involving a
long segment of a major nerve trunk and extending into the nerve branches. Diffuse neurofibromas most commonly occur in children and young adults and are typically localized to the subcutaneous tissues (Fig. 12 on page 22).

**Morton neuroma**

Morton neuroma is a nonneoplastic lesion that consists of perineural fibrosis involving and entrapping a plantar digital nerve.

It is more frequent in women (80% of the cases).

Most lesions occur in the second or third intermetatarsal spaces at (or just distal to) the level of the transverse metatarsal ligament and plantar to it.

The clinical manifestation is forefoot pain, which is exacerbated during walking and is typically described as a burning or electric sensation.

On MR imaging, Morton neuroma typically appears as a well-defined, teardrop-shaped mass.

On T1-weighted images it is isointense to muscle (Fig. 13 on page 23 a and c). On T2-weighted images the lesion is less conspicuous, making differentiation from surrounding muscle and fat difficult. It is typically hypointense to fat, with low signal intensity attributed to fibrotic tissue (Fig. 13 on page 23b).

After intravenous gadolinium administration it shows variable enhancement.

In some cases Morton neuroma is associated with fluid in the intermetatarsal bursa.

**Plantar fibromatosis**

Plantar fibromatosis (Ledderhose disease) is a common form of superficial fibromatosis that arises in the proximal or central portion of the plantar aponeurosis of the foot.

The lesion occurs most frequently between the ages of 30 and 50 and men are affected twice as commonly as women.

Bilateral involvement is seen in 20-50% of patients.

Concomitant palmar disease (Dupuytren disease) occurs in 10-65% of patients.
Patients typically present with a soft tissue mass composed of one or more firm, subcutaneous nodules on the medial aspect of the sole of the foot. Nodules are multiple in 33% of cases. In a majority of cases, patients are asymptomatic. Less commonly, they may experience pain, which is usually associated with prolonged standing or walking. Large lesions may rarely affect or invade adjacent muscles or neurovascular structures.

The typical MR imaging appearance of plantar fibromatosis is of a well or ill-defined superficial soft-tissue mass occurring along the deep plantar aponeurosis. The medial aspect of the plantar aponeurosis is involved more frequently (78% of the cases) than the lateral portion.

The lesions typically have heterogeneous signal intensity equal to or less than that of skeletal muscle on both T1- and T2-weighted images (Fig. 14 on page 24).

Less commonly (22% of the cases), they may have high signal intensity on T2-weighted images, reflecting a more cellular composition with relatively less collagen (Fig. 15 on page 25).

The enhancement after gadolinium administration is variable, with marked enhancement seen in approximately 50% of lesions.

**Elastofibroma**

Elastofibroma is a slow-growing lesion that is most commonly encountered in the connective tissue along the inferomedial border of the scapula, deep to the latissimus dorsi and rhomboid major muscles.

It is more frequent in patients older than 55 years.

Subescapular elastofibromas are bilateral in about 25% of cases.

Extrascapular sites are much less common and include regions of the greater trochanter and the olecranon.

Clinical symptoms include stiffness (25% of patients) and pain (10% of patients). Symptomatic lesions are usually greater than 5 cm.

On MR imaging, elastofibromas are typically ill-defined, heterogeneous soft-tissue masses with signal intensity similar to that of skeletal muscle. Intermixed linear or curvilinear streaks of fat signal intensity are frequently present (Fig. 16 on page 26). Contrast enhancement after gadolinium administration is usually heterogeneous.
**Desmoid**

Desmoid tumors, also called deep or aggressive fibromatosis, are uncommon mesenchymal neoplasms.

Its incidence in the general population is 2 to 4 cases per million per year, with a peak incidence in the third and fourth decades, and a slight female preponderance.

They are locally aggressive without potential for distant metastases. Local recurrence and adjacent organ involvement are the main complications of the disease.

The risk factors for desmoids include familiar adenomatous polyposis (FAP), Gardner syndrome, trauma, prior surgery, pregnancy and oral contraceptive use.

Desmoids tumors can be intraabdominal, within the abdominal wall or extraabdominal.

Desmoids associated with FAP and Gardner syndrome are typically intraabdominal. Desmoids associated with pregnancy tend to arise within the rectus abdominis or internal oblique muscles.

Extraabdominal desmoids are intimately associated with muscle and fascia and the most common locations are the shoulder and upper extremity (33%), gluteal region and lower extremity (30%), chest wall or back (17%) and head and neck (10%).

Multiple lesions are seen in 15% of cases.

**MR imaging** is the best radiologic modality to evaluate desmoids tumors.

Extraabdominal desmoids tumors are usually centered in an intermuscular location, with a rim of fat surrounding them ("split fat sign"), although invasion of adjacent muscle is frequent.

Linear extension along fascial planes (the "fascia tail sign") is also a common manifestation of these lesions.

The lesions may be well defined or have irregular infiltrative margins.

MR imaging pattern of desmoids tumors is variable. The most common appearance is a heterogeneous lesion, with intermediate signal intensity seen with standard pulse sequences. The heterogeneous signal intensity is due to the varying proportions of cellular tissue, myxoid tissue and collagen. Prominent low-signal-intensity bands are often present with all pulse sequences and represent areas of collagen (Fig. 17 on page 27).
Over time, they become more hypointense because of increasing collagen deposition and decreasing cellularity whereas recurrent or actively growing desmoids tend to have a higher T2 signal, probably because of higher cellularity.

After administration of gadolinium contrast material, the lesions typically demonstrate moderate to marked enhancement.

**Myxoma**

Myxoma is a benign mesenchymal neoplasm composed of undifferentiated stellate cells in a myxoid stroma.

Myxomas most commonly involve the heart, but other areas may be affected including the muscle, subcutaneous and aponeurotic tissue, bone, genitourinary system and the skin.

**Intramuscular myxoma**

Intramuscular myxoma is of particular interest to radiologists because it may have imaging features similar to other myxoid lesions (including myxoid liposarcoma).

It is a lesion usually seen in adults, with a peak presentation between the fifth and seventh decades.

Patients typically present with a painless, palpable mass; less than 25% complain of pain or tenderness.

Myxoma is usually a solitary lesion, although multiple tumors are reported. Multiple myxomas are almost always associated with fibrous dysplasia of bone (Mazabraud syndrome).

The lesions are most common in the thigh (more than 50% occur in this location). Less common sites include the shoulder, buttocks and upper arm.

On **MR imaging** myxomas show low to intermediate signal intensity on T1-weighted images (Fig. 18 on page 28 a and b) and markedly high signal intensity on T2-weighted images (Fig. 18 on page 28c).

Lesions are usually homogeneous or mildly heterogeneous and are well-defined in most cases.

A small rim of fat representing atrophied surrounding muscle, usually most prominent at the superior and inferior extent of the lesion, can be seen.
On T2-weighted images, surrounding high signal intensity caused by leakage of the myxomatous tissue into adjacent muscle may be present.

Following contrast administration, myxomas show mild enhancement, in a diffuse or thick peripheral and septal pattern (Fig. 19 on page 29).

Cystic areas can be seen in 52% of myxomas.

**Subcutaneous and aponeurotic myxoma**

These lesions are more frequent in middle aged males.

Most common sites of involvement include the trunk, lower extremity and head / neck. Lesions in the eyelid region are associated with Carney complex (cutaneous and cardiac myxomas, spotty pigmentation and endocrine overreactivity).

Cutaneous myxomas have an increased likelihood of local recurrence (30-40%).

The imaging appearance is similar to their intramuscular counterparts.

**Synovial cyst**

Synovial cysts are synovial-lined justa-articular fluid collections. They are the consequence of either a herniation of the synovial membrane through the joint capsule or fluid distention of a paraarticular bursa. They may or may not communicate with the adjacent joint.

These lesions are often associated with osteoarthritis or inflammatory diseases.

Synovial cysts are more frequently seen about the knee, hip and to a lesser extent, shoulder, wrist, elbow, ankle, foot and hand.

They are usually asymptomatic although sometimes they may cause pain, swelling and nerve compression.

On **MR imaging** they appear as a juxtaarticular rounded or lobulated mass with well defined borders and homogeneous signal intensity, low on T1-weighted sequences and bright on T2-weighted-sequences (Fig. 20 on page 30 and Fig. 21 on page 31).

Occasionally they may be hyperintense on T1-weighted images, reflecting high proteinaceous content (infection, hemorrhage).
After intravenous contrast administration they show a thin even rim of enhancement with no internal enhancement (Fig. 22 on page 32).

Distinction between a synovial cyst and a ganglion is not usually possible by radiological means. Ganglia are lined by a capsule composed of fat spindle cells and do not have synovial lining. They commonly occur in the hand, wrist and feet.

**Images for this section:**

![Images of subcutaneous lipoma. Axial 3D T1-weighted MR images without (a) and with fat suppression (b) and T2-weighted MR images without (c) and with fat suppression (d) show an encapsulated oval lesion in the left anterior abdominal wall (arrows). It shows homogeneous signal intensity that parallels subcutaneous fat on all sequences. There is no evidence of thickened septae or soft tissue component.](image-url)
Fig. 2: Intramuscular lipoma. Coronal (a) and axial (b) T1- and axial fat-suppressed T2-weighted (c) MR images reveal a well-defined mass in the left adductor longus muscle that shows homogeneous signal intensity which parallels subcutaneous fat on all sequences. There is no evidence of thickened septae or soft tissue component.
Fig. 3: Intramuscular hemangioma. Axial T1-weighted (a) and fat-suppressed T2-weighted (b) MR images show a soft tissue mass in the medial muscular compartment of the left thigh. The lesion has intermediate signal intensity on T1-weighted image, with some fatty areas (white arrow). On T2-weighted image it demonstrates a high-signal-intensity, with lobulated margins and internal septae (black arrows).
Fig. 4: Intramuscular hemangioma. Coronal fat-suppressed T2-weighted MR image (a) reveals a high-signal-intensity soft tissue mass along the lateral muscular compartment of the left thigh. On fat-suppressed T1-weighted image (b) the lesion demonstrates an intermediate-signal-intensity. After intravenous contrast administration (c) it reveals diffuse enhancement. There are some punctated areas showing low signal intensity with all sequences which represent phleboliths (arrows).
Fig. 5: Pigmented villonodular synovitis. Sagital proton density-weighted MR images reveal nodular proliferative synovial tissue with low signal intensity in infrapatellar and posterior aspects of knee (arrows). There is also a large joint effusion (*).
Fig. 6: Pigmented villonodular synovitis (same patient as in figure 5). Sagittal fat-suppressed T2-weighted MR images reveal nodular proliferative synovial tissue with low to intermediate signal intensity in infrapatellar and posterior aspects of knee (arrows). There is also a large joint effusion (*).
Fig. 7: Pigmented villonodular synovitis (same patient as in figures 5 and 6). Coronal gradient-echo MR images of the right knee demonstrate diffuse hypointense synovial thickening, with the blooming artifact attributed to the presence of hemosiderin (arrows). There is also a large joint effusion surrounded by thickened synovial rinds of hemosiderin-laden tissue (*).
**Fig. 8:** Giant cell tumor of the tendon sheath. Sagital T1- and axial T1- and T2-weighted MR images of the right hand, show a soft tissue lesion adjacent to the flexor tendon of the fourth finger (*). The lesion is isointense to muscle on both T1- and T2-weighted sequences.
**Fig. 9:** Benign schwannoma. Coronal T1- (a) and sagital fat suppressed T2-weighted (b) MR images show a fusiform lesion in the posterior tibial nerve. It demonstrates low-signal-intensity on T1-weighted image and high signal intensity on T2-weighted image.
Fig. 10: Benign schwannoma. Sagital T1-weighted MR images before (a) and following (b) intravenous contrast administration reveal a lesion in the distal right arm, in the median nerve distribution. After contrast administration it shows heterogeneous enhancement.
**Fig. 11:** Neurofibroma. Axial (a) and coronal (b) fat-suppressed T2-weighted MR images show a lesion with peripheral high-signal intensity with a central hypointense region (*) - the "target sign".
Fig. 12: Neurofibromatosis. Coronal fat-suppressed T2-weighted MR images of a 30 years old female patient with type 1 neurofibromatosis reveal multiple intramuscular high-signal intensity lesions in the thighs, representing neurofibromas. Some of them show the "target sign".
Fig. 13: Morton neuroma. Axial T1- (a) and fat-suppressed T2-weighted (b) and sagittal T1-weighted (c) MR images show a soft tissue lesion in the interspace between the third and fourth metatarsals (arrows). On T1-weighted images the lesion is isointense to muscle. On T2-weighted image it has low signal intensity.
Fig. 14: Plantar fibromatosis. Sagital T1-weighted (a) and axial T1- (b) and T2-weighted (c) MR images show a soft tissue fusiform lesion along the deep plantar aponeurosis (arrows). The lesion has low-signal-intensity with all pulse sequences.
**Fig. 15:** Plantar fibromatosis. Sagittal T1- (a) and fat-suppressed T2-weighted (b) MR images show a soft tissue lesion along the deep plantar aponeurosis (arrows). The lesion is isointense to muscle on T1-weighted image and demonstrates areas of high-signal intensity on T2-weighted image, reflecting a more cellular composition with relatively less collagen.
Fig. 16: Elastofibroma. Axial T1- (a) and fat-suppressed T2-weighted (b) MR images show a ill-defined, heterogeneous soft-tissue masse along the inferomedial border of the right scapula. The lesion has signal intensity similar to that of skeletal muscle with intermixed linear streaks of fat signal intensity (arrows).
Fig. 17: Desmoid tumor. Axial T1- (a) and T2-weighted (b) MR images demonstrate a lesion in the left rectus abdominis muscle. The lesion is isointense to muscle on both sequences and has low-signal-intensity bands representing areas of collagen (arrows).
Fig. 18: Intramuscular myxoma. Sagital T1- (a) and axial T1- (b) and fat-suppressed T2-weighted (c) MR images show an intramuscular soft tissue mass in the lateral aspect of the thigh, with signal characteristics similar to that of fluid (arrows).
**Fig. 19:** Intramuscular myxoma (same patient as in figure 18). Axial fat-suppressed T1-weighted MR images before (a) and following (b) intravenous contrast administration. The lesion shows mild diffuse enhancement (arrow).
Fig. 20: Synovial cyst. Coronal fat-suppressed T2- (a) and axial fat-suppressed T2- (b) and T1-weighted (c) MR images show a cystic lesion in the medial aspect of the right knee joint.
Fig. 21: Synovial cyst. Axial T1- (a and b) and fat-suppressed T2-weighted (c and d) MR images show a cystic lesion in the dorsal aspect of the right hand (*) which is in communication with the adjacent articular space (arrows).
**Fig. 22:** Synovial cyst (same patient as in figure 21). Axial T1-weighted MR images before (a) and following intravenous contrast administration (b) demonstrate a thin peripheral rim of enhancement (arrow) with no internal enhancement.
Conclusion

MR imaging is the best modality for evaluating soft tissue lesions.

Some benign soft-tissue lesions have typical MR imaging characteristics.

Familiarity with these specific features is very important because when they are present, the radiologist can have greater confidence in suggesting a diagnosis.

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