Magnetic Resonance Imaging of Superficial Soft-tissue Lumps and Bumps

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Learning Objectives

We aim to illustrate the characteristic magnetic resonance (MR) features of various superficial soft-tissue lumps and bumps, according to the anatomic location of the lesion.
Background

Superficial soft-tissue lesions are frequently encountered by radiologists in everyday practice. Characterization of these soft-tissue lesions remains problematic, despite advances in imaging. By systematically using clinical history, anatomical location, and signal intensity characteristics on MR images, one can determine the diagnosis for the subset of determinate lesions that have characteristic clinical and imaging features as well as narrow the differential diagnoses for lesions with non-specific or indeterminate characteristics.

Superficial soft tissue tumors may be divided according to their location: lesions that arise in the cutaneous layer (epidermis or dermis), subcutaneous layer (within the substance of the subcutaneous adipose tissue), or fascial layer (fascia overlying the muscle).

In addition, tumor-like lesions (such as hematomas and heterotopic ossificans) should be considered in the differential diagnosis whenever a superficial soft-tissue mass is encountered.
Imaging Findings OR Procedure Details

Superficial lumps and bumps are commonly encountered in clinical practice. Being amongst the first topics taught in medical school regarding the clinical evaluation of these superficial lesions, most of us are probably still familiar with the classic teaching of the "3 Ss, 3 Cs, 3 Ts and the F'er", representing site, size, shape, colour, consistency, contour, tenderness, tethering, transillumination and fluctuance of the lesion.

There are, however, limitations in clinical evaluation with considerable overlap between benign and malignant tumours. The use of imaging has been widely used as a valuable adjunct in facilitating accurate diagnosis of these lesions, especially MR imaging due to its unparalleled ability for soft-tissue differentiation. Accurate diagnosis is crucial as this will impact on the management of the lesion (e.g., conservative, surgical).

Various lesions from each anatomic layer (cutaneous, subcutaneous, fascia) will be discussed. Two common pseudotumors (heterotopic ossificans and haematoma) will also be highlighted.

**Cutaneous**

**Epidermal cyst**

Epidermal cysts are cysts filled with keratin debris and bounded by a wall of stratified squamous epithelium. An unruptured cyst is typically well-defined with high signal intensity on T2-weighted MR images Fig. 1 on page 22. Variable low-signal components may be seen within it on T2-weighted images. Gadolinium-enhanced images may demonstrate peripheral rim enhancement and central non-enhancement with no enhancement of the surrounding soft tissue. Ruptured epidermal cysts tend to have a more varied appearance, which included presence of variable septa as well as thick irregular rim enhancement and fuzzy adjacent soft-tissue enhancement on gadolinium-enhanced images.

Malignant change in an epidermal cyst is extremely rare. Malignant change should be suspected in a large or rapid-growing cyst or with a history of cyst recurrence. In the case of our patient, there was a moderately-differentiated squamous cell carcinoma seen arising from the squamous epithelial lining of the cyst Fig. 2 on page 23.

**Myopericytoma**
Myopericytoma is a rare soft-tissue neoplasm characterized by a perivascular proliferation of round-to-spindle pericytic cells of myoid differentiation, hence showing semblance to smooth muscles. It has a propensity to occur in the dermis and subcutaneous layer of the extremities in middle-aged adults. Myopericytomas are generally considered to be benign lesions, though a few malignant cases have also been described. Recurrence has also been reported in 10%-20% of patients with myopericytoma. On MR imaging, it demonstrates isointense signal to muscle on T1-weighted images, with small to large hyperintense focus, representing hemorrhage Fig. 3 on page 10. Apart from the hemorrhagic focus, most the mass usually reveals intense enhancement after contrast administration.

**Subcutaneous**

**Lipoma**

Most mesenchymal masses arise within the subcutaneous adipose tissue. Lipomas are the most frequently encountered subcutaneous tumors. A lipoma has a typical homogeneous appearance with fatty contents, and may contain a few thin discrete septa Fig. 4 on page 10.

**Peripheral Nerve Sheath Tumors: Schwannoma, Neurofibroma and Malignant Peripheral Nerve Sheath Tumor**

Solitary benign peripheral nerve sheath tumors are divided into two major groups: schwannoma (neurilemoma) and neurofibroma. Lesions are usually solitary, unless associated with neurofibromatosis 1 (von Recklinghausen disease).

A schwannoma is most frequently seen in the lower extremity, followed by the trunk, upper extremity, then the retroperitoneum. The MR appearance typically shows homogeneous isointense signal relative to skeletal muscle on T1-weighted images and increased signal intensity on T2-weighted images - these imaging features help identify that a tumor in question is likely of neurogenic origin, but are largely non-specific amongst the neurogenic tumors.

Certain features such as the relative location of the lesion within a nerve, depiction of the nerve entering or exiting the mass, and the presence of particular signs (such as the fascicular sign and target sign) are useful in distinguishing between benign and malignant nerve sheath tumors Fig. 5 on page 11. The target and fascicular signs are typically seen in benign lesions. The target sign is characterized by central low signal intensity and peripheral high signal intensity in T2-weighted images, which correspond to central fibrous components and peripheral myxomatous elements seen at pathologic analysis.
Fascicular sign refers to the appearance of the fascicular bundles in neurogenic tumors and normal nerves.

A schwannoma is generally eccentric to the nerve, and is also inseparable from the nerve. A capsule may be seen in up to 70% of the cases, reflecting growth of schwannoma within the epineurium. Peripheral enhancement of the lesion may be seen after contrast administration. Malignant transformation is extremely rare.

The vast majority (90%) of neurofibromas are solitary. Neurofibromas that are present in the setting of neurofibromatosis 1 are almost invariably multiple, with visceral and deep nerve involvement and an increased risk of malignant transformation.

Neurofibroma is classically central to the nerve and may obliterate the nerve, in contrast to schwannoma where the mass is eccentric to the mass. Neurofibroma also tends to enhance more homogeneously post-contrast compared to a schwannoma. Plexiform neurofibroma is typically much larger, often disfiguring and affects function due to sheer size as well as neurovascular compromise Fig. 6 on page 21. In contrast to a simple neurofibroma, plexiform neurofibroma tends to appear more infiltrating and demonstrating diffuse involvement along a nerve and its branches; enhancement is generally inhomogeneous.

Malignant peripheral nerve sheath tumors are high-grade sarcomas which account for approximately 6% of all sarcomas, with approximately one-half occurring in the setting of neurofibromatosis 1. Malignant peripheral nerve sheath tumors commonly arise from major nerve trunks, especially the proximal extremities and trunk. Even though they have no specific imaging features, their aggressive biologic behavior may be reflected by the indistinct margins, infiltration of the nerve and adjacent structures as well as lesion heterogeneity (as a result of hemorrhage and necrosis) Fig. 7 on page 19.

**Giant Cell Tumor of the Tendon Sheath**

Giant cell tumor of the tendon sheath occurs most commonly in the volar aspect of the fingers, particularly the first 3 digits. Surgical excision is curative, although recurrence may occur in up to 25%. Malignant transformation is rare. The tumor is histopathologically identical to pigmented villonodular synovitis (PVNS) and shares similar MR appearance due to underlying hemosiderin accumulation. MR imaging typically demonstrates a well-defined mass adjacent to or enveloping a tendon, which is hypo- to iso-intense to muscle on T1-weighted images. Low signal intensity is usually seen on T2-weighted images, with a variable degree of heterogeneity Fig. 8 on page 18. Homogeneous enhancement is usually seen post-contrast.
Hemangioma

Hemangioma is the most frequently encountered vascular soft-tissue abnormality. Hemangioma demonstrates hyperintense signal T2-weighted images and shows vascular space enhancement post-contrast administration Fig. 9 on page 17. Punctate or reticular areas of low signal intensity may be present, corresponding to fibrous tissue, fast flow within vessels, or foci of calcification. Areas of thrombosis appear as nodular areas of low signal intensity areas, similar to phleboliths. On T1-weighted images, the signal intensity is usually intermediate between that of muscle and fat.

Benign Hyalinized Lesion

Histologically, benign hyalinized lesion is a hypocellular lesion composed of broad fascicles and nodules of hyalinized collagenous tissue.

MR appearance shows a well-circumscribed mass demonstrating hypo- to iso-intense signal on T1-weighted images. The mass appears hypointense on T2-weighted images due to the cellular nature of the lesion. Post-contrast images reveal mild to moderate heterogenous enhancement. Fig. 10 on page 16

Fascia

Nodular Fasciitis

Nodular fasciitis represents benign proliferation of fibroblasts and myofibroblasts. It is typically manifested as a small (usually less than 4cm) superficial mass which is rapidly growing. Due to its rapid growth, it may simulate a malignant neoplasm clinically. Common sites of involvement include the upper extremity, particularly the volar aspect of the forearm. The lesion is benign and rarely recur after surgical excision.

Nodular fasciitis may be categorized according to the predominant histologic feature of the lesion, namely myxoid, cellular, or fibrous. Such histologic diversity is responsible for the variable MR appearance of the lesions. For hypercellular lesions, the signal intensity is nearly isointense to muscle on T1-weighted images and hyperintense on T2-weighted images Fig. 11 on page 15. On the other hand, highly collagenous lesions can have hypointense signal on all MR sequences. Contrast enhancement is typically diffuse and homogeneous.

Fibroma of the Tendon Sheath

Fibroma and giant cell tumor of the tendon sheath may be clinically indistinguishable as a slow-going painless mass in the peripheral extremities, particularly in the hands and
may interfere mechanically with tendon or joint function. They also occur in similar patient populations (middle-aged adults).

MR appearance typically demonstrates the attachment of the tumor to a tendon or tendon sheath Fig. 12 on page 14. The lesion is hypo- to iso-intense to muscle on both T1- and T2-weighted images. Contrast enhancement is variable. The absence of haemosiderin aids in the differentiation of a fibroma from giant cell tumor of the tendon sheath as the latter may reveal a "blooming artifact" that is not seen in a fibroma of the tendon sheath.

**Myxofibrosarcoma**

Myxofibrosarcoma, also known as a myxoid variant of malignant fibrous histiocytoma, is one of the most common sarcomas commonly occurring in the extremities of elderly people. It tends to present as a slow-growing, painless and palpable mass. Although the lesion runs as indolent course, it is known for its high incidence of local recurrence.

Myxofibrosarcoma has a significant myxoid component with marked variations in cellularity, nuclear pleomorphism and mitotic activity. Low-grade myxofibrosarcoma may closely resemble other myxoid tumors, such as myxoma, myxoid liposarcoma, and myxoinflammatory fibroblastic sarcoma.

Typical MR appearances include low to intermediate signal intensity on T1-weighted images, and high signal intensities of both the solid and myxoid components on T2-weighted images Fig. 13 on page 13. After contrast administration, nodular and peripheral enhancement is often seen within the solid components. The lesion tends to spread along the fascial planes and muscles.

**Tumor mimics**

**Heterotopic Ossificans**

Heterotopic ossificans refers to the ectopic formation of bone, commonly after an inciting trauma or neurological event (particularly stroke). It is a common soft tissue pseudotumor.

The MR appearance changes with the age of the lesion. Early features are largely non-specific as the peripheral calcification is often unapparent or indistinct. Oedema in the surrounding soft tissues may be present, appearing as a high T2-weighted signal in the periphery. Heterogeneous high T2 signal is frequently seen within the intraluesional content centrally, with an often indistinct low signal-intensity rim representing
calcification. T1-weighted images may show ill-defined signal changes that are isointense to surrounding muscle. Intravenous contrast administration results in early intense, heterogeneous enhancement of lesions. The presence of hyperintense signal intensity centrally and marked rim enhancement may be confounded with septic bursitis or abscess. Diffuse enhancement of the lesion may mimic for soft-tissue infection.

After several weeks to months of progressive maturation, MR will demonstrate a better-defined low-signal rim corresponding to the mature cortical bone seen on radiographs. High T1 and T2 signals that are isointense to fat develop centrally, probably representing marrow fat Fig. 14 on page 12. Late lesions typically do not enhance, or may enhance minimally. In the more mature lesions, presence of high T1- and T2-weight signal patterns representing marrow fat may mimic lipomatous lesions, particularly so if the areas of low signal intensity is not recognized as calcification or ossification. Conventional radiography and computed tomography are useful in the evaluation of the osseous nature of this lesion. Whilst soft tissue mass or swelling is the earliest radiographic finding, bone formation can be seen as early as 2 weeks. The classic appearance is that of a peripheral zone of calcification with a relatively lucent centre, which can be seen by 2 months.

**Soft-tissue Haematoma**

Hematomas may mimic soft tissue sarcomas. Most hematomas demonstrate variable and marked heterogeneity, depending on the age of the lesion as well as the metabolic state of the haemoglobin molecule. Furthermore, poorly-contained hematomas may have an infiltrative appearance that can look highly aggressive.

In the acute phase (few days old), hematomas are typically isointense on T1-weighting and hypo- to iso-intense on T2-weighting, reflecting the earliest stage of oxygenated hemoglobin to deoxyhemoglobin. Subacute (1 week to 3 month old) hematomas are usually hyperintense on T1- and T2-weighted images as the haemoglobin becomes extracellular methemoglobin Fig. 15 on page 20. Weeks to months later, the methemoglobin breaks down into hemosiderin with decreased signal intensity on both T1- and T2-weighting. Hematoma may not be readily distinguishable from haemorrhage into a malignant tumor; therefore any nodular areas of soft-tissue enhancement should raise suspicious to exclude an underlying neoplasm.
Fig. 3: Rare myopericytoma of cutaneous and subcutaneous tissues in a 63 year-old male who presented with a 3 year-history of painless lump at the back of ankle. (a-c) MR imaging demonstrates a hyperintense lesion with isointense rim on both T1 and T2 weighted images (a & b). A small blood-fluid level is also seen on the axial T2-weighted image. There is intense enhancement of rest of the lesion after contrast administration.

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Fig. 4: 37 year-old-female with a benign lipoma of the foot. (a-c) Axial T1-weighted, T2-weighted and post contrast T1-weighted with fat suppression) images reveal a lobulated mass in the dorsal aspect of forefoot, between the second and third toes. The lesion demonstrates fat signal intensity on all sequences. There are several thin septations within the lesion which do not show post-contrast enhancement.

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Fig. 5: 3rd toe subcutaneous neurilemoma (schwannoma) in a 49-year-old man. (a) Axial T1-weighted image shows a well encapsulated isointense lesion in the plantar subcutaneous fat of 3rd toe. It lies superficial to the flexor tendon and wraps around it. (b) Axial gradient image does not show any susceptibility changes (c) Post contrast fat saturated T1-weighted image reveals subtle diffuse enhancement within the lesion. (d) Coronal T2-weighted fat saturated image shows the fasicular sign suggestive of neurogenic origin of the lesion.

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**Fig. 14:** late stage myositis ossificans in a 55 year-old paraplegic female who presented with pain and tenderness over a palpable mass in the right thigh. (a-c) Axial T1-weighted, fat saturated T2-weighted and post contrast T1-weighted images reveal a lobulated mass in the anterior right thigh with identical signal intensity to that of normal bone marrow on all MR pulse sequences. No post contrast enhancement is noted. (d) Plain radiographs demonstrate extensive soft tissue ossification around the right hip joint.

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Fig. 13: Local recurrence in a 42 year-old-female, operated 4 years back for a high grade myxofibrosarcoma. (a-c) Axial T1-weighted image, T2-weighted fat saturated image and post contrast T1-weighted image reveals an ill-marginated soft tissue mass in the anterior compartment at the expected location of biceps muscle. It is intermediate to high signal intensity on T1-weighted image (a), hyperintense on T2-weighted image (b) and shows uniform enhancement on post contrast fat saturated image. Enhancing tumor is also seen adjacent to brachial vessels, median nerve and basilic vein.

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Fig. 12: 48 year-old-female with low grade fibrosarcoma of extensor carpi ulnaris (ECU) tendon sheath. (a-c) A well circumscribed, ovoid mass is seen inseparable from the ECU tendon. It is of low signal intensity on T1 and T2 weighted images (a & b). Mildly heterogenous hyperintense signal intensity is also noted on T2-weighted fat saturated image (b). The lesion shows diffuse and avid enhancement on post contrast fat saturated T1-weighted image (c).

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Fig. 11: 32 year-old-man with nodular fascitis in medial side of thigh. (a & b) Axial T1-weighted pre and post contrast (with fat saturation) images show a homogenously enhancing iso to hypointense lobulated lesion in the subcutaneous plane. (c) On T2-weighted image, the lesion appears heterogenously hyperintense and demonstrates small extensions into the subjacent fascia (arrows). This 'fascial tail sign' is an important MR diagnostic sign. There are no susceptibility changes seen on gradient image (d).
Fig. 10: 30 year-old-man with a subcutaneous benign hyalinized lesion at the level of lateral malleolus. (a-c) Coronal T1-weighted, fat saturated T2-weighted and T1-weighted post contrast images show a well marginated, lobulated lesion which is heterogeneously iso to hypointense on T1-weighted image (a). It shows signal drop-out on fat saturated T2-weighted image (b) with mild to moderate heterogenous enhancement on post contrast T1-weighted image (c). No susceptibility changes suggestive of blood products are seen on the axial gradient image (d).

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**Fig. 9:** 58 year-old-female presented with 10-year history of an elbow lump, progressively increasing in size. (a-c) A lobulated, well marginated mass is seen in the subcutaneous plane at the level of elbow. The mass is hypo to iso intense on T1-weighted image (a) with tiny hyperintense foci (suspicious of fat islands) (arrows). It is of high-signal-intensity on T2-weighted image (b) interspersed with linear and lacelike areas of low or intermediate signal intensity (arrow). These T2 characteristics correlate well with the fibrous and fatty septa (low signal) between endothelial-lined vascular channels (high signal) identified on histologic examination. Mild to moderate heterogeneous enhancement is seen on post contrast T1-weighted fat saturated image (c).

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Fig. 8: Giant cell tumor of flexor tendon sheath in a 45 year-old-man who presented with a non tender lump since 1 year. (a) Axial T1-weighted, T2-weighted (with fat saturation), gradient and post contrast T1-weighted images reveal a well encapsulated, lobulated solid lesion wrapping the flexor tendon. It demonstrates intermediate signal intensity on T1-weighted image (a), iso to slightly hyperintense signal intensity on T2-weighted fat saturated image (b), small foci of susceptibility on gradient image (c) and avid, heterogenous enhancement on post contrast image (d).

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Fig. 7: 59-year-old female with malignant peripheral nerve sheath tumor in the subcutaneous tissues of right knee. Patient is a known case of neurofibromatosis 1. (a) Coronal T1-weighted image shows an intermediate to hyperintense signal intensity lobulated lesion with irregular inferior margins. (b) Sagittal STIR image shows heterogeneously hyperintense signal intensity within the mass. Mild perilesional edema and fat stranding is also noted inferiorly (c) On T1-weighted post contrast images performed with fat saturation, the mass shows heterogenous and avid enhancement, especially inferiorly.

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**Fig. 15:** Subcutaneous hematoma at the level of lateral malleolus in a 78 year-old-man. (a-c) Axial T1-weighted, fat saturated T2-weighted and post contrast T1-weighted (with fat saturation) images demonstrate a moderate sized lesion with intermediate signal intensity on T1-weighted image (a) and hyperintense signal intensity on T2-weighted image (b). The lesion has a hyperintense rim on T1-weighted (arrow) and T2-weighted images (a & b) which appears dark (compatible with blood products) (arrow) on gradient sequence (d). The lesion shows no significant post contrast enhancement (c).

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Fig. 6: 57 year-old-man with known Von Reckling Hausen’s disease and right gluteal plexiform neurofibroma. (a-c) Axial T1-weighted image, T2-weighted image with fat saturation and post contrast T1-weighted (with fat saturation) image shows a heterogenously hypointense soft tissue mass in the right gluteal region infiltrating the subcutaneous fat and overlying skin (a). This mass is relatively hyperintense on T2-weighted image (b). On post contrast T1-weighted image (c), the lesion shows marked heterogenous enhancement.

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Fig. 1: Unruptured epidermal cyst in back in 29-year-old man. (a) Axial T1-weighted image shows ovoid hypointense subcutaneous mass. (b) Axial T2-weighted fat saturated image shows bright mass with low-signal components within. (c) On post contrast T1-weighted fat saturated images, there is thin and smooth rim enhancement.
**Fig. 2:** Rare malignant degeneration with squamous cell carcinoma in a 80 year-old female with long standing history of epidermal cyst. Gadolinium-enhanced fat-suppressed T1-weighted images (c & d) show the epidermal cyst with eccentric areas of thick irregular peripheral rim and septal enhancement with infiltration of underlying gluteal muscle.

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Conclusion

Superficial lumps and bumps are commonly encountered in clinical practice, and an initial work-up can be made based on the anatomic location of the lesion. MRI is a particularly useful adjunct in the evaluation of a suspected superficial soft-tissue tumour due to its superior ability for soft-tissue differentiation as well as true multiplanar capability with various techniques available (eg fat-suppression).

Having a good knowledge of the anatomical location and characteristic MR appearance of soft tissue tumors, one can quickly narrow the differential diagnoses for a particular lesion. However, it is important to recognize the presence of pseudotumors which may confound the diagnosis.
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