Intramuscular and myofascial oedema pattern in the lower limb: a pictorial essay

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Learning objectives

Intramuscular and myofascial oedema is commonly detected in musculoskeletal MRI studies of the lower limbs. There is a broad spectrum of background pathophysiology with causes including muscle trauma, infection, inflammatory and metabolic aetiologies. Other characteristic patterns such as oedema secondary to DVT and neuropathic causes are discussed.

The aim of this exhibit is:

1. To describe the spectrum of lower limb oedema patterns on MRI scans;

2. To identify characteristic imaging appearances;

3. To assist in formulating the differential diagnosis based on imaging features and acknowledge limitations to specificity on MRI.
**Background**

Pathologic conditions that cause abnormalities in muscle size, shape, including swelling and oedema will change signal intensity on both T1 and T2 fat saturated (FS)-weighted images. In theory, increased extracellular fluid with muscle oedema can lead to prolonged relaxation time of both T1 and T2 because the relaxation time of water in the extracellular space is four times that of the myoplasm. This translates to an increased T2-weighted signal images, which is usually due to the presence of increased intracellular or extracellular free water.

There is a broad gamut of traumatic and non-traumatic causes of lower limb conditions. Relying solely on clinical examination to make an accurate diagnosis can be extremely difficult due to many overlapping signs of leg pain and swelling. MRI is an invaluable non-invasive tool which can be of assistance in forming an accurate diagnosis and therefore provide guidance for the appropriate treatment and possible early intervention when required. This poster aims at highlighting the importance of identifying the patterns of lower limb oedema through a pictoral discussion.

Lower limb conditions investigated with MRI at the Gold Coast Hospital Health Service from Jan 2011 to Jul 2014 were obtained, with diagnosis subsequently confirmed using clinical and surgical data.

Conditions have been divided according into their location of presentation; Intramuscular, myofascial or mixed oedema.

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Intramuscular

**Muscle strain (Fig. 1-3):**

Muscle strain can occur in instances of indirect muscle injury caused by over-lengthening contractions. Most strains commonly occur at the musculotendinous junction (the weakest link in the muscle) and typically occur in muscles which cross two joints such as the hamstrings, gastrocnemius and rectus femoris muscles.

Muscle strains are graded as mild, moderate and severe (Grade 1, 2 and 3 respectively) depending on the severity of the injury. In Grade 1 strains, the tendon is overstretched without tearing of the muscle fibres, while Grade 2 represents a partial tear and Grade 3 with complete tear or disruption of the muscle fibres.

**Contusion and myositis ossificans/Laceration (Fig. 4):**

Muscle contusion can occur due to direct trauma, blunt injury or compressive force to the muscle, with muscle oedema commonly seen over the area of point of impact. The presence of a haematoma is generally observed in more severe cases of contusion, which may reveal a mass like structure seen representing the haematoma in addition to oedema. Compared to muscle strain, muscle oedema in contusion tends to produce most significant changes in deeper muscle areas.

Muscle contusion/haematoma can evolve to myositis ossificans which has pseudotumour appearances on MRI but has characteristic marginal zone of calcification on xray and CT which helps to confirm the diagnosis.

Muscle lacerations result from penetrating injuries with associated subcutaneous oedema and haematoma. Similar to muscle contusion, muscle oedema is focal and sharply defined with muscle discontinuation.

**Delayed-onset muscle soreness (DOMS) (Fig. 5):**

DOMS is a type of injury due to overuse, especially after performing an unaccustomed exercise and is believed to result in reversible structural damage to the muscle architecture. Symptoms usually develops over a few hours or days after the incident, in contrast to muscle strain or contusion which have a more acute presentation. In severe forms of DOMS it may progress to rhabdomyolysis.
Diabetic myopathy (Fig. 6):

Acute diabetic myopathy presents with sudden onset of pain and swelling of the affected muscle region. The presentation of chronic myopathy is usually insidious. It generally affects the lower limb, such as the thighs and calves, and occurs secondary to pathological processes of inflammation, ischaemia and infarction of the affected muscles.

The exact mechanism remains unclear, however is believed to reflect progressive thrombosis of small and medium sized arterioles with activation of coagulation cascade leading to progressive endothelial damage and eventual muscle ischaemia and necrosis.

There is often clinical and imaging overlap with muscle oedema related to diabetic neuropathy.

Infectious myositis (Fig. 7-8):

Infectious myositis can be an acute, subacute or chronic infection of the skeletal muscle, which arises from haematogenous spread or the direct spread of infection from adjacent tissues as in cases of osteomyelitis. It is most commonly caused by staphylococcus aureus, but mycobacterium tuberculosis is also involved to a lesser degree. Although any skeletal muscle can be involved, it has a tendency to affect large muscles in the body, such as the quadriceps muscles and gluteal muscles. Clinically, it can present with muscle pain, fever, mild leucocytosis and elevated ESR.

Inflammatory myositis (Fig. 9):

Polymyositis and dermatomyositis are both autoimmune conditions, which are chronic systemic connective tissue diseases that generally presents with swelling and gradual weakness with loss of muscle mass. Polymyositis is characterized by muscle inflammation only, while dermatomyositis also presents with the addition of skin rash symptoms. Both conditions clinically present with symmetric proximal muscle weakness and imaging confirms a proximal, symmetric myopathy of the lower limbs usually affecting the vasti in the early stages of disease.

Morel-Lavallee (Fig. 10-11):

Morel-Lavallee lesion is an acute on chronic shear injury to the soft tissues, most commonly involving the soft tissues adjacent to the greater trochanter, lower back and buttock region. It is a result of a high energy tangential force that causes separation from the superficial fascia to the underlying musculature. MRI is the preferred mode of imaging in the evaluation of these lesions, which has been characterised with T2 weighted
hyperintensity which may resemble a simple fluid collection or contain blood products or fat necrosis.

Deep venous thrombosis (DVT) (Fig. 12):

DVT may mimic other pathology and can cause pain and swelling of the affected limb. DVT is more likely to occur on the background of recent prior surgery, poly- and lower limb trauma and patients may present unexpectedly on imaging. MRI findings are non-specific and include loss of normal venous flow voids, venous distension and mural thickening on T1- and T2-weighted imaging. Contrast is rarely administered and venous duplex ultrasound may confirm the diagnosis.

Ankle syndesmosis injury/High ankle sprain (HAS) (Fig. 13):

Ankle syndesmosis injury/HAS reflects a severe sprain of the ankle with the clinical presentation including severe ankle pain, often an audible "pop" at the time of injury, palpation tenderness over the anterior and posterior tibulofibular ligaments and positive clinical tests including the "dial" test. The most common mechanism of injury is dorsiflexion and external rotation on a planted foot. MRI may diagnose and grade HAS injuries including tears of the AITFL, PITFL, interosseous ligament and membrane, assess for diastasis of the inferior tibiofibular joint and myofascial oedema tracking along the IOM and posterior muscles including FHL, indicating a higher grade of injury.

Ruptured Baker's cyst (Fig. 14):

Baker's cyst is developed from the enlargement of gastrocnemius-semimembranosus bursa, which commonly presents as asymptomatic mass located below the popliteal fossa. Its presence can cause thrombophlebitis, compartment syndrome or entrapment neuropathy, which can be caused by the cyst itself or cyst rupture. This can lead to clinical symptoms of swelling, pain or stiffness of the knee, which is often aggravated by walking.

Rhabdomyolysis (Fig. 15-16):

Rhabdomyolysis is a potential life threatening condition which is characterised by the breakdown of myocytes resulting in the release of toxic intracellular content into the circulatory system. It is associated with a range of diseases, trauma, medications and toxins. Serum creatine kinase (CK) levels are frequently elevated approximately 2 to 12 hours post muscle injury, and both myoglobinemia and myglobinuria can occur. MRI studies have reported diffuse muscle oedema associated with medication-induced rhabdomyolysis.
Necrotising fasciitis (Fig. 17):

Necrotising fasciitis is an uncommon type of rapidly progressive infection caused by virulent toxin-producing bacteria, and is characterised by the spreading of progressive necrosis of the subcutaneous fat and fascia. The difficulties lies with distinguishing between NF and cellulitis due to overlapping presentations. Whilst infection in cellulitis and pyomyositis generally involves the overlying skin, NF can move along the fascial planes and along the underlying muscle, which is usually confirmed during surgery only.

The presence of gas within the necrotised fasciae is characteristic, but may be lacking. The main MRI finding is thickening of the deep fasciae due to fluid accumulation and reactive hyperemia.

Compartment syndrome (Fig. 18):

Compartment syndrome occurs when the tissue pressure is increased in a confined fascial space, most typically due to bleeding or swelling in post trauma setting. In an acute situation, clinical presentations may include severe pain which is disproportion to the original injury, paraesthesia, distension and muscle weakness.

Early MRI in the acute stages generally show extremity swelling with diffuse oedema within the affected compartment, with increased interstitial fluid in the involved compartment shown in the T2-weighted images.

Denervation (Fig. 19-20):

Denervation occurs in a wide range of settings including trauma as seen in spinal cord injury, peripheral nerve injury or compression, neoplasia, infections, autoimmune processes, vasculitis, and neuritis. MRI provides excellent anatomic resolution and demonstrate denervation associated changes in specific muscles innervated by the affected nerves. Unfortunately, muscle oedema in subacute muscle denervation has been reported to be absent on MRI imaging in the initial few weeks (2-4 weeks) after the denervation, which most likely represent the shifting of fluid from the intracellular to extracellular spaces. This would then further progress into fat infiltration and muscle atrophy.

Calcific tendonitis (Fig. 21):

Calcific tendonitis is a self limiting condition that is caused by the formation of small calcium deposits, which results in inflammation of the surrounding muscles. The exact cause of this condition is unclear, but is believed to be related to tendon degeneration.
Usually the calcium deposition causes tenosynovitis with acute severe pain and tenderness. If calcium crystals precipitation involves the intramuscular part of the tendon, it may cause severe inflammation leading to a high signal intensity on T2 weighted MRI images. This appearance can be similar in other conditions such as denervation injury, focal myopathies and neoplasms.
**Fig. 1:** Muscle strain (Grade 1): 40 yrs M with acute hamstring injury. Coronal and Axial T2FS weighted images confirm Grade 1 peripheral hamstring tear of the distal biceps femoris proximal to the myotendinous junction. Mild myofascial oedema. No discontinuity of fibres.

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**Fig. 2:** Muscle strain (Grade 2): T2FS weighted axial and sagittal sequences confirm partial thickness defect in the mid vastus intermedius compatible with Grade 2 tear with mild adjacent myofascial oedema. Mild feathery intramuscular oedema within the vastus lateralis. Case contributed by Dr. Shamir Patel, Calgary, Canada.

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Fig. 3: Muscle strain (Grade 2): Corresponding T1 weighted axial and sagittal sequences confirm blood products/small haematoma in the mid vastus intermedius Grade 2 tear. Case contributed by Dr. Shamir Patel, Calgary, Canada.

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Fig. 4: Muscle contusion and myositis ossificans: 13yrs M - Enlarging gluteal mass, remote history of ? trauma. Coronal and axial T2FS and axial T1 sequences confirm lesion in the inferior left gluteus maximus muscle with T2 hypointense capsule/mineralisation. Extensive intramuscular oedema in the adjacent gluteus maximus muscle tracking along the sciatic neurovascular bundle with reactive fluid in the left trochanteric bursa. Subsequent CT and progress x-ray confirm zonal calcification typical of myositis ossificans.

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Fig. 5: DOMS: 13 yrs F - Exercise background of recent dancing and sprinting/hurdles, presented with delayed onset of generalised thigh and hamstring pain. T2FS images demonstrate symmetric, predominantly peripheral oedema within the rectus femoris muscles with a degree of oedema tracking along the central tendon compatible with DOMS. Mild intramuscular oedema within the right semimembranosus. Imaging and clinical appearances compatible with DOMS.

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Fig. 6: Diabetic myopathy: 61 yrs F - Background of long term poorly controlled type 2 diabetes mellitus with end stage diabetic nephropathy and retinopathy. STIR images confirm diffuse oedema in the distal calf musculature extending into the plantar intrinsic musculature in keeping with diabetic neuropathy.

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**Fig. 7:** Infectious myositis secondary to haematogenous spread: 57 yrs M - One week history of unilateral lower limb swelling on a background of generalised sepsis. Coronal, axial T2FS and axial T1FS demonstrate diffuse T2 signal within the anterolateral compartment of the left thigh with muscle enlargement, oedema and enhancement of the anterior muscle compartment of the thigh. Relative sparing of the posterior compartment of the left thigh. Subsequent muscle biopsy of the left vastus lateralis showed selective type 2 muscle fibre atrophy and necrotising myopathy with confirmed staphylococcus epididymitis infection.

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**Fig. 8:** Infectious myositis secondary to direct spread: 39 yrs F - Axial T2FS weighted images demonstrates myofascial abscess secondary to military tuberculosis extending from the right buttock to the ischioanal fat, which further connects to the right hamstring tendons and semitendinosus muscle. There is also significant oedema within the right trochanteric bursa with significant rim enhancement consistent with trochanteric bursitis.

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**Fig. 9:** Inflammatory myositis: 54 yrs F with dermatomyositis - T2FS hyperintense muscle oedema symmetrically within the gluteal and thigh musculature. Case contributed by Dr Shamir Patel, Calgary, Canada.

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**Fig. 10:** Morel-Lavelle: 39 yrs M - Right hip soft tissue swelling over the last 3 months, remote trauma. T2FS images shows multilobulated lesion centred within the subcutaneous fat overlying the right gluteal region and tracking along the right iliotibial band. Several fluid levels and minimal septal enhancement overlying the inferior aspect of the right gluteus maximus.

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Fig. 11: Morel-Levalle: Corresponding absence of nodular enhancement on post T1FS excluded tumour.

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Fig. 12: DVT: 35 yrs F presented with calf pain - Axial T1FS, T2FS and coronal STIR SPC demonstrate occlusive thrombus within the popliteal vein with extensive myofascial oedema tracking into the popliteal fossa and around the common peroneal nerve branches.

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**Fig. 13:** High ankle sprain (HAS): 34 yrs M with HAS after surfing - High grade partial tear of the anterior inferior tibiofibular ligament (AITFL) with associated T2 hyperintense oedema is seen in the anterior subcutaneous tissues. Oedema extends into the intraosseous membrane with linear T2 hyperintensity within the inferior syndesmosis suggestive of partial tear. Myofascial oedema extends posterior to the distal tibial metaphysis deep to the posterior compartment musculature.

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**Fig. 14:** Ruptured Baker’s cyst: 54 yrs M presented with left knee pain post twisting mechanism while playing AFL - There is a moderate sized Baker’s cyst with mild oedema within the inferior aspect, which is reflective of a degree of cyst rupture/leakage.

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Fig. 15: Rhabdomyolysis: 23 yrs M - Unconscious for 36 hours lying on his left leg and presented with clinical weakness in the left sciatic nerve distribution. T2FS coronal and axial images show marked thickening and intramuscular oedema involvement in the left piriiformis, gluteus minimus and medius, lateral aspect of gluteus maximus, obturator internis, superior gemelli, quadratus femoris, lateral adductor magnus and lateral aspect of the vastus lateralis muscles.

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Fig. 16: Rhabdomyolysis: Corresponding focal regions of non-enhancement on T1FS with peripheral rim enhancement suggestive of early myonecrosis. Marked thickening of
the piriformis muscle and quadratus femoris muscles, which compress the sciatic nerve as it exits the greater sciatic notch.

Fig. 17: Necrotising Fasciitis (NF): 30 yrs M with NF following a penetrating injury to the right elbow - T2FS axial image shows areas of high signal intensity in the deep fasciae surrounding muscle of the lateral, posterior, and medial compartments of the right arm (fasciitis and collections; arrows), as well as areas of high signal intensity in the subcutaneous tissue (cellulitis; asterisk). b, c demonstrates unenhanced T1-weighted axial image and post-contrast fat-suppressed T1-weighted image show enhancement within the subcutaneous tissue (asterisk) as well as in some of the hyperintense fasciae seen in a (arrows)


Fig. 18: Compartment syndrome: 49 yrs M with right knee injury post collision and falling off skateboard at high speed frontal impact - CT images demonstrate Schatzker type 2 split depression fracture of the lateral tibial condyle with associated large lipo-haemarthrosis. Subcutaneous gas lateral calf in keeping with fasciotomy. X-ray confirmed right lateral tibial plateau and 5th metatarsal neck fracture.
**Fig. 19:** Central denervation: 59 yrs M in rehabilitation admission following right middle cerebral artery infarct and right sided hemiplegia with ongoing left hip pain post - T2FS images show hyperintense signals within the left gluteal region musculature with mild muscle oedema with the left vastus lateralis, iliopsoas, obturator internis and rectus femoris.

**Fig. 20:** Muscle denervation oedema secondary to centra cause/spinal pathology: 68 yrs paraplegic M with T4 and L1 metastatic lesions from colorectal cancer presents with back pain - Pathologic fracture of T4 with retropulsion and posterior bulging of the posterior vertebral body into the spinal canal. T2 images show extensive signal alteration within the gluteal and pelvic muscles bilaterally which is reflective of denervation secondary to proximal myelopathy. Diffuse denervation changes and fatty involution of the gluteal musculature is also noted, more marked on the left and likely reflective of proximal myelopathy.
Fig. 21: Calcific tendonitis: 42 yrs F presents with localised left hip pain for two days with associated - Focal oedema within the left rectus femoris and adjacent iliopsoas tendon adjacent to the anterior inferior iliac spine compatible with acute calcific tendinitis with minor myofascial oedema tracking into the pelvis. CT confirms the focal calcium hydroxyapatite deposits.
Conclusion

There are a broad spectrum of pathophysiological causes of lower limb oedema. Identifiable patterns on MRI studies guides us to a better understanding of its cause, which allows us to make an accurate diagnosis of the condition so that the appropriate treatment and management can be promptly initiated.
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