Infections of the musculoskeletal system: Radiologic Findings

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Learning objectives

To describe the radiological findings of the different types of infections of the musculoskeletal system.

Background

Musculoskeletal system infections can take many forms depending on the structures involved; different layers of soft tissues, bones or joints can be affected.

Because clinical parameters present low sensitivity and specificity for the detection of musculoskeletal infection, radiology plays an important role in the diagnosis. Computed tomography (CT) is useful for detecting the anatomical compartment involved by the infection, thereby allowing the most appropriate treatment to be chosen. Magnetic resonance (MR) imaging provides greater contrast resolution, better compartmental anatomy and greater sensitivity than CT for the detection of musculoskeletal system infections, but generally it is not available in the emergency department, is more expensive and requires longer examination time.

There are groups of patients that present an increased risk of developing musculoskeletal infections: intravenous drug abuse patients, HIV-infected patients, those with diabetes mellitus, peripheral vascular disease, sickle cell disease, immunosuppression, etc.

CLASSIFICATION

Musculoskeletal infections are classified according to the affected structures in:

- Soft tissue infections

  Cellulitis
  Necrotizing/non-necrotizing fasciitis
  Myositis
  Soft tissue abscess
The clinicoradiological distinction between different types of soft tissue infections is frequently difficult but necessary since treatment differs. The key elements which guide differentiation between different types of infections are the following:

- Depth of the involvement (subcutaneous tissue, superficial fascia, deep fascia, muscle).
- Presence of necrosis.

Cross-sectional imaging methods allow the distinction by means of the analysis of compartmental anatomy.

The skin consists of two distinct layers: the epidermis and the dermis. Immediately below the skin there is a layer of conjunctive subcutaneous tissue, the superficial fascia, which contains cutaneous nerves, blood and lymphatic vessels, lymphatic ganglia, as well as a large amount of fatty tissue; it is also known as subcutaneous tissue. Under the superficial fascia lies the deep fascia, a much more densely packed and strong layer of fascia. This is a layer of connective tissue that covers the muscles helping to maintain them divided and protected. All the skeletal muscles are surrounded by their own deep fascia.

**Imaging findings OR Procedure details**

**SUPERFICIAL CELLULITIS**

Superficial cellulitis represents an acute infection of the dermis and subcutaneous tissue. Inflammatory changes in superficial cellulitis do not extend beyond the superficial fascia.

Patients with cellulitis present with clinical symptoms of pain, edema, erythema and warmth.

Despite the fact that the diagnosis of cellulitis is clinical, CT is useful in differentiating superficial cellulitis from cellulitis associated with deep-seated infection; if the infection spreads to deeper tissues, necrotizing fasciitis, myositis or osteomyelitis can occur. Cellulitis may also be complicated by soft tissue abscess formation.
Superficial cellulitis demonstrates the following radiological findings: skin thickening, septation and stranding of the subcutaneous fat and thickening of the superficial fascia. There is **NO involvement of the deep fascia.** (Fig 1,2)

Edema due to heart failure or stasis has a similar appearance, and therefore clinical correlation is required.

Treatment of superficial cellulitis is conservative and consists of antibiotics and locally supportive measures.

**NECROTIZING / NON-NECROTIZING FASCIITIS**

Necrotizing fasciitis is a rapidly progressive infection of the deep fascia with secondary necrosis of the subcutaneous tissues.

The clinical symptoms are often non-specific, thus requiring a high degree of clinical suspicion. It may manifest with symptoms of fever and pain in early stages. The skin can be normal or show subtle findings similar to cellulitis; in advanced stages the skin becomes friable and takes on a black color. Crepitation due to subcutaneous emphysema is rarely palpable. The intense pain followed by anesthesia suggests the diagnosis.

Necrotizing fasciitis represents a surgical emergency. It has a morbidity and mortality rate of 70-80%, with one of the most important predictors of mortality being the delay in diagnosis.

It can occur after trauma, around foreign bodies in surgical wounds or it can be idiopathic (i.e. Fournier gangrene).

The most common type of necrotizing fasciitis is a polymicrobial infection caused by aerobic organisms and gas-forming anaerobic organisms, and therefore the presence of **gas in subcutaneous tissue** is a specific finding. A less frequent form is caused by Streptococcus pyogenes (around 10% of cases).

The other imaging findings are similar to cellulitis but more severe and with **involvement of the deep fascia.** Involvement of the superficial and deep fascia, fluid collections along the deep fascial planes and even extension of the edema into the intermuscular septa and muscles can be observed. (Fig 3,4)
The absence of enhancement of the fascias confirms the presence of necrosis and distinguishes necrotizing from non-necrotizing fasciitis.

Treatment of necrotizing fasciitis consists of antibiotics, early fasciotomy and surgical debridement of the necrotic tissue. Non-necrotizing fasciitis does not require emergency surgery but does require clinical and imaging monitoring due to the potential development of necrosis.

**MYOSITIS**

Myositis is an acute, subacute or chronic infection of skeletal muscle.

Pyomyositis or bacterial myositis, formerly considered a tropical disease, is now seen with increasing frequency in temperate climates, especially due to the emergence of HIV infection.

Besides HIV infection, other risk factors of pyomyositis are the following: rhabdomyolysis, muscle trauma (a hematoma may form and act as a nidus for infection), skin infections, infected insect bites, intravenous drug addiction and diabetes mellitus.

Myositis most frequently affects young adults. It usually manifests with subacute symptoms including fever, muscular pain and localized numbness.

Pyomyositis can be divided into three clinical stages: 1) the invasive stage, in which the edema in the affected muscle causes pain, 2) the suppurative phase in which the patient develops fever and, if not treated, an abscess, and 3) the late stage that leads to toxicity and sepsis.

Typically, a single muscle is involved although in 11-43% of patients there is involvement of multiple sites. Any muscle group can be affected although the most frequently involved muscles are the following by order of frequency: quadriceps > gluteus and iliopsoas muscles > upper extremity muscles.

The following imaging findings can be observed in myositis: **enlargement and decreased attenuation of the affected muscle** due to edema with effacement of adjacent fat planes. The muscular involvement is disproportionate to the involvement of the subcutaneous tissue. **Intramuscular fluid collections** can be observed. (Fig 5,6)
Intravenous contrast is useful to help differentiate necrotic from viable musculature and to demonstrate abscess formation.

Treatment of myositis consists of antibiotics and drainage in case of muscular abscesses.

**SOFT TISSUE ABSCESS**

Although the majority of bacterial infections of soft tissues remain localized, they can be complicated by abscess formation, especially in immunosuppressed patients.

At CT, an abscess is seen as a *well-defined fluid collection* with peripheral pseudocapsule and *ring enhancement*. (Fig 7)

Treatment consists of antibiotics and percutaneous drainage.

**OSTEOMYELITIS**

Osteomyelitis is an infectious process that involves all components of the bone but fundamentally the bone marrow.

It can be classified as acute, subacute and chronic.

It can result from hematogenous spread, direct inoculation or extension from a contiguous focus of infection.

Hematogenous osteomyelitis usually manifests with a slow, insidious progression of symptoms. In contrast, osteomyelitis due to direct inoculation presents with prominent local signs and symptoms.

The most frequently involved bones are the tibia, wrist bones, femur, ribs and thoracolumbar spine.

Conventional radiography is not sensitive in the detection of early osteomyelitis because bone changes are generally not evident until 14-21 days after the onset of infection.
Scintigraphy is the most sensitive method for the detection of early osteomyelitis but it has a low specificity.

MR imaging is the modality of choice for the early diagnosis of osteomyelitis since it is more sensitive than CT in demonstrating bone marrow edema and the associated soft-tissue inflammatory changes; however, CT presents greater availability.

The following imaging findings can be observed in osteomyelitis: effacement of fat planes, soft-tissue swelling, medullary low-attenuation areas or trabecular coarsening, focal cortical erosions, subperiosteal abscess and periosteal reaction. (Fig 8,9)

The presence of an extramedullary fat-fluid level is an uncommon but specific finding for osteomyelitis in the absence of trauma.

In **CHRONIC OSTEOMYELITIS**, prominent reparative changes occur with cortical thickening, irregular sclerosis around osteolytic areas, trabecular distortion and possible formation of Brodie’s abscess, sequestrum, involucrum, cloaca and fistula. (Fig 10,11)

**Sequestrum**: a necrotic bone fragment separated from the viable bone. It is visualised as a detached hyperdense bone fragment and is the most specific finding of chronic active osteomyelitis. It can move to the medullary cavity or drain through a fistulous tract. Its location is essential because it should be surgically removed and because it allows to diagnose chronic active osteomyelitis. (Fig 12)

**Involucrum**: neoformed bone tissue around the devitalised bone; a periosteal reaction acts to circumscribe the sequestrum, producing a thick sheet of new bone.

**Cloaca**: an opening in the involucrum through which granulation tissue and sequestrum may be drained. It communicates the medullary cavity with the adjacent soft tissues. (Fig 12)

**Fistula**: a tract that communicates the skin to the bone.

**Brodie's abscess**: it is a type of subacute or chronic osteomyelitis defined by a well-demarcated focus of active infection of variable size, lined by granulation tissue and surrounded by eburnated bone. Radiographically it is seen as a well-defined lytic lesion with a sclerotic margin in metaphyseal-diaphyseal location. The margin typically has precise borders in the centre and irregular borders in the periphery. It is common in children and more frequent in the tibia and femur. (Fig 13,14)
Treatment of osteomyelitis consists of early intravenous antibiotic therapy and surgical curettage when necessary, basically in chronic osteomyelitis.

We are not going into depth in the specific forms of osteomyelitis such as tuberculosis and bacillary angiomatosis (especially frequent in HIV patients) in this paper.

SEPTIC ARTHRITIS

Septic arthritis can result from hematogenous spread or contiguous extension from adjacent soft-tissue infection or osteomyelitis.

Large joints with abundant blood supply to the metaphyses are more prone to bacterial infection, with the most commonly involved joints being the shoulder, hip and knee. In intravenous drug abusers, the sternoclavicular joint is more frequently affected.

Septic bursitis can result from extension of an infection from the joint space into adjacent bursae.

Patients with septic arthritis usually present with symptoms of joint pain, fever, erythema, soft-tissue swelling, decreased range of motion of the joint and purulent synovial fluid.

Imaging findings of septic arthritis include: joint effusion, osteoporosis, bone erosions, poorly defined joint margins, decreased joint space, fat-fluid level (specific sign in the absence of trauma). (Fig 15)

MR imaging is more sensitive in the detection of early changes, revealing signal intensity alterations in the bone marrow and soft tissues with edema-like signal intensity.

If untreated, it can result in irreversible joint damage within 48 hours of the onset of infection. Therefore, early diagnosis is critical.

Treatment includes aspiration and culture of joint fluid, essential for determining the causative organism and its sensitivity to antibiotics.

Images for this section:
**Fig. 1**: Superficial cellulitis of the leg in a 81-year-old female. Ultrasound scan shows thickening of subcutaneous tissue and hypoechoic strands.

![Ultrasound image showing superficial cellulitis](image)

**Fig. 2**: Axial CT image of the same patient shows skin thickening with underlying subcutaneous stranding and septation.
**Fig. 3:** Necrotizing fasciitis of the left leg in a 85-year-old female. Axial CT image shows thickening and stranding of subcutaneous tissue and subcutaneous emphysema with gas dissecting along fascial planes.
**Fig. 4:** Axial CT image of the same patient at a more distal level shows gas dissecting along deep fascial planes.
Fig. 5: Pyomyositis in a 18-year-old male. Axial CT image shows enlargement and mild hypoattenuation of the left iliacus muscle with two intramuscular fluid collections.
Fig. 6: Axial CT image of the same patient shows enlargement and fluid collections in the left piriformis muscle.
Fig. 7: 50-year-old male with intramuscular abscesses secondary to tibial osteomyelitis. Axial CT image shows well-defined intramuscular fluid collections with peripheral enhancement.
Fig. 8: Osteomyelitis in a 54-year-old man with supracondylar amputation of the right lower limb. Coronal CT reconstruction of the distal femur shows soft-tissue swelling and obliteration of fat planes around the stump, areas of cortical interruption and periosteal reaction.
Fig. 9: Axial CT image of the same patient shows the same findings.
Fig. 10: 69-year-old man with chronic osteomyelitis of the right femur. Axial CT image shows osteolytic areas and trabecular coarsening in the right femoral head and neck.
**Fig. 11:** Axial CT image of the same patient at the level of the proximal third of the femoral shaft shows cortical thickening, irregular sclerosis and a hyperdense bone fragment separated from surrounding bone in the external diaphyseal region (sequestrum).
Fig. 12: 50-year-old male with chronic osteomyelitis of the tibia. A detached bone fragment is visualised separated from surrounding bone in medial tibial plateau (sequestrum) and destruction of the adjacent cortex (cloaca).
Fig. 13: Brodie’s abscess in a 45-year-old male. Coronal CT reconstruction shows a geographic lytic lesion with peripheral sclerosis in distal femoral metaphysis. Periosteal reaction is also observed.
**Fig. 14:** Axial CT image of the same patient shows the lytic lesion with well-defined borders and peripheral sclerosis, periosteal reaction, effacement of fat planes and soft-tissue swelling.
Fig. 15: Septic arthritis in a 36-year-old male with post-traumatic tetraparesia who presents with fever. Axial CT image shows left hip joint effusion and periarticular soft-tissue swelling with effacement of fat planes.
Conclusion

Musculoskeletal system infections can take many forms depending on the structures involved (soft tissues, bones, joints).

Because clinical and laboratory parameters present low diagnostic sensitivity and specificity for the detection of musculoskeletal infection, radiology plays an essential role in the early diagnosis, also allowing detection of the anatomical compartment involved by the infection and thereby helping to guide treatment options.

The clinicoradiological distinction between the different types of soft tissue infections is frequently difficult but necessary since the treatment is different. The key elements for differentiation are the depth of the involvement and the presence of necrosis.

Cellulitis is characterised by involvement that does not extend beyond the superficial fascia.

The key finding in necrotizing fasciitis is involvement of the deep fascia, and the presence of gas in subcutaneous tissue is a specific sign.

In myositis, muscle involvement that is disproportionate to the subcutaneous tissue involvement is observed.

Infections of the bone and joints (osteomyelitis and septic arthritis) have characteristic radiological findings.

Personal Information

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