MR imaging of bone and joint infection

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Introduction

Evaluation of suspected bone and joint infection is a common conundrum and radiology plays a vital role in not only ascertaining the presence of infection but also to assess the associated complications.

Pathophysiology

Osteomyelitis is the infection of the bone, which can develop via three routes, ie haematogenous seeding, contiguous spread from adjacent infection or direct implantation which could be traumatic or iatrogenic.

In contiguous spread the infection starts in the soft tissues which then involves the periosteum (periostitis), subsequently the infection spreads to the cortex (ositis) then involving the medullary cavity (osteomyelitis).

Imaging modalities

As with most musculoskeletal conditions plain radiographs are the initial investigation of choice, however the radiographs may be equivocal or unremarkable in acute infection, in which case more advanced imaging is usually required.

CT again has a limited role in acute infections and usually MRI and nuclear medicine scintigraphy is used. The general advantages of MRI over scintigraphy are its superb anatomic detail, quicker performance and the ability to evaluate both bone and adjacent soft tissue.¹ The negative predictive value of MRI for excluding osteomyelitis is 100%; that is, if the marrow is completely normal on all pulse sequences, then infection can be reliably excluded.

The positive predictive value is, however, not as good ranging from 53-94% because non infective causes of marrow oedema, such as reactive marrow oedema and cases of neuropathic arthropathy, can cause similar appearances.¹

MR protocol

Patient positioning and coil selection depends on the region to be evaluated, with surface coils preferred whenever possible. Imaging should be acquired in at least two orthogonal planes, usually axial and coronal images with sagittal images used in spine and knee imaging.

Sequences usually employed are a T1W, and fat suppressed T2W sequences with Gd enhanced sequences used in problem solving cases. Osteomyelitis is divided into three phases: Acute, subacute and chronic findings based on the patient’s clinical picture, on the duration of the disease and on imaging findings.⁸

Acute osteomyelitis

On MRI the first sign of acute osteomyelitis is obliteration of medullary fat seen as high signal on STIR/T2 weighted fat saturated images and low signal on T1 weighted sequences. This usually has ill defined margins (figure 1). Subsequently soft tissue oedema and periosteal reaction is seen. All the changes become apparent on MRI sooner than plain films.

Subacute osteomyelitis

On plain radiographs subacute osteomyelitis is seen as areas of lucency with or without sclerosis. Brodie’s abscess is a special type of subacute osteomyelitis occurring in children, most frequently in tibia and fibula. It is seen as a metaphyseal, well-defined lytic lesion with sclerotic margins.

On MRI it is seen as a well-circumscribed serpigenous or oval lesion which is low to intermediate signal on T1 and high signal on T2. It is surrounded by a low intensity rim that represents fibrous tissue and reactive bone. There is also associated marrow oedema (figure 2).

Chronic osteomyelitis

Chronic osteomyelitis is defined as infection of more than six weeks duration. The most specific sign is the presence of sequestrum, which is best appreciated on CT. Specific signs on MRI include:

- Subperiosteal fluid collection seen as high signal on T2 sequences which represents either fluid or abscess. Cloaca, which is seen as a defect in the periosteum, created by infection which is hard to visualise on T1 and high signal tract on T2 sequences.
- Involuture – thick sleeve of periosteal new bone surrounding dead cortical bone.
- Sequestrum – fragment of dead bone surrounded by granulation tissue which is low signal on both T1 and T2 weighted sequences and shows peripheral contrast enhancement.
- Sinus tract – channel extending from bone to skin surface, lined with granulation tissue, seen at bright signal of T2 and is difficult to visualise on T1 sequences (figure 3).

Abscess is a cavity filled with pus and lined by granulation tissue whereas phlegmon is a mass of inflammatory soft tissue. Both are low signal on T1 and high on T2 weighted sequences.

Post-operative osteomyelitis has similar MR imaging appearances to those in non-violated bones, however signal changes related to fibrovascular tissue can persist up to 12 months. Furthermore, residual metallic debris can cause significant susceptibility artifacts preventing accurate image interpretation.¹

Diabetic foot

Due to perpetual increase in the number of diabetics (3.2 million affected in UK) there has been a corresponding increase in the number of complications, one of them being pedal infection. As it is always a diagnostic challenge to look for active infection, even in the presence of clinical findings, radiological investigations plays a pivotal role (figure 4).
A few problem solving tools are: firstly, the presence of normal marrow signal on all sequences excludes osteomyelitis; secondly, the sclerotic marrow excludes active or chronic active osteomyelitis; thirdly, the marrow oedema of osteomyelitis affects the entire bone rather than subarticular signal change of arthropathy; and lastly, infection affects the pressure points as compared to neuropathic arthropathy, which involves predominantly midfoot joints.\textsuperscript{5,6}

**Septic arthritis**
Whenever a mono-arthropathy is encountered, diagnosis of septic arthritis must be considered, seen as joint effusion, synovial thickening and subarticular marrow oedema changes (figure 5). There can be associated erosions. There can be, however, an overlap between septic arthritis and active rheumatoid arthritis. Aspiration or synovial biopsy should be considered in suspected septic arthritis cases.

**Vertebral infections**
Haematogenous spread usually causes vertebral osteomyelitis. This may progress and involve the intervertebral disc and lead to discitis. Occasionally discitis can result from direct inoculation from iatrogenic process. MR shows end plate irregularity and narrow oedema. Disc involvement is seen as loss of intranuclear cleft and high signal intensity within the disc. In addition, both pyogenic and tuberculous spondylitis can have associated paravertebral and epidural abscesses (figure 6). The latter may show a subligamentous component, involving the longitudinal ligaments. In addition, the presence of multiple levels of vertebral involvement suggests tuberculosis rather than pyogenic infection.\textsuperscript{1}

**Conclusion**
MR plays an indispensible role in radiological evaluation of bone and joint infection, having a very high negative predictive value and providing excellent soft tissue detail to assess associated soft tissue complications.

**References**

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**Figure 1**
Acute osteomyelitis: Coronal T1 (A) and fat saturated T2 (B) images showing marrow signal loss (arrow in A) and oedema (arrow in B) with associated soft tissue inflammation.

**Figure 2**
Subacute osteomyelitis: Sagittal T1 (A) showing the penumbra sign, intermediate signal periphery of the subacute intraosseous abscess. Sagittal (B), coronal (C) and axial (D) T2 fat saturated images showing intraosseous abscess with peripheral marrow oedema.
Figure 3
Chronic osteomyelitis: Sagittal T2 fat suppressed and sagittal T1 images showing marrow oedema and intraosseous abscess. Axial post contrast image showing peripherally enhancing abscess (white arrow in C) and a cloaca (black arrow in C) communicating posteriorly into the popliteal fossa.

Figure 4
Septic arthritis: Plain film (A) shows periarticular osteopenia with associated erosion of the humeral head (arrow). Coronal MR (B) and sagittal (C) fat saturated images show marrow oedema (black arrow) and active florid synovitis (white arrows in B and C).

Figure 5
Pedal osteomyelitis: DP view of the foot (A) showing destruction of the second and third metatarsal heads. Axial T1 (B), T2 fat suppressed (C) post contrast T1 images (D) showing bone erosion of the second and third metatarsal head, soft tissue oedema (arrows in B and C) and enhancing soft tissue abscess under second metatarsal head (black arrow in D).

Figure 6
Pyogenic discitis: Sagittal T1 (A) and post contrast T1 fat suppressed sagittal (B) and axial (C) images showing, end plate erosion at L3/L4 level with marrow abnormality (arrows in A and B). Associated intradiscal (white arrow in A and B) and paraspinal abscess (black arrow).