Imaging Diagnosis of Osteomyelitis in Children

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Learning objectives

Osteomyelitis in pediatric patients is an important disease, because children are constantly growing and if the infection reaches the physis and epiphysis (because of the delayed diagnosis), serious sequelae may appear. Some of them are growth disturbances, joint instability, chronic infection, misalignment and limb deformity.

The clinical presentation in the pediatric age group can be nonspecific and the diagnostic images play an important role in early diagnosis, to determine the need for surgical debridement and evaluate complications.

In this poster we propose the following objectives:

• Review diagnostic performance of imaging study in osteomyelitis.
• Define the role of imaging in the monitoring of osteomyelitis treatment.
Background

INTRODUCTION

Osteomyelitis is an infection of bone and bone marrow. Hematogenous seeding of infection is most common in children and usually involves the metaphysis of the long bones.

Bone can also be infected by contiguous spread of infection of soft tissue, joint infections, puncture wounds or open fractures.

Metaphysis are highly vascularized and have a slow flow through capillary loops, which together with low oxygen tension, promotes bacterial growth.

A small abscess forms in the marrow of the metaphysis, followed by destruction of the adjacent bone. The inflammatory response to infection leads to increased intraosseous pressure, which can cause thrombosis of the vascular channels and extension of the infected exudate into several sites, as indicated in Fig. 1 on page 10.

The infection can extend through the porous metaphyseal cortex into subperiosteal space and form subperiosteal abscess.

In infants before 18 months of ages, the transphyseal capillaries remains opens, allowing the spread of infections from metahysis to ephysis and in some cases to joint.

EPIDEMIOLOGY

In developed countries, recent reports of osteomyelitis rates are 2 to 13 per 100,000 children.

Boys are slightly more often affected than girls, and fastgrowing long bones such as the tibia and femur are the most affected regions. Approximately 25% of cases affect the flat bones including the pelvis. A single bone is usually affected and multifocal involvement although rare, is more common in newborns, infants and immunocompromised patients.

The most common organism is Staphylococcus aureus, but in new born and infants there are other organisms as a Streptococcus agalatie and E. coli.

Between three months and toddlers the Kingella Kingae is another important microorganism.
Others microorganisms in childrens are *beta-hemolytic Streptococcus*, *Streptococcus pneumonia*, *Pseudomonas aeruginosa* (infection by puncture wounds) and *Neisseria gonorrhoeae* (in adolescent). *Salmonella spp* are important pathogens in sickle cell diseases.

In recent years the incidence of methiciline-resistant *Staphylococcus aureus* (MRSA) osteomyelitis has increased and is responsible for 30% of cases in some areas. MRSA infection has been associated with multifocal diseases, longer hospital stay, increased risk of subperiostal/muscle abscess, deep venous thrombosis and septic pulmonary emboli in comparison with methiciline-susceptible *S. aureus* (MSSA).

There are other microorganisms that can cause bone infection as viruses, spirochetes and fungi mainly in immunocompromised patients.

*Mycobacterium tuberculosis* is an important cause of osteomyelitis in less developed countries and most commonly affects the spine.

**CLINICAL CONSIDERATIONS**

The clinical presentation of osteomyelitis can be confusing and nonspecific in the pediatric population.

Clinical manifestations in children are limping or an inability to walk, fever and focal tenderness, and sometimes visible redness and swelling around an affected bone.

Infection in the neonate and infant is usually clinically silent. They may present irritability, poor appetite, pseudoparalysis of the affected limb, pain on movement and fever. Severe cases may have symptoms of sepsis.

Spinal osteomyelitis is characteristically manifested as back pain.

Children with MRSA osteomyelitis have high temperature, tachycardia, and a painful limp more often than those with methicillin-susceptible *S. aureus*.

Standard laboratory tests, such as sedimentation rate, C-reactive protein (CRP), and procalcitonin are usually elevated. The decrease of CPR usually suggests favorable response to treatment and is useful in monitoring these patients. Leukocytosis may be present (> 12,000 / ml) and blood cultures should be obtained to try to identify the causative organism (they are positive in 32-60% of cases).

Some authors consider the bone puncture in cases of osteomyelitis with torpid course, and cases of chronic osteomyelitis. In other centers it is routinely performed prior to initiation of antibiotic therapy, allowing the identification of pathogen in 40-60% of cases.
Complication of osteomyelitis are Brodie’s abscess formation, sequesters, fistulas and sinus tract lesions.

Other reported complications are septic arthritis, loss of function, slipped epiphysis, early closing of the physis that lead to growth retardation, or angulation deformation in the long bones.

The treatment is intravenous antibiotics therapy followed of several weeks of oral antibiotic therapy. Surgical debridement may be necessary in some cases (abscess formation, necrotic bone or failure to respond to antibiotic therapy).

IMAGING MODALITIES

Imaging evaluation depends on clinical presentation.

In acute hematogenous osteomyelitis the duration of the illness is less than 2 weeks. It is typically seen in young children, characterized by a rapid onset of symptoms and septic clinical course. Its typical localization is the metaphysis of the tibia and femur.

In subacute osteomyelitis the duration of diseases is 2 weeks to 3 months and a low-grade clinical course is common. Subacute Brodie's abscess constitutes a well-defined purulent infection of the bone surrounded by granulation tissue and sclerotic bone and typically involves the metaphysis of a long bone. It can also cross the physis and reach the epiphysis. It may develop sequestrum (fragments of necrotic bone inside the cavity), and may be associated with soft-tissue involvement after eroding the cortex.

Chronic osteomyelitis is characterized by bone sclerosis, thickened cortex, mostly well-defined soft-tissue abnormalities, and occasional sequestrum. An involucrum of new bone can be seen and may be perforated by sinus tract (cloacae) through which infection exits toward the surrounding soft tissues and eventually outside through the skin.

PLAIN FILM

Plain radiography is used in the initial evaluation and can be normal or show some soft tissue swelling and loss of normal fat planes within the first 48 to 72 hours after onset of symptoms. Osteolytic lesions, osteopenia and periosteal reaction appear 10-15 days after the onset of the disease. Fig. 2 on page 10. The sensitivity and specificity of plain radiographs are 43%-75% and 75%-83%, respectively.
At least two orthogonal views of the body part of interest should be obtained; views of the opposite limb may be useful for comparison to detect subtle changes.

In spondylodiscitis decrease of intervertebral space or vertebral erosions in the lateral radiograph can be observed.

Radiographs can detect other pathologies such as fractures and tumors that can clinically mimic osteomyelitis.

Bone destruction may appear as an area of permeative destruction and lucency that may be associated with surrounding bone sclerosis Fig. 3 on page 11.

Follow-up radiographs may be normal if therapy is successful, or periostal new bone formation may be noted.

Plain radiographs are also valuable for evaluation of complications, such as development of Brodie abscess, growth deficiency, and bone deformity.

ULTRASOUND

Ultrasound (US) is low-cost and has a high sensitivity in detection of subperiosteal and soft-tissue collections and can guide their diagnostic or therapeutic drainage.

It also distinguishes between phlegmon and abscess and detects joint effusions Fig. 4 on page 12. It is important to use a linear high-frequency transducer.

On sonography, the earliest manifestation of osteomyelitis is juxtacortical soft tissue swelling with early periosteal thickening. Early inflammatory changes are depicted as areas of hyperemia on color or power Doppler imaging.

A subperiosteal abscess is seen as an echogenic line adjacent to the cortex with a hypoechoic collection.

The sensitivity and specificity to osteomyelitis were reported in a range of 46%-74% and 63%-100%, respectively. However, US requires expertise and is highly operator dependent.

NUCLEAR IMAGING

The multiphase bone scan is usually positive after 24 to 48 hours from the onset of symptoms.
The scintigraphic procedures include whole body imaging and high-resolution static images optimized for a given location and pinhole images may be useful as well. The addition of tomographic cross-sectional single photon emission tomography (SPECT) improved anatomical orientation of nuclear medicine and is considered obligatory in some clinical situations, e.g. vertebral osteomyelitis.

The main advantage of scintigraphy is its ability to imaging the entire skeleton in patients whose symptoms cannot be localized and can detect multiple foci of bone infection. It can detect extension of metaphyseal osteomyelitis into the epiphysis through the growth plate.

The overall sensitivity and specificity for radionuclide bone scanning are 73-100% and 73-79%, respectively. In the neonate, however, the sensitivity of radionuclide bone scanning is decreased, ranging from 53 to 87%.

Technetium 99m methylene diphosphonate is the most widely scintigraphic procedure used in the diagnosis of bone infection.

Uptake depends on increased blood flow and osteoblastic activity. The increased uptake in the early (perfusion), intermediate (blood pool), and late (bone uptake) phases is typical for osteomyelitis.

More than 90% of the positive bone scans are "hot," with increasing uptake of 99mTc-MDP. Less commonly, decreased uptake ("cold" foci) is detected in osteomyelitis due to ischemia.

Scintigraphy has frequent false positive findings caused by physiological uptake of the physis, by prior traumatic injuries or tumors. Gallium-67 scintigraphy or indium-labelled leucocyte scan has been used to increase the specificity for infection, but are more complex techniques Fig. 5 on page 13.

FDG PET-CT appears to be considerably more sensitive and specific, but has limited availability and means higher radiation exposure.

**MAGNETIC RESONANCE IMAGING**

MR imaging has become the predominant modality for the evaluation of bone infections. MRI has the advantage of both high sensitivity (82-100%) and specificity (75-96%). It can also display high-resolution images and evaluate the complications such as abscesses, joint effusions and soft tissue extension.

The disadvantages include slighter higher cost relative to bone scintigraphy; prolonged imaging times, which may require sedation and scanner availability depending on the resources of each hospital.
The earliest manifestation of bone infection on MR images is the edema which is hyperintensity on T2 and STIR sequences **Fig. 6 on page 14**.

Bone and/or soft tissues abscess will be hypointense on T1, hyperintense on T2/STIR, with peripheral ring enhancement of granulation tissue after contrast administration **Fig. 7 on page 15**.

Brodie abscess presents as an intramedullary cavity, which is low signal intensity on T1 and high on STIR and T2-weighted images. The peripheral ring of granulation tissue has high signal intensity on all sequences and can enhance after contrast administration, whereas the outer ring of bony sclerosis has low signal intensity on all sequences, producing a target appearance **Fig. 8 on page 16**. There is often reactive edema in the surrounding bone marrow.

Gadolinium can also define areas of necrotic bone, which do not enhance after contrast administration.

Sinus tracts can be identified as T2 hyperintense signals. In chronic osteomyelitis, there is a good delineation between the normal and abnormal marrow and the normal and abnormal soft tissues surrounding the bones.

In case of spinal involvement, MRI is very important in the evaluation of the extent of the spondylodiscitis and presence of epidural abscesses. **Fig. 9 on page 17**.

In pelvic osteomyelitis, MR imaging is useful because the primary focus of disease is difficult to detect and the incidence of associated soft tissue abnormalities is high (may have intrapelvic extension). It usually occurs in a metaphyseal equivalent portion (adjacent to the sacroiliac joint, triradiate cartilage, pubic symphysis, ischiopubic synchondrosis and iliac apophyses).

MRI is used to differentiate osteomyelitis from other pathologies as stress injury, in which the edema is more confined to bone. In a soft tissue mass, a sharp transition between normal and abnormal marrow and invasion of adjacent structures suggest a tumor, whereas an abscess, a draining sinus and extensive perilesional edema suggest infection.

The spread of infection to the epiphysis is rare and is more common in infants under 18 months of age. MRI plays an important role in these cases, because abscesses affecting epiphyseal cartilage cannot be seen in precontrast images. The enhancement of these abscesses after administration of gadolinium allows a correct diagnosis. **Fig. 10 on page 18**.
There has been an increasing use of whole-body MRI to detect multifocal disease or abnormalities that are not well-localized.

Chronic bacterial osteomyelitis should be differentiated from chronic recurrent multifocal osteomyelitis (CRMO), a nonbacterial inflammatory disease involving multiple osseous structures, typically the metaphysis of long bones and the clavicle. Whole-body MRI is a useful modality for the evaluation of this disease; symmetric involvement is highly suggestive of this condition, which responds to anti-inflammatory agents rather than antibiotics.

If there is no clinical response after 48 hrs of systemic antibiotic therapy and elevated inflammatory markers remain, repeating MRI should be considered to exclude complications that would require surgical interventions. In addition, if immediate surgical therapy is planned, earlier imaging with MRI may be of use.

**COMPUTED TOMOGRAPHY**

CT is of limited clinical value in acute osteomyelitis. It is more useful in advanced or chronic disease to detect cortical destruction, sequestrum and sinus tract. [Fig. 11 on page 19.]

Bony sequestra can be identified within the marrow with a surrounding involucrum, living bone that forms around the necrotic sequestrum. Postcontrast imaging can define soft tissue abscess as nonenhancing fluid surrounded by a rim of enhancing tissue.

In some cases, intraosseous gas or within the medullary canal might be visible.
Images for this section:

Fig. 1: Pathway for the spread of infectious focus in the metaphysis (bone abscess, BA). 1, spread to the bone marrow (BM); 2, formation of a subperiosteal abscess; 3, penetration of the periosteum (P) and spread to the adjacent soft tissues; 4, 5, and 6, spread across the growth plate (GP) to the epiphysis (E), and eventually to the joint space (JS).

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Fig. 2: A) Five years old patient with pain in the right ankle. Initial X-ray: soft tissue edema of ankle, no other findings. In this patient, scintigraphy was performed and diagnosis of osteomyelitis of right fibula and septic arthritis was obtained, and required surgical drains. B) Control X-ray one year after treatment: Right fibula with sclerotic cortical thickening of scar appearance.

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Fig. 3: A) Patient 2 years of age with fever and pain in the right lower extremity. X-ray of pelvis present a lytic lesion surrounded by sclerosis in the right proximal femur. B) The same patient was performed diagnosis of subacute/chronic osteomyelitis in the proximal femur and in the control radiography three months after treatment, reparative sclerosis changes were seen.

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Fig. 4: Patient with suspected synovitis in his right hip. Ultrasound: synovitis and effusion in right hip.

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Fig. 5: Five years old patient, with fever and pain in the right ankle. (A) Technetium 99 Scintigraphy: inflammatory disease of moderate severity in right tibio-talar joint, with probable septic involvement. (B) Gallium Scintigraphy was conducted to confirm the diagnosis of osteomyelitis in the right fibula.

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Fig. 6: Patient 9 years old, with fever as the only symptom before hospitalization. MRI: Bone edema in the greater trochanter of the right femur, which compromises the core of ossification and neck/proximal femoral metaphysis. A) Fat-sat DP and B) Fat-sat T2.

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Fig. 7: Patient 7 years of age, with fever, vomiting and pain in the left leg. MRI: Edema of the distal femoral metaphysis, associated to subperiosteal abscess, which present peripheral enhancement after intravenous contrast administration. A) T1 TIRM, B) Axial Fat-sat T1 and C) Postcontrast fat-sat T1.

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Fig. 8: Patient 10 months old, with initial fever who during hospitalization present pain and swelling in his right shoulder. MRI: Proximal humeral metaphysis abscess with peripheral hypointense rim on all sequences, with mild perilesional edema. After contrast administration it presents a peripheral enhancement, compatible with Brodie abscess (target sign). It is associated with myositis subscapularis muscle. A) and B) Postcontrast fat-sat T1. C) T1 TIRM COR.

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**Fig. 9:** Patient 13 years old with back pain, fever and headache. MRI: Epidural posterior collection, of fusiform shape, located at the level of D2-D9, hypointense on T1, hyperintense T2(A), which has a peripheral and septal uptake, after the administration of intravenous contrast(B. Postcontrast fat-sat T1). Appears to be associated with an image of involvement around the right facet joint on D7-D8, suggestive of arthritis(C. Sagittal T2).

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**Fig. 10:** Patient 10 months old, with osteomyelitis of the proximal humeral metaphysis, with suspected involvement of the physis. Post-surgical MRI shows clear involvement of the physis (A: Fat-sat T1), most evident in the postcontrast fat-sat T1 sequence(B).

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**Fig. 11:** Infant 17 months old with pain and edema in the left wrist. CT: Metaphyseal lytic lesion of ulna with cortical destruction, which is in contact with not ossified epiphysis. It is associated with periosteal reaction and adjacent soft tissue inflammation. A) Coronal CT, B) Volume rendering reconstruction and C) Soft tissue window CT.

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Findings and procedure details

CLINICAL FEATURES

We have diagnosed 10 cases of osteomyelitis in children in our hospital, from July of 2011 to September of 2014. The range age of patients is from 10 months to 14 years old. The male: female ratio was 9:1.

Most patients had an acute course of the disease with less than 2 weeks duration (from 1 day to 11 days) and only one patient had 2-3 weeks of symptoms before hospital admission.

In most cases the patients had fever, localized pain and swelling in a joint or limb, and functional limitation. One patient had fever as the only symptom before admission. After a positive blood culture for S. aureus, bone scintigraphy was performed and it detected the focus of infection in the left femur.

One infant had fever associated with diarrhea before admission. During the 7th day of hospitalization, he presented edema, erythema and pain in his right shoulder.

In only five subjects it was possible to identify the pathogen bacteria, three by blood culture and two by aspirated material culture. In three patients methicillin-sensitive St. aureus and in another St pyogenes was the causative agent. In the other patient methicillin-resistant St. aureus was isolated, both in the blood culture and in the culture of the drained material.

IMAGING DIAGNOSIS FINDINGS

Our patients were diagnosed by MRI and/or bone scintigraphy. In one patient the diagnosis was made with scintigraphy and CT.

MRI protocol standard used in most of our patients was multiplanar sequences on T1, fat-sat DP/T2, STIR, gradient echo T2 and postcontrast fat-sat T1.

In all patients in whom scintigraphy was performed, it was made with technetium 99 and in some cases Gallium-67 was required to complete study.

Table 1 and 2, summarize some clinical features and imaging diagnosis findings of our patients. Table 1 on page 24 Table 2 on page 24.
In patient 1, with a longer history (2-3 week of symptoms) the bone scan presented hyperemia in the vascular and bone phase in the distal third of right femoral diaphyseal-metaphyseal bone, above the growth plate, compatible with osteomyelitis Fig. 12 on page 25. MRI was also performed, showing signs of subacute osteomyelitis with Brodie’s abscess Fig. 13 on page 26.

This patient received intravenous antibiotic therapy for 2 weeks and he underwent surgical drainage of the abscess.

Clinical evolution was satisfactory, although MRI control at 3 months after hospitalization, showed postoperative changes in the area of the abscess with bone marrow edema of adjacent diaphysis, and dubious areas of low contrast uptake. Therefore scintigraphy with technetium 99 and Gallium 67 were performed, showing mild inflammation in the right distal femur, similar to reparative changes Fig. 14 on page 27. Antibiotic treatment was completed by six months.

Patient 2, with 11 days of clinical course, presented a lytic lesion surrounded by sclerosis in the proximal right femur on plain radiography Fig. 3 on page 28.

Technetium 99m scintigraphy showed an area of enhancement on right proximal femur on vascular and bone phase, suggestive of septic inflammatory process (osteomyelitis). MRI presented changes suggestive of subacute/chronic osteomyelitis with mild joint effusion Fig. 15 on page 29.

The patient received intravenous antibiotic therapy, followed by oral antibiotic and presented good outcome.

In a patient 3, with acute clinic on left knee, the initial radiography showed soft tissue edema. MRI findings were consistent with acute osteomyelitis of the left distal femoral metaphysis, associated with subperiosteal abscess and myositis Fig. 16 on page 30. The patient received intravenous antibiotic therapy, but symptoms persisted. A new MRI was performed showing enlarged subperiosteal abscess, which required several surgical intervention. MRSA was isolated as causing organism and therefore the antibiotic therapy was changed.

Subsequently, the patient progressed to improvement and treatment was completed with oral antibiotic.

In the outpatient controls, new imaging studies (Radiography and MRI) were made, which showed signs suggestive of subacute-chronic osteomyelitis. Scintigraphy was performed (Fig. 17 on page 31) and confirmed the persistence of inflammatory/infectious process, whereby antibiotic treatment was restarted and the patient carried on his treatment in another hospital, where surgical intervention was performed.
Patient 4, with acute evolution of symptoms, presented pain in the dorsal spine and slight limitation for movement. During his hospitalization, he presented progressive loss of strength in lower extremities with sensation of paresthesia and loss of sphincter control. MRI showed findings consistent with epidural abscess extending D2-D9, with an image on the right facet joint in D7-D8, suggestive of septic arthritis/osteomyelitis. Laminectomy and surgical drainage was performed, along with intravenous antibiotic treatment for 3 weeks. The patient progressed satisfactorily, with improvement in his neurological symptoms and resolution of epidural abscess in successive MRI Fig. 18 on page 32. Outpatient oral antibiotic treatment was completed.

The infant (patient 5) with initial nonspecific symptoms, presented during the hospitalization symptoms at right shoulder. US was performed, showing right articular glenohumeral synovitis. Subsequently scintigraphy showed severe inflammatory process of right shoulder (arthritis) and decrease of growth plate uptake, which suggest indirect sign of septic process (osteomyelitis). Study was completed with shoulder MRI showing: subacute osteomyelitis with abscess of the right proximal humeral metaphysis, with probable involvement of the physis. Marked glenohumeral joint synovitis without abundant joint effusion and subscapularis muscle myositis were also identified. Surgical drainage was performed and intravenous antibiotic treatment was completed for two weeks with proper evolution. The patient received oral antibiotic treatment and outpatient follow-up Fig. 19 on page 33.

To the remaining patients with acute course of the disease, several diagnostic image tests were performed during hospitalization (Rx, CT, MRI and/or bone scintigraphy) where the final diagnosis was obtained. All patients received intravenous antibiotic therapy followed by oral antibiotic and presented adequate evolution. Only one patient required surgical joint lavage due to associated arthritis. Diagnoses of these patients were:

- Patient 6: Osteomyelitis of right distal femur with small subperiosteal abscess, associated with pyomyositis of the femoral biceps Fig. 20 on page 34.
- Patients 7 and 8: Osteomyelitis of the right fibula associated with tibiotalar arthritis Fig. 21 on page 35.
- Patient 9: Osteomyelitis of the right femur trochanter Fig. 22 on page 36.
- Patient 10: Osteomyelitis of the left distal ulna Fig. 23 on page 37.
### Table 1: Summary table of the clinical features and radiological findings of our patients.

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<table>
<thead>
<tr>
<th>PATIENT</th>
<th>AGE</th>
<th>DIAGNOSIS</th>
<th>IMAGING FINDINGS</th>
<th>PATHOGEN ISOLATED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14 years</td>
<td>Subacute osteomyelitis</td>
<td>Scintigraphy: hyperemia in the distal third of right femoral diaphyseal-metaphyseal bone. MRI: subacute osteomyelitis with Brodie's abscess in the right distal femoral metaphysis. Control MRI: postoperative changes in the area of the abscess with bone marrow edema of adjacent diaphysis, and dubious areas of low contrast uptake. Control Scintigraphy: reparative changes.</td>
<td>Drainage culture: methicillin-sensitive Staphylococcus aureus (MSSA)</td>
</tr>
<tr>
<td>2</td>
<td>2 years</td>
<td>Subacute/chronic osteomyelitis</td>
<td>Radiography: lytic lesion surrounded by sclerosis in the proximal right femur. Tc-99m Scintigraphy: area of enhancement on right proximal femur, suggestive of septic inflammatory process. MRI: subacute/chronic osteomyelitis with mild joint effusion.</td>
<td>Blood culture: negative</td>
</tr>
<tr>
<td>3</td>
<td>7 years</td>
<td>Subacute osteomyelitis</td>
<td>Initial X-ray: soft tissue edema. MRI: acute osteomyelitis of the left distal femoral metaphysis, associated with subperiosteal abscess and myositis. Control X-ray: permeative lesion of the distal metaphysis of the left femur with periosteal reaction. Post-treatment MRI: Bone edema with hypointense areas in distal femoral metaphysis, suggestive of intramedullary necrosis. Control scintigraphy confirmed the persistence of inflammatory / infectious process.</td>
<td>Drainage culture and blood culture: St. aureus methicillin resistant. MRSA</td>
</tr>
<tr>
<td>4</td>
<td>13 years</td>
<td>Osteomyelitis with arthritis in D7-D8 and epidural abscess</td>
<td>MRI: epidural abscess extending D2-D9, with signs of septic arthritis on right facet joint of D7-D8. Control MRI: resolution of epidural abscess.</td>
<td>Bone culture and abscess culture: MSSA.</td>
</tr>
</tbody>
</table>
### Table 2: Summary table of the clinical features and radiological findings of our patients.

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Fig. 12: Scintigraphy with technetium 99: hyperemia in the vascular and bone phase in the distal third of right femoral diaphyseal-metaphyseal bone, compatible with osteomyelitis.

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**Fig. 13:** MRI: Pseudonodular lesion in metaphyseal-diaphyseal region of the right distal femur, on target shape. Intramedullary cavity presents a low signal on T1 and high signal on T2, with peripheral hypointense rim on all sequences (A: Axial fat-sat DP/T2). After intravenous administration of contrast, showed peripheral enhancement of cavity (granulation tissue). It is associated with perilesional edema of bone marrow (B and C: Postcontrast fat-sat T1).

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**Fig. 14:** 1. MRI. A) Coronal T1. B) and C) Postcontrast fat-sat T1. Postsurgical changes: drain residual cavity with granulation tissue. Persists bone edema with areas of low contrast uptake after administration of intravenous contrast. 2. Bone scintigraphy with gallium 67: Slight uptake in metaphyseal-diaphyseal region of the right distal femur, suggestive of reparative changes (D).

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**Fig. 3:** A) Patient 2 years of age with fever and pain in the right lower extremity. X-ray of pelvis present a lytic lesion surrounded by sclerosis in the right proximal femur. B) The same patient was performed diagnosis of subacute/chronic osteomyelitis in the proximal femur and in the control radiography three months after treatment, reparative sclerosis changes were seen.

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Fig. 15: MRI. A) Fat-sat T2, B) and C) Postcontrast fat-sat T1. Pseudonodular lesion in the right femoral neck with cystic and sclerotic components, which has mild enhancement after intravenous contrast administration. Bone edema is not observed.

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Fig. 16: A) X-ray of left knee: soft tissue edema without bone changes. MRI: Edema of the distal femoral metaphysis, associated to subperiosteal abscess, which present peripheral enhancement after intravenous contrast administration. B) Sagittal TIRM and C) Postcontrast fat-sat T1.

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**Fig. 17:** A) Control X-ray of knee: permeative lesion of the distal metaphysis of the left femur with periosteal reaction, suggestive of disease progression. B) Control MRI: Persistence of bone edema with patched hypointense areas in distal femoral metaphysis, which have low uptake after intravenous contrast administration, suggestive of intramedullary necrosis (Postcontrast fat-sat T1). C) In the next control MRI showed increase of intramedullary necrosis areas (Post contrast fat-sat T1). Bone scintigraphy with technetium 99 (D) and gallium 67(E): persistence of inflammatory/septic pathology in distal third of the left femur.

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**Fig. 18:** 1) Diagnostic MRI: Posterior, extramedullary, epidural collection, of fusiform shape, located at the level of D2-D9, hypointense on T1, hyperintense T2, which has a peripheral and septal uptake, after the administration of intravenous contrast (A). Appears to be associated with an image of involvement around the right facet joint on D7-D8, suggestive of arthritis (B). A) Postcontrast fat-sat T1 and B) Sagittal T2. 2) Control MRI: Postsurgical changes (laminectomy), with resolution of the abscess. Discrete dorsal hyperkyphosis, secondary to anterior wedging of the disc spaces D5-D6 and D6-D7 (C. Postcontrast fat-sat T1).

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**Fig. 19:** A) Scintigraphy: severe inflammatory process of right shoulder (arthritis/osteomyelitis). Diagnostic MRI: Proximal humeral metaphysis abscess with peripheral hypointense rim on all sequences, with mild perilesional edema. After contrast administration has a peripheral enhancement cavity (B. Postcontrast fat-sat T1). It is associated with myositis of the subscapularis muscle (C. Fat-sat DP). Control MRI (D. Postcontrast fat-sat T1): Postsurgical changes, with residual cavity in the proximal humeral metaphysis and clear involvement of the physis.

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Fig. 20: A) Scintigraphy: moderate-severe inflammatory articular disease in right hip and knee. MRI: bone edema of right distal femoral metaphysis with disruption of the posterior cortex of the metaphysis (C). Subperiosteal abscess (D) and mild piomiositis of biceps femoris muscle. B) Coronal TIRM. C) and D) Axial fat-sat T2.

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Fig. 21: A) Tc-99 m Scintigraphy: inflammatory disease of moderate severity on right tibiotalar joint, unable to rule out septic involvement. B) Gallium 67 Scintigraphy: osteomyelitis in the right fibula.

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**Fig. 22:** A) Scintigraphy: increased uptake on right femur trochanter, compatible with osteomyelitis. MRI: bone edema in the greater trochanter of the right femur, which compromises the nucleus of ossification and neck/proximal femoral metaphysis. B) Coronal fat-sat DP, C) Axial fat-sat T2 and D) Sagittal STIR.

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**Fig. 23:** A) X-ray wrist: osteolysis of distal ulna and thickening of soft tissues. B) Scintigraphy: increased uptake in the distal third of the left ulna with low uptake in growth cartilage, suggestive of osteomyelitis. CT: lytic lesion in the left ulnar metaphysis, with cortical destruction, periosteal reaction and soft-tissue swelling. C) Soft-tissue windows, D) Bone windows and E) Volume rendering reconstruction.

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Conclusion

1. Osteomyelitis is the most common musculoskeletal infection in the pediatric age, and is of great importance because children are constantly growing and improper diagnosis and treatment can leave serious sequelae.

2. In the pediatric age, clinical symptoms of osteomyelitis are nonspecific, which makes it difficult proper diagnostic approach, whereby diagnostic imaging studies play an important role.

3. Although radiography remains the initial assessment of these patients in many cases, the final imaging diagnosis is performed by bone scan and/or MRI.

4. Bone scintigraphy is useful in the diagnosis of patients with not localized disease, but MRI is increasingly being used when focalized symptoms exist, because it provides a more detailed diagnosis of the disease (extension and study of complications), without exposure of the patient to ionizing radiation.

5. Despite some of the disadvantages of the MRI (need for sedation and limited availability in some centers), several authors have suggested it is the best imaging technique in the diagnosis of osteomyelitis. It is also increasingly used for the study of multifocal disease with whole-body MRI.

6. The bone scan and MRI are useful in monitoring patients, but the latter is more useful to guide the surgical treatment.
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