Pediatric osteomyelitis: an approach to differential diagnoses

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Learning objectives

• To revise the physiopathology and imaging findings of pediatric osteomyelitis with different imaging modalities.

• To describe the differential entities that can mimic acute and chronic osteomyelitis in children, focusing on diagnostic pearls and potential pitfalls to make a correct diagnosis.
Background

**Epidemiology**

Osteomyelitis (OM) is a significant cause of morbidity and mortality in children throughout the world, with a reported incidence of about 1:5,000, and responsible for 1% of all pediatric hospitalizations. Children under 5 years of age are the most affected, with boys affected twice as often as girls. Staphylococcus aureus is by far the most common agent (80%), followed by the respiratory pathogens Streptococcus pyogenes and S. pneumoniae.

**Physiopathology**

OM is inflammation of the bone accompanied by bone destruction, usually due to bacterial infection. Bacteria may reach bone by three main routes: hematogenous seeding (most common), direct implantation from traumatic wounds and spread from a contiguous source of infection like cellulitis or septic arthritis. Blood-borne organisms deposit in the metaphysis of long bones, most frequently femur (36%), tibia (33%) and humerus (10%), due to a large supply of slow-flowing blood and to the presence of endothelial gaps of the metaphyseal vessels. Risk factors include trauma, sepsis, immunodeficiency, sickle cell disease and vascular catheters. When OM is diagnosed, it can be classified as acute if the duration of symptoms has been less than 2 weeks, subacute for longer than 2 weeks, and chronic for months after the onset of symptoms.

**Diagnostic workout**

Clinical findings are variable and nonspecific, which in addition to the lack of specificity of children’s complaints can pose diagnostic difficulties. Classic symptoms and signs include limping or inability to walk, fever, focal pain and sometimes erythema and soft tissue swelling. The most sensitive inflammatory markers are erythrocyte sedimentation rate (ESR) and C reactive protein (CRP) which are almost always raised, although normal values do not exclude OM. White blood cell count (WBC) is an unreliable indicator as in many cases it remains normal. Blood cultures are only positive in 40% of cases of acute OM and negative in 100% of cases of sub-acute OM. Imaging plays thus a main role in establishing the initial diagnosis and the extent of disease spread. Also, it helps making the correct differentiation with several pathologies that can mimic OM, in order to initiate a timely and appropriate therapy and avoid complications, unnecessary biopsies and long-term antibiotic treatment.
Findings and procedure details

1. THE IMAGING OF OM (FIG. 1; FIG. 2; FIG. 3)

1.1 PLAIN RADIOGRAPHY

Plain radiography has low sensitivity and specificity for detecting acute OM. In the first 7-10 days, only 20% of patients will have an abnormal radiograph. Bone marrow edema, which is the earliest pathological feature, is not visible on plain films. The findings of OM include soft tissue swelling, periosteal reaction and a well-circumscribed bony lucency representing an intraosseous abscess. In chronic OM, usually occurring after trauma or surgery, a sequestrum may be visible on plain radiographs as a focal sclerotic lesion with a lucent rim. An involucrum is seen as thickened and sclerotic bone surrounding the sequestrum. Additional findings include cortical destruction, ill-defined bony lucencies and a disorganised trabecular pattern. The findings of chronic OM are best demonstrated with CT.

A high index of suspicion and further imaging with other modalities will often be required. Despite its limitations, plain radiography remains the first-line imaging test, as it is necessary to exclude other pathologies such as injuries or tumors. It is also useful for assessing the progression of disease on follow-up films.

1.2 MAGNETIC RESONANCE IMAGING (MRI)

MRI allows early detection of OM, assessment of the extent of involvement and the activity of the disease in cases of chronic bone infection. It has a very high sensitivity and a normal MRI virtually excludes OM. Bone marrow edema can be detected as early as 1 to 2 days after the onset of infection, producing an ill-defined low-signal intensity on the T1-weighted images and a high signal on T2-weighted and short-tau-inversion recovery (STIR) or fat-suppression (FS) sequences. MRI is also sensitive for detection of periosteal elevation and presence of a subperiosteal fluid collection or abscess. In subacute OM the Brodie’s abscess appears as a fluid filled cavity with an enhancing lining rim of low signal sclerosis and peripheral edema in the metaphyseal zone. The "penumbra sign" results from a discrete layer of highly vascular granulation tissue surrounding the abscess cavity that is hyperintense to the main abscess on T1-weighted images and has intense rapid enhancement after administration of gadolinium. This feature has been reported to be 27% sensitive but 96% specific for the diagnosis of OM. Imaging chronic OM is helpful to evaluate the extent of infection in bone and surrounding soft tissue, identification of an abscess, sequestrum and sinus tract/cloaca. The sequestrum can be difficult to visualize on MRI, appearing dark on all sequences, surrounded by enhanced granulation tissue. The involucrum is seen as a thickened shell of bone around the sequestrum. Cloaca can
be seen as a cortical defect that drains pus from within the medulla to the surrounding soft tissues.

Limitations of MRI include its inability to distinguish infectious from reactive inflammation and imaging sites with metallic implants.

1.3 COMPUTED TOMOGRAPHY (CT)

CT is more available than MRI, has superior bony resolution and is better at demonstrating osseous changes such as cortical destruction, periosteal reaction and sequestrum formation. As with plain films, the sequestrum on CT appears as a sclerotic lesion with a lucent rim. However, CT is limited by its inability to demonstrate bone marrow edema and by its poorer soft tissue resolution. A normal CT does not exclude OM. Other limitations include ionizing radiation exposure and image degradation by streak artifact when metallic implants are present. Despite these disadvantages, CT is a useful alternative when MRI is unavailable or contraindicated.
Fig. 1: Acute haematogenous OM in an 11-year-old girl. (A) Axial T2 and (B) coronal STIR show extensive metadiaphyseal high signal in the medullary cavity (green asterisks) affecting the distal 2/3 of the right femur, that can represent either bone marrow edema or intramedullary abscess, with associated marked edema in the surrounding soft tissues. The periosteum is separated from the cortex by high signal material representing pus (red arrows) that disseminates to the surrounding soft tissues. (C) Axial and (D) coronal T1FS after the administration of intravenous contrast confirms the presence of a subperiosteal abscess by showing lack of enhancement. There is also lack of medullary enhancement, confirming the presence of intramedullary abscess.

References: Radiology, Centro Hospitalar de São João, Faculdade de Medicina da Universidade do Porto - Porto/PT.
Fig. 2: The "penumbra sign" of Brodie’s abscess in an 8-year-old boy. (A) Anteroposterior (AP) radiograph shows an osteolytic lesion with a sclerotic margin in the inferior aspect of the greater trochanter of the left femur, representing a Brodie’s abscess (blue arrow). (B) Axial and (C) coronal T1 images shows a fluid filled hypointense cavity in the left proximal femoral metaphysis with a rim of discrete peripheral zone of higher intensity than the central abscess cavity due to highly vascularized granulation tissue (red arrow). This feature has been called the "penumbra sign" and has a high specificity for the diagnosis of OM, with a reported specificity of 96%. (D) Axial and (E) coronal STIR images shows hyperintense fluid filled abscess cavity (red arrowheads) and edema in the surrounding bone marrow and soft tissues (green arrows). Thick layer of perilesional bone formation and sclerosis as a hyposignal on T1 and STIR sequences were seen.

References: Radiology, Centro Hospitalar de São João, Faculdade de Medicina da Universidade do Porto - Porto/PT.
Fig. 3: Chronic osteomyelitis in a 16-year-old boy. (A) AP radiograph shows marked periosteal thickening and a central osteolytic lesion (blue arrow). (B) Sagittal and (C) axial CT with bone windows show a central sclerotic fragment of bone which is separate from the rest of the humerus by a lucent rim, consistent with a sequestrum (red arrow). Cortical thickening is also noted, as seen in radiography, representing an involucrum which is a result of periosteal new bone formation. There is also noted a linear defect of the cortical bone in the anterior aspect of the humerus, better identified in (C), representing a cloaca (red arrowhead).

References: Radiology, Centro Hospitalar de São João, Faculdade de Medicina da Universidade do Porto - Porto/PT.

2. DIFFERENTIAL DIAGNOSIS (FIG. 4)
### Differential Diagnosis of Osteomyelitis (OM)

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**Fig. 4:** Differential diagnosis of OM.

**References:** Radiology, Centro Hospitalar de São João, Faculdade de Medicina da Universidade do Porto - Porto/PT.

### 2.1 STRESS FRACTURES (FIG. 5; FIG. 6)

The most common cause of stress fractures is a chronic and repeated workload. A multiplicity of factors determines a more vulnerable propensity of children and adolescents to stress injuries: weak chondro-osseous junctions, increased physical activity, less muscle mass, narrower bones with thinner cortices, hormonal changes and decreased mineral content of bones. The differential diagnosis of a stress injury can be challenging because it can appear aggressive at imaging assessment. However, challenges in the diagnosis result most commonly from the absence of a complete history and inability to address a precipitator activity.

MRI is the best diagnostic modality, showing a well-defined and linear fracture, depicted as low signal intensity on T1-weighted and high signal on STIR and T2-weighted images. Intravenous contrast agents increase the conspicuity of the nonenhancing fracture line surrounded by enhanced medullary space. A good point on differentiating OM from stress...
fractures is the evaluation of soft tissue edema, as the edema in stress fractures is confined primarily to the bone. The soft-tissue findings in OM may be just as prominent as the marrow abnormality. Also, other findings can be depicted in OM such as an intraosseous abscess.

Fig. 5: Stress fracture in a 14-year-old boy athlete. (A) Sagittal and (B) coronal T1 images show a low signal linear fracture in the lateral condyle of the left femur immediately above to the epiphyseal plate (blue arrows). There is also apparent a discrete linear fracture in the distal aspect of the lateral condyle. (C) Sagittal and (D) coronal T2FS images show exuberant bone marrow edema (green asterisks)
surrounding the hypointense fracture lines. There is also present a small intra-articular effusion. Note that there is no edema in the surrounding soft tissues.

References: Radiology, Centro Hospitalar de São João, Faculdade de Medicina da Universidade do Porto - Porto/PT.

Fig. 6: Stress fracture in a 16-year-old girl athlete. Coronal (A) T1 and (B) T2FS images show a linear fracture in the tibial diaphysis accompanied by bone marrow edema. Note that there is no edema in the surrounding soft tissue. This fracture was initially misdiagnosed as osteoid osteoma.

References: Radiology, Centro Hospitalar de São João, Faculdade de Medicina da Universidade do Porto - Porto/PT.
2.2 VASO-OCCLUSIVE DISEASE (FIG. 7)

For the diagnosis of vaso-occlusive disease it is important to access the history of precipitating factors, such as sickle cell disease or the use of corticosteroids. Plain films will show typical serpiginous sclerotic lesions and MRI will show linear hypointense T1- and T2-weighted images in the metaphysis and epiphysis.

Fig. 7: Osteonecrosis in the left humeral head in a 10-year-old girl with sickle cell disease and complaints of pain and limited range of motion in this area. (A) Sagittal T1 and (B) fluid-sensitive sequence show serpiginous hypointense lines consistent with the diagnosis of osteonecrosis (blue arrows).

References: Radiology, Centro Hospitalar de São João, Faculdade de Medicina da Universidade do Porto - Porto/PT.

2.3 PRIMARY BONE SARCOMAS

Differential diagnosis with bone tumors is of high suspicion in the presence of a soft tissue mass, invasion of adjacent structures and a possible narrow transition between normal and abnormal bone marrow. In contrast, OM tends to cause more rapid destructive changes compared to malignant bone tumors. Abscesses demonstrate peripheral rim enhancement whereas tumors usually enhance heterogeneously.

2.3.1 OSTEOSARCOMA (FIG. 8)
Osteosarcoma although rare (0.2% of all malignant tumors) is the most common primary bone malignancy in the pediatric population. It has a male predominance and patients most commonly present between the ages of 10 and 25. It is classified as primary and secondary. Primary are further sub-typed as intramedullary/central and surface osteosarcomas (the periosteal and parosteal forms). It mainly occurs in the metaphyseal areas (91%) of long bones of the extremities: lower end of femur, upper end of tibia, upper end of humerus and upper end of femur. More than half of these tumors occur around the knee.

The characteristic radiographic findings include a permeative pattern of bone destruction with a variable amount of mineralized osteoid, aggressive periosteal reaction and an extraosseous soft tissue component containing foci of ossification. Conventional radiography provides the fundamental basis for the primary diagnosis of osteosarcoma, but MRI and CT are often used to determine the precise anatomic location and soft tissue extension.

**Fig. 8:** Osteosarcoma in the left distal femoral metaphysis in a 9-year-old boy. (A) Lateral radiograph shows bone sclerosis with wide zone of transition (blue arrow), osteoid matrix in soft tissues (red arrow), and Codman’s triangle (blue arrowhead). The
lesion (green arrows) displays low signal on T1 (D), heterogeneous signal on T2FS (B and C) and avid enhancement in post contrast study (E). There is associated bone destruction and periosteal infiltration (yellow asterisks).

References: Radiology, Centro Hospitalar de São João, Faculdade de Medicina da Universidade do Porto - Porto/PT.

2.3.2 EWING'S SARCOMA (FIG. 9; FIG. 10)

Ewing's sarcoma (EWS) is the second most common malignant bone tumor in children and young adults. The peak prevalence is between the ages of 10 and 15 years, with an incidence rate of 1 to 3 cases per 1 million children and a slight male predilection (male-to-female ratio, 1.5:1). There are numerous reports of EWS being misdiagnosed as OM on imaging studies. Only 70% of cases of EWS are correctly predicted by radiography, and 76% are correctly predicted by RMI. According to multivariate analysis, only ethnicity and the presence of a soft-tissue mass are significant predictors of the diagnosis of EWS. Ethnicity is a significant predictor of diagnosis, as black populations are far more likely to have OM than EWS. The value of the transition zone is unclear, as EWS can have a wide or a narrow transition zone.

There is a wide skeletal distribution for EWS (femur is the most common site) and the majority of long-bone lesions are metadiaphyseal. At radiography, typical imaging features are: bone destruction with a moth-eaten to permeative pattern, associated soft-tissue mass without calcifications or bone matrix and aggressive periosteal reaction. MRI reveals marrow replacement, cortical destruction, with an associated soft-tissue mass in 96% of cases.
Fig. 9: EWS of the left humeral diaphysis in a 13-year-old girl. (A) AP radiograph shows a permeative lytic bone lesion in the mid humeral diaphysis with hair-on-end periosteal reaction (blue arrows), Codman’s triangles (red arrowheads) and extrinsic erosion of the thickened cortex. There is also soft tissue displacement, suggestive of an associated soft-tissue mass (blue dashed line). There is no apparent osteoid matrix. Axial (B) T2FS, (C) T1 and (D) post contrast T1FS images reveal a circumferential soft-tissue mass (S) that demonstrates high signal intensity on T2, nonspecific intermediate signal intensity on T1 and diffuse enhancement. There is also abnormal marrow (M) and abnormal cortex enhancement.

References: Radiology, Centro Hospitalar de São João, Faculdade de Medicina da Universidade do Porto - Porto/PT.
Fig. 10: EWS in a 16-year-old boy. (A) AP plain film depicts a permeative lytic lesion in the proximal tibia, with aggressive periosteal reaction and a well-defined transitional area (red arrow). (B) CT scan shows marrow replacement by a soft tissue lesion without osteoid matrix. CT is better at demonstrating osseous changes such as endosteal scalloping, sunburst periosteal reaction (blue arrows) and Codman's triangle (white arrowhead). (C) coronal T1FS post contrast, (D) axial T2 and (E) axial T1FS post contrast sequences reveal an expansive lesion in the proximal tibia (green arrow) with heterogeneous enhancement, bone destruction and extension to the surrounding soft tissues.

References: Radiology, Centro Hospitalar de São João, Faculdade de Medicina da Universidade do Porto - Porto/PT.

2.4 METASTATIC CANCER (FIG. 11)

Medical history is important and frequently patients have a known primary tumor. Bone metastases are usually multifocal and the clinical parameters are also important, since in most cases there are no signs of inflammation.
Fig. 11: Metastases from neuroblastoma. (A) Coronal and (B) axial T1 post contrast images show an osseous lytic metastasis causing bone destruction of the left sphenoid bone and orbit. (C) Axial and (D) coronal T2 images also reveal in the same patient secondary involvement of the left posterior thoracic wall and left iliac bone, respectively. The child had pathologically proved adrenal neuroblastoma treated surgically one year before.

References: Radiology, Centro Hospitalar de São João, Faculdade de Medicina da Universidade do Porto - Porto/PT.

2.5 LANGERHANS CELL HISTIOCYTOSIS (FIG. 12; FIG. 13)
Langerhans cell histiocytosis (LCH) is a rare disease with an annual incidence of 4.6 per million in children under 14 years of age. LCH has three different forms:

- The unifocal form (70%), limited to a single bone or a few bones, and may involve the lung.
- The multifocal unisystem (chronic recurring) form (20%), involving multiple bones as well as the reticuloendothelial system.
- The multifocal multisystem (fulminant) form (10%), often fatal and typically diagnosed in the first 2 years of life.

Osseous involvement in children with LCH is very similar to that seen in multiple myeloma. LCH has a predilection for the flat bones. The skull is the most common flat bone involved, followed by the mandible, ribs, pelvis, and spine. Skull lesions have a well-defined lytic "punched-out" appearance on radiographs and can be asymptomatic or associated with focal pain and soft tissue swelling. A solitary lytic lesion of the cranial vault is a typical radiographic finding. A vertebra plana appearance in the spine is another typical radiographic finding.

When LCH affects long bones it typically occurs in the diaphysis or metaphysis, but it tends to be centered on the diaphysis while haematogenous OM tends to originate in the metaphysis. The femur, humerus, and tibia are the most commonly involved long bones. Early lesions often appear lytic, expansible, and aggressive on plain films. Less aggressive lesions present cortical thickening and a smooth periosteal reaction. As lesions become chronic, they may resolve or appear sclerotic. CT and MRI depict intramedullary lesions with extramedullary soft-tissue components that have decreased T1 signal intensity and increased T2 signal intensity.

LCH can be difficult to differentiate from multifocal OM.
**Fig. 12**: Radiographs of different children with LCH. (A) and (B) radiographs show well defined osteolytic lesions with regular margins (red arrows). (C) reveals a permeative aspect of the left pubis, making difficult differential diagnosis with aggressive lesions. (D) and (E) radiographs of a 10-year-old child show vertebra plana (red arrow)

**References**: Radiology, Centro Hospitalar de São João, Faculdade de Medicina da Universidade do Porto - Porto/PT.
Fig. 13: LCH in a 15-year-old boy. (A) AP radiograph shows a well-defined osteolytic lesion adjacent to the greater trochanter of the right femur (red arrow). (B) Axial CT scan shows the lytic character of the lesion with well-defined margins and without extracompartmenal extension.

References: Radiology, Centro Hospitalar de São João, Faculdade de Medicina da Universidade do Porto - Porto/PT.

2.6 OSTEOID OSTEOMA (FIG. 14; FIG. 15)

Osteoid osteoma is a benign bone tumor that occurs most frequently in males between 7 and 25 years old. Most patients present a history of night pain relieved by the administration of salicylates. It presents as a cortical nidus smaller than 2 cm surrounded by a densely sclerotic margin and cortical thickening. Osteoid osteomas can mimic a sequestrum. However they are usually round whereas sequestra are irregularly shaped and on post contrast sequences osteoid osteomas enhance avidly while sequestra do not enhance. Osteoid osteomas are not associated with bone destruction.
Fig. 14: Intracortical osteoid osteoma in a 15-year-old boy presenting with pain in the left leg relieved by salicylates. (A) AP radiograph of the left femur shows a mid diaphyseal radiolucent nidus (red circle) surrounded by fusiform cortical thickening (white arrowheads). (B) Axial unenhanced CT image shows a low-attenuation nidus (red arrowhead), without mineralization, surrounded by reactive bone formation. (C) Coronal T1, (D) axial STIR and (E) sagittal STIR show the high signal nidus. Green asterisk shows edema in the bone marrow. No cortical destruction or extra osseous soft tissue extension.

References: Radiology, Centro Hospitalar de São João, Faculdade de Medicina da Universidade do Porto - Porto/PT.
Fig. 15: Intracortical osteoid osteoma in a 14-year-old boy presenting with left hip pain. (A) Coronal CT shows a calcified nidus in the medial aspect of the proximal left femoral metaphysis, surrounded by cortical thickening (blue arrow). (B) Axial T1FS and (C) post contrast sequence reveal an enhancing nidus associated with bone marrow and soft tissue edema.

References: Radiology, Centro Hospitalar de São João, Faculdade de Medicina da Universidade do Porto - Porto/PT.

2.7 CHRONIC RECURRENT MULTIFOCAL OSTEOMYELITIS (FIG.16)

Chronic recurrent multifocal osteomyelitis (CRMO) is an uncommon autoinflammatory disorder of uncertain origin characterized by aseptic OM. Most patients present between 9 and 14 years of age and there is a female predominance, with a female-to-male ratio of 2.1:1.

Clinical and radiologic features that help in differentiating CRMO from heamatogenous OM are: (a) chronic clinical course, with most patients being healthy between recurrent episodes; (b) unusual location of lesions such as involvement of the clavicle and anterior thoracic cage; (c) multifocal and symmetric distributed lesions; (d) multiple foci of osteolysis with associated sclerosis or hyperostosis; (e) Absence of fistula, sequestra, or abscess formation; (f) lack of response to antibiotics; and (g) comorbid inflammatory disorders such as inflammatory bowel disease, psoriasis or palmoplantar pustulosis.

Evaluation of the osseous lesions with biopsy and culture is often required to establish the diagnosis of CRMO, especially early in the course of the disease, as the imaging findings can be nonspecific.
**Fig. 16**: CRMO in a 2-year-old girl. Technetium 99m (99mTc) bone scan (anterior projection) shows multifocal increased uptake in the anterior aspect of the thoracic cage, most exuberant in the right side, and in the extremities of several bones. Bilaterally symmetric radionuclide-avid lesions are present in the distal tibia and calcaneal bones. Radiographs show sclerosis and hyperostosis secondary to chronic periosteal reaction in the anterior aspect of the second to eight right costal arcs (red arrows in B); long bones of both forearms especially in the left side and right metacarpals (red arrows in C); and tibia, peroneus and calcaneal bones of both limbs (red arrows in D). (E) Coronal STIR image shows bone marrow and soft tissue edema, and periosteal reaction in right costal arcs (blue arrows). (F) Coronal STIR reveals the same signal changes addressing distal tibial metaphysis, proximal left tibial metaphysis, distal right femoral metaphysis, and proximal left femur. Biopsy and negative culture results led to a diagnosis of CRMO.

**References**: Radiology, Centro Hospitalar de São João, Faculdade de Medicina da Universidade do Porto - Porto/PT.
Fig. 1: Acute haematogenous OM in an 11-year-old girl. (A) Axial T2 and (B) coronal STIR show extensive metadiaphyseal high signal in the medullary cavity (green asterisks) affecting the distal 2/3 of the right femur, that can represent either bone marrow edema or intramedullary abscess, with associated marked edema in the surrounding soft tissues. The periosteum is separated from the cortex by high signal material representing pus (red arrows) that disseminates to the surrounding soft tissues. (C) Axial and (D) coronal T1FS after the administration of intravenous contrast confirms the presence of a subperiosteal abscess by showing lack of enhancement. There is also lack of medullary enhancement, confirming the presence of intramedullary abscess.
Fig. 2: The "penumbra sign" of Brodie's abscess in an 8-year-old boy. (A) Anteroposterior (AP) radiograph shows an osteolytic lesion with a sclerotic margin in the inferior aspect of the greater trochanter of the left femur, representing a Brodie's abscess (blue arrow). (B) Axial and (C) coronal T1 images shows a fluid filled hypointense cavity in the left proximal femoral metaphysis with a rim of discrete peripheral zone of higher intensity than the central abscess cavity due to highly vascularized granulation tissue (red arrow). This feature has been called the "penumbra sign" and has a high specificity for the diagnosis of OM, with a reported specificity of 96%. (D) Axial and (E) coronal STIR images shows hyperintense fluid filled abscess cavity (red arrowheads) and edema in the surrounding bone marrow and soft tissues (green arrows). Thick layer of perilesional bone formation and sclerosis as a hyposignal on T1 and STIR sequences were seen.
**Fig. 3:** Chronic osteomyelitis in a 16-year-old boy. (A) AP radiograph shows marked periosteal thickening and a central osteolytic lesion (blue arrow). (B) Sagittal and (C) axial CT with bone windows show a central sclerotic fragment of bone which is separate from the rest of the humerus by a lucent rim, consistent with a sequestrum (red arrow). Cortical thickening is also noted, as seen in radiography, representing an involucrum which is a result of periosteal new bone formation. There is also noted a linear defect of the cortical bone in the anterior aspect of the humerus, better identified in (C), representing a cloaca (red arrowhead).

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Fig. 4: Differential diagnosis of OM.

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**Fig. 6:** Stress fracture in a 16-year-old girl athlete. Coronal (A) T1 and (B) T2FS images show a linear fracture in the tibial diaphysis accompanied by bone marrow edema. Note that there is no edema in the surrounding soft tissue. This fracture was initially misdiagnosed as osteoid osteoma.

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Fig. 7: Osteonecrosis in the left humeral head in a 10-year-old girl with sickle cell disease and complaints of pain and limited range of motion in this area. (A) Sagittal T1 and (B) fluid-sensitive sequence show serpiginous hypointense lines consistent with the diagnosis of osteonecrosis (blue arrows).

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Fig. 8: Osteosarcoma in the left distal femoral metaphysis in a 9-year-old boy. (A) Lateral radiograph shows bone sclerosis with wide zone of transition (blue arrow), osteoid matrix in soft tissues (red arrow), and Codman's triangle (blue arrowhead). The lesion (green arrows) displays low signal on T1 (D), heterogeneous signal on T2FS (B and C) and avid enhancement in post contrast study (E). There is associated bone destruction and periosteal infiltration (yellow asterisks).

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Fig. 9: EWS of the left humeral diaphysis in a 13-year-old girl. (A) AP radiograph shows a permeative lytic bone lesion in the mid humeral diaphysis with hair-on-end periosteal reaction (blue arrows), Codman’s triangles (red arrowheads) and extrinsic erosion of the thickened cortex. There is also soft tissue displacement, suggestive of an associated soft-tissue mass (blue dashed line). There is no apparent osteoid matrix. Axial (B) T2FS, (C) T1 and (D) post contrast T1FS images reveal a circumferential soft-tissue mass (S) that demonstrates high signal intensity on T2, nonspecific intermediate signal intensity on T1 and diffuse enhancement. There is also abnormal marrow (M) and abnormal cortex enhancement.

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Fig. 10: EWS in a 16-year-old boy. (A) AP plain film depicts a permeative lytic lesion in the proximal tibia, with aggressive periosteal reaction and a well-defined transitional area (red arrow). (B) CT scan shows marrow replacement by a soft tissue lesion without osteoid matrix. CT is better at demonstrating osseous changes such as endosteal scalloping, sunburst periosteal reaction (blue arrows) and Codman’s triangle (white arrowhead). (C) coronal T1FS post contrast, (D) axial T2 and (E) axial T1FS post contrast sequences reveal an expansive lesion in the proximal tibia (green arrow) with heterogeneous enhancement, bone destruction and extension to the surrounding soft tissues.

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Fig. 11: Metastases from neuroblastoma. (A) Coronal and (B) axial T1 post contrast images show an osseous lytic metastasis causing bone destruction of the left sphenoid bone and orbit. (C) Axial and (D) coronal T2 images also reveal in the same patient secondary involvement of the left posterior thoracic wall and left iliac bone, respectively. The child had pathologically proved adrenal neuroblastoma treated surgically one year before.

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Fig. 12: Radiographs of different children with LCH. (A) and (B) radiographs show well defined osteolytic lesions with regular margins (red arrows). (C) reveals a permeative aspect of the left pubis, making difficult differential diagnosis with aggressive lesions. (D) and (E) radiographs of a 10-year-old child show vertebra plana (red arrow)

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Fig. 13: LCH in a 15-year-old boy. (A) AP radiograph shows a well-defined osteolytic lesion adjacent to the greater trochanter of the right femur (red arrow). (B) Axial CT scan shows the lytic character of the lesion with well-defined margins and without extracompartmental extension.

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Fig. 14: Intracortical osteoid osteoma in a 15-year-old boy presenting with pain in the left leg relieved by salicylates. (A) AP radiograph of the left femur shows a mid diaphyseal radiolucent nidus (red circle) surrounded by fusiform cortical thickening (white arrowheads). (B) Axial unenhanced CT image shows a low-attenuation nidus (red arrowhead), without mineralization, surrounded by reactive bone formation. (C) Coronal T1, (D) axial STIR and (E) sagittal STIR show the high signal nidus. Green asterisk shows edema in the bone marrow. No cortical destruction or extra osseous soft tissue extension.

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**Fig. 15:** Intracortical osteoid osteoma in a 14-year-old boy presenting with left hip pain. (A) Coronal CT shows a calcified nidus in the medial aspect of the proximal left femoral metaphysis, surrounded by cortical thickening (blue arrow). (B) Axial T1FS and (C) post contrast sequence reveal an enhancing nidus associated with bone marrow and soft tissue edema.

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Fig. 16: CRMO in a 2-year-old girl. Technetium 99m (99mTc) bone scan (anterior projection) shows multifocal increased uptake in the anterior aspect of the thoracic cage, most exuberant in the right side, and in the extremities of several bones. Bilaterally symmetric radionuclide-avid lesions are present in the distal tibia and calcaneal bones. Radiographs show sclerosis and hyperostosis secondary to chronic periosteal reaction in the anterior aspect of the second to eight right costal arcs (red arrows in B); long bones of both forearms especially in the left side and right metacarpals (red arrows in C); and tibia, peroneus and calcaneal bones of both limbs (red arrows in D). (E) Coronal STIR image shows bone marrow and soft tissue edema, and periosteal reaction in right costal arcs (blue arrows).(F) Coronal STIR reveals the same signal changes addressing distal tibial metaphysis, proximal left tibial metaphysis, distal right femoral metaphysis, and proximal left femur. Biopsy and negative culture results led to a diagnosis of CRMO.

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Conclusion

• There are several entities that can mimic osteomyelitis. Radiologists have to recognize the imaging findings of pediatric osteomyelitis and be familiar with the differential diagnosis in order to initiate appropriate treatment and avoid possible devastating outcomes.
References


