Osteoid Osteoma: What every Radiologist should know

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Learning objectives

To describe the physiopathology and radiologic characteristics of osteoid osteoma.

To illustrate the radiological features of osteoid osteoma and its mimics using a multimodality approach with conventional radiography, computed tomography (CT) and magnetic resonance (MR).

Background

Osteoid osteoma has a characteristic radiologic presentation, but when typical imaging findings are not present, it can be difficult to differentiate from other pathologies.

In this poster the authors display the spectrum of radiologic findings using different imaging modalities. We present several osteoid osteomas in different anatomical locations, and we discuss the most important aspects in differential diagnosis including infectious disease, inflammatory pathology and other tumors.

INTRODUCTION

Osteoid osteoma accounts for approximately 10 % of benign bone tumors. It occurs most frequently in the second decade of life at presentation, with a male predominance (male-to-female ratio of 4:1).

Typically, patients have bone pain that is not related to physical activity and often worsens at night. It is promptly relieved by the administration of salicylates or other nonsteroidal antiinflammatory drugs. Less common manifestations are growth disturbance, bone deformity and painful scoliosis.

Osteoid osteoma is characterized by a "nidus" with a surrounding reactive sclerosis, cortical thickening and bone marrow edema.

The term nidus refers to the tumor itself. It does not usually exceed 2 cm and it is composed of bone at various stages of maturity within a highly vascular connective tissue
stroma. The center of the nidus usually is the most highly mineralized part, and present a variable amount of calcification.

**Imaging findings OR Procedure details**

**CONVENTIONAL RADIOGRAPHY FINDINGS:**

- Radiographs characteristically show a round or oval cortical radiolucent focus representing the nidus (usually smaller than 2 cm), which may present a variable amount of central mineralization, accompanied by a variable degree of surrounding reactive sclerosis and cortical thickening.
- May be difficult to identify the radiolucent nidus if sclerosis is extensive.

**COMPUTED TOMOGRAPHY FINDINGS:**

- Computed tomography provides the best characterization of both the nidus and the surrounding cortical sclerosis.
- The nidus is visualized as a round or oval well-defined lesion with low attenuation and demonstrates varying degrees of central mineralization.
- When reactive sclerosis is present, it can ranges from mild sclerosis to extensive periosteal reaction and new bone formation, which may obscure the nidus.
- Sometimes lesions may have little to no reactive sclerosis.
- Thin-section (2-3-mm) axial and longitudinal multiplanar reformatted CT images obtained with a bone algorithm and viewed with bone window settings better depict small nidi.
- Although the use of intravenous contrast material is not necessary, enhancement of a hypervascular nidus may be seen at dynamic CT.

**MAGNETIC RESONANCE IMAGING FINDINGS:**

- The nidus has low to intermediate signal intensity on T1-weighted images and variable signal intensity on T2-weighted images, depending on the amount of mineralization present in the center of the nidus. Because of the increases in spatial resolution, a mineralized nidus may be visualized like a high-signal-intensity periphery (the unmineralized portion) and a central area of low signal intensity (the mineralized portion).
• Signal hyperintensity is seen in the surrounding reactive zone on T2-weighted or short inversion time inversion-recovery images when edema in adjacent bone marrow and soft tissue is present.

• The nidus may demonstrate strong enhancement after the administration of gadolinium-based contrast material.

• Imaging findings may be nonspecific and may mimic other diseases (stress fracture or osteomyelitis) if extensive surrounding edema obscures the nidus.

• MR imaging sometimes fails to depict small nidi, because the signal in the nidus often is similar to that in cortical bone.

CLASSIFICATION

Osteoid osteoma is classified according to the location of the nidus:

• **Cortical** (most common type): typically demonstrates fusiform sclerotic cortical thickening in the shaft of a long bone, especially femur (Fig. 1 on page 6; Fig. 2 on page 7; Fig. 3 on page 7) and tibia (Fig. 4 on page 8).

• **Intramedullary**: typically located in femoral neck (Fig. 5 on page 9), carpal and tarsal bones, and the vertebral posterior elements. Osteosclerosis is usually mild to moderate in this type.

• **Subperiosteal**: It may be most common in the neck of the talus (Fig. 6 on page 10) and it is also frequently located along the medial aspect of the femoral neck and in the hands and feet. (Fig. 7 on page 11; Fig. 8 on page 12)

LOCATIONS

Osteoid osteoma may occur in any bone.

Most lesions are found in the long bones of the lower extremity (femur and tibia: 50% of cases). Approximately 30% occur in the spine, hands or feet. The least common locations are the scapula, ribs, pelvis, mandible, patella and skull (Fig. 9 on page 13).

An unusual location may complicate the diagnostic process.
UNUSUAL LOCATIONS

Spinal osteoid osteoma: (Fig. 10 on page 14)

- Spinal lesions account for 10% of osteoid osteomas.
- Most common location is the lumbar segment, and involvement of the posterior elements is more common than that of the vertebral body.
- The sacrum is the least commonly affected spinal segment.
- It is difficult to visualize the lesion in plain films because of the complexity of spinal anatomy and overlapping areas of soft tissue and bowel air.

Hands and feet osteoid osteoma: (Fig. 11 on page 15)

- Intramedullary osteoid osteoma occurs in the carpal and tarsal bones, and may display less reactive sclerosis.
- All types of osteoid osteoma may occur in the metacarpal, metatarsal and phalangeal bones.
- Soft-tissue and bone marrow edema may be prominent in osteoid osteoma of the hands and feet, a finding that may resemble to other diseases (infection or inflammatory arthritis).

INTRAARTICULAR OSTEOID OSTEOMA (Fig. 12 on page 16)

- It is considered a separate clinical entity that occurs within or near a joint (the hip is the most commonly affected).
- The symptoms may contribute to the diagnostic confusion: pain is not always worse at night and joint tenderness and effusion may be prominent.
- Due to a lack of the inner layer of the periosteum (called cambium), which is responsible of bone formation, reactive cortical thickening is minimal or absent.

DIFFERENTIAL DIAGNOSIS

Severe inflammatory changes can make osteoid osteoma difficult to diagnose, and may mimic other diseases:

- Prominent periosteal reaction and a young age: osteomyelitis or malignant bone tumor (such as Ewing sarcoma). (Fig. 13 on page 17)
- Severe synovial hypertrophy and prominent joint effusion: septic arthritis or chronic inflammatory arthritis.
• Extensive soft-tissue and bone marrow edema that masked the nidus: traumatic injury or infection.

Osteoid osteoma VS Intracortical abscess (Table 1 on page 18)

Intracortical abscess and osteoid osteoma often are indistinguishable with plain radiography.

The appearance of an intracortical abscess when bony sequestrum is present may be confused with calcification in an osteoid osteoma nidus. (Fig. 14 on page 17; Fig. 15 on page 18)

The presence of a linear or serpentine tract leading away from the abscess cavity may be helpful for differentiation.

Images for this section:

CASE 1: Intracortical osteoid osteoma of the right distal femoral diaphysis in a 17-year-old man.
**Fig. 1:** Intracortical osteoid osteoma of the right femoral diaphysis in a 17-year-old man.

**CASE 2:** Intracortical osteoid osteoma of the left femoral diaphysis in a 22-year-old woman.

Axial CT image demonstrates a low-attenuation nidus (arrow) with central mineralization, surrounded by reactive bone formation.

**Fig. 2:** Intracortical osteoid osteoma of the left femoral diaphysis in a 22-year-old woman.
CASE 3: Intracortical osteoid osteoma of the right femoral diaphysis in a 15-year-old man.

Anteroposterior radiograph of the pelvis (A) shows a radiolucent nidus (arrow) with surrounding reactive sclerosis and fusiform cortical thickening.

Axial CT image (B) reveals a low-attenuation nidus (arrow), without mineralization, amid an area of cortical thickening. Intramedullary sclerosis (*) is seen adjacent to the nidus.

Axial T1-weighted MR image (C) shows the nidus (arrow in C) within the area of cortical thickening.

Axial T2-weighted fat-suppressed MR image (D) shows the high-signal-intensity nidus with no mineralization (arrow in D). Note the edema in the surrounding soft tissue (*).

Fig. 3: Intracortical osteoid osteoma of the right femoral diaphysis in a 15-year-old man.
CASE 4: Intracortical osteoid osteoma of the left distal tibial diaphysis in a 20-year-old man.

![Lateral radiograph of the left lower leg (A) shows a faint radiolucent nidus (arrow) with surrounding reactive sclerosis.](image)

Fig. 4: Intracortical osteoid osteoma of the left distal tibial diaphysis in a 20-year-old man.

Axial (B) and sagittal reformatted (C) CT images reveal a low-attenuation nidus (arrow) with minimal central mineralization amid an area of fusiform cortical thickening. Reactive sclerosis (*) is seen adjacent to the nidus.
CASE 5: Intramedullary osteoid osteoma of the left femoral neck in a 30-year-old woman.

Axial CT image (A) shows a low-attenuation nidus (arrow) with peripheral sclerosing bone and faint central mineralization.

Coronal unenhanced T1-weighted (B) and coronal T2-weighted fat-suppressed (C) MR images show the low-signal-intensity nidus (arrow) and a high-signal-intensity, unmineralized periphery (arrowheads in C).

Fig. 5: Intramedullary osteoid osteoma of the left femoral neck in a 30-year-old woman.
Case 6: Subperiosteal osteoid osteoma of the talus in a 31-year-old woman.

Sagittal reformatted CT image (A) shows a calcified nidus (arrow in A) and surrounding reactive sclerosis (*) in the neck of the talus.

Sagittal unenhanced T1-weighted MR image (B) shows the low-signal-intensity nidus with central calcification (arrow in B).

Sagittal gadolinium-enhanced T1-weighted fat-suppressed MR image (C) shows the enhancing nidus (arrow in C). Extensive edema of the talus bone marrow and hypertrophied synovial enhancement in the tibiotalus joint (*) are also seen.

Fig. 6: Subperiosteal osteoid osteoma of the talus in a 31-year-old woman.
CASE 7: Subperiosteal osteoid osteoma of the left humeral diaphysis in a 16-year-old man.

Fig. 7: Subperiosteal osteoid osteoma of the left humeral diaphysis in a 16-year-old man.
CASE 8: Subperiosteal osteoid osteoma of the ulna diaphysis in a 28-year-old woman.

Lateral radiograph (A) shows a densely mineralized nidus (arrow) amid an area of fusiform cortical thickening. Axial CT image (B) shows the nidus with pronounced mineralization within the lesion (arrow), surrounded by reactive bone formation. Note the attenuation of the reactive bone is slightly lower than that of the native cortex (green arrowheads in B). The nidus is classified as subperiosteal because it is adjacent to the outer margin of the native cortex.

Fig. 8: Subperiosteal osteoid osteoma of the ulna diaphysis in a 28-year-old woman.
CASE 9: Osteoid osteoma of the skull in a 30-year-old man.

Axial CT image shows the nidus (arrow) with central mineralization located in the right squama temporalis. No apparent sclerosis is surrounding the lesion.

Fig. 9: Osteoid osteoma of the skull in a 30-year-old man.
CASE 10: Osteoid osteoma of the lumbar spine (L1) in a 23-year-old man.

Axial CT image (A) shows a radiolucent nidus (arrow) with faint internal mineralization in the left transverse apophysis of L1. Note the reactive sclerosis in the marrow surrounding the nidus and the hypertrophy of the left transverse apophysis.

Axial T1-weighted (B) and axial T2-weighted fat-suppressed (C) MR images show mild periosteal elevation (arrow in B) and bone marrow edema (*) in C in the left transverse apophysis of L1. Note no nidus is seen.

Fig. 10: Osteoid osteoma of the lumbar spine (L1) in a 23-year-old man.
CASE 11: Subperiosteal osteoid osteoma of the talus in an 18-year-old man.

Fig. 11: Subperiosteal osteoid osteoma of the talus in an 18-year-old man.

Sagittal reformatted CT image (A) shows sclerosis in the talus neck (*) in A). No nidus is seen.
Sagittal T1-weighted (B) and sagittal T2-weighted fat-suppressed (C) MR images show the low-signal-intensity calcified nidus (arrow) and extensive bone marrow edema in the talus (*) in C). Edema in surrounding soft tissue is also seen.
CASE 12: Intraarticular osteoid osteoma of the left lateral cuneiform bone in a 15-year-old woman.

Fig. 12: Intraarticular osteoid osteoma of the left lateral cuneiform bone in a 15-year-old woman.

CASE 13: Infantile cortical hyperostosis of the left distal femoral diaphysis in a 14 year-old woman.

Fig. 13: Infantile cortical hyperostosis of the left distal femoral diaphysis in a 14 year-old woman.
**CASE 14:** Osteoid osteoma of the second left intermediate phalanx in a 17-year-old man.

Axial unenhanced T1-weighted MR image (A) shows the low-signal-intensity calcified nidus (arrow in A). Axial (B) and coronal (C) T2-weighted fat-suppressed MR images show the low-signal-intensity nidus with central calcification (arrow in B) and a high-signal-intensity, unmineralized periphery (arrowheads). Note the edema in the bone marrow of the second left intermediate phalanx (* in C) and in the surrounding soft tissue. Imaging features resemble Brodie abscess.

**Fig. 14:** Osteoid osteoma of the second left intermediate phalanx in a 17-year-old man.

**CASE 15:** Osteoid osteoma of the second right proximal phalanx in a 20-year-old woman.

Lateral (A) and frontal (B) radiographs of right index finger show a densely mineralized nidus (arrow) in the distal diaphysis of the proximal phalanx. Mild reactive sclerosis (*) and cortical expansion are seen in the surrounding bone. Note the soft tissue swelling of proximal portion of the finger.

**Fig. 15:** Osteoid osteoma of the second right proximal phalanx in a 20-year-old woman.
**Table 1: Osteoid osteoma vs Intracortical abscess**

<table>
<thead>
<tr>
<th>Method</th>
<th>Osteoid Osteoma</th>
<th>Intracortical Abscess</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Computed Tomography</strong></td>
<td>The inner surface of the nidus appears smooth, and a round calcification is seen in the center of the nidus.</td>
<td>The inner margin is irregular, and an irregularly shaped sequestrum is seen eccentrically.</td>
</tr>
<tr>
<td><strong>Magnetic Resonance</strong></td>
<td>The nidus has low to intermediate signal intensity on T1-weighted MR images and variable signal intensity on T2-weighted images.</td>
<td>Low signal intensity on T1-weighted MR images.</td>
</tr>
<tr>
<td></td>
<td>Signal hyperintensity is seen in the surrounding reactive zone on T2-weighted MR images.</td>
<td>High signal intensity on T2-weighted MR images.</td>
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<td></td>
<td>The nidus may demonstrate strong enhancement after the administration of gadolinium-based contrast material.</td>
<td>Peripheral rim enhancement on gadolinium-based contrast material–enhanced images. The center does not enhance.</td>
</tr>
</tbody>
</table>
Conclusion

It is important to be familiar with the radiological imaging features of osteoid osteoma and its mimics.

Osteoid osteoma is characterized by a "nidus" with a surrounding reactive sclerosis, cortical thickening and bone marrow edema.

It may occur in any bone, but most lesions are found in the long bones of the lower extremity.

Osteoid osteoma is classified according to the location of the nidus: cortical, intramedullary or subperiosteal.

Intraarticular osteoid osteoma is considered a separate clinical entity.

Computed tomography is the imaging modality of choice for visualization the nidus and for treatment planning.

Soft-tissue and bone marrow edema, joint effusion, and synovitis are better appreciated at MR imaging than at CT.

To make a correct diagnosis it is essential to identify the nidus, and be open to the possibility of an osteoid osteoma when it is accompanied by severe inflammatory changes that can make difficult the diagnosis.

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References


