Osteoid Osteoma

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**Educational Objectives**

As a result of reading this article, physicians should be able to:

1. Discuss the clinical presentation of and different imaging modality options for suspected osteoid osteomas.
2. Develop an insight into the histopathology and histochemistry of osteoid osteomas.
3. Use diagnostic processes in the differential diagnosis of suspected osteoid osteomas.
4. Apply current treatment depending on the location and accessibility of the lesion.

**Abstract**

Osteoid osteoma is the third most common benign bone tumor. The authors describe the clinical presentation, diagnostic investigations, differential diagnosis, histopathology, and treatment options for this condition, including a comprehensive review of the literature. Osteoid osteomas have wide variations in presentation and tend to present in the second decade of life, with pain that is worse at night and is relieved by salicylates. Plain radiographs and computed tomography scans are the mainstay of imaging; however, bone scintigraphy, single-photon emission computed tomography, magnet...
ic resonance imaging, and sonography are also used. Osteoid osteomas consist of a nodule with surrounding sclerotic bone. The differential diagnosis covers a wide range of conditions due to the variable presentation of osteoid osteoma. The natural history is for regression to occur within 6 to 15 years with no treatment; however, this can be reduced to 2 to 3 years with the use of aspirin and nonsteroidal anti-inflammatory drugs. Computed tomography–guided percutaneous techniques, including trephine excision, cryoablation, radiofrequency ablation, and laser thermocoagulation, are described.

Osteoid osteoma is a small, distinctive, nonprogressive, benign osteoblastic lesion that is usually accompanied by severe pain. Jaffe\(^1\) was the first to report the identification of this osteoblastic lesion in 1935. As the third most common biopsy-analyzed benign bone tumor after osteochondroma and nonossifying fibroma, osteoid osteoma is a relatively common lesion. It represents 11% to 14% of benign bone tumors. Two percent to 3% of excised primary bone tumors are osteoid osteomas.\(^2,3\)

**Clinical Presentation**

Osteoid osteoma can manifest at any age, but the majority of patients are aged between 5 and 20 years, with 50% of patients aged between 10 and 20 years.\(^4,5\) Osteoid osteomas are 1.6 to 4 times more prevalent in males.\(^4\) In the majority of cases, osteoid osteoma occurs in long bones, affecting the metaphysis or diaphysis. The most common loci are the femur and the tibia, with the most characteristic site being the femoral neck and the intertrochanteric region.\(^5\) Rarely, it also involves the epiphyseal and intracapsular aspect of long bones (known as intra-articular osteoid osteomas). Less commonly affected are the spine and the small bones of the hand and feet. It can involve the talus, predominantly the talar neck. Flat bones in the body and the skull are rarely affected. Osteoid osteoma is usually localized within the bone cortex. Subcortical, intracortical, and intraperiosteal osteoid osteomas have been described. Osteoid osteomas of the spine account for approximately 6% of cases and almost always involve the posterior arch area close to the pedicles.\(^6,7\) The lumbar spine is the most commonly affected region. Multiple osteoid osteoma nidi in the same or different bones are rare.\(^8,9\)

Pain is the most common clinical presentation. Its usual characteristics are dull, unremitting, initially mild and intermittent pain that increases in intensity and persistence over time. It tends to become increasingly severe at night and is usually relieved by salicylates and nonsteroidal anti-inflammatory drugs (NSAIDs). The indolent nature of early osteoid osteoma may result in delayed presentation. Swelling, erythema, and tenderness may be present in bones in subcutaneous locations.\(^5\) Referred pain and muscular atrophy may result in the misdiagnosis of a neurological disorder.\(^10\) This observation is common in patients who have a painful osteoid osteoma in posterior elements of the spine, where a postural scoliosis is found due to paravertebral muscle spasm but is reversible after treatment.\(^4\)

Osteoid osteomas in the region of the proximal femur or pelvis may present with symptoms of knee pain, and the diagnosis may require a bone scan. Intra- or juxta-articular lesions are commonly associated with synovitis.\(^11\) Joint pain with flexion contracture, abated range of motion, and antalgic gait can be a clinical pattern of an intra-articular osteoid osteoma.\(^5\) In children, the most common presenting symptom is nocturnal pain. In a young child with an osteoid osteoma, a limp may be the only symptom. If the lesion is close to an open physis, it can cause lengthening, angular deformity, or both of the extremity.\(^4\)

**Imaging**

**Plain Radiographs**

Plain radiographs are the initial imaging study of choice. The osteoid osteoma appears as a small, radiolucent nodule (usually less than 1 cm) surrounded by a variable area of sclerotic bone or cortical thickening (Figure 1). The nidus can be difficult to detect when it is obscured by sclerotic cortical bone or in cases of intra-articular lesions, where bone deposition from the intracapsular periosteum is usually less.\(^12,13\) In addition, intramedullary-located osteoid osteomas may not exhibit surrounding bone sclerosis.\(^14\) Indirect manifestations of synovial inflammation and joint effusion may be evident, or symptoms that mimic osteoarthritis may be present.\(^13,15\) When treatment is delayed, secondary osteopenia and changes in bone morphology may be observed.\(^11\) If the nidus is larger than 1.5 cm, the lesion is usually designated as an osteoblastoma.\(^16,17\) Osteoblastomas are seen radiologically as lesions with a lucent, slow-growing, expansile area with irregular sclerosis and no definite nidus.\(^18\)

**Computed Tomography**

The most common appearance of osteoid osteoma on computed tomography (CT) is as a small, well-delineated, low-attenuation nodule surrounded by a dense sclerotic reaction (Figure 2). Foci of calcification may be visible. A recently described CT finding is the presence of fine, linear, low-density vascular channels that can surround osteoid osteomas. When present, such vascular grooves have high sensitivity and specificity in the diagnosis of osteoid osteoma.\(^19\)

A CT scan is useful in diagnosing intra- or juxta-articular osteoid osteomas, and it has been proposed that CT must be used in all patients with suspected osteoid osteomas because it has better diagnostic accuracy compared with plain radiographs or magnetic resonance imaging in these cases.\(^20,21\) Preoperative localization of osteoid osteomas can be facilitated using CT guidance.\(^22,23\) Percutaneous ablation of lesions under CT guidance is well
established and is discussed later (Figure 3).\textsuperscript{24-28} Computed tomography–guided ablation of osteoid osteomas has also been described in technically challenging locations, such as the spine.\textsuperscript{29,30}

**Bone Scintigraphy**

Due to the correlation between osteoblastic activity and the intensity of radiopharmaceutical uptake, bone scintigraphy usually shows intense uptake in the arterial phase within the richly vascular nidus and in the delayed phase within surrounding reactive bone (Figure 4).\textsuperscript{31} Usually, an intense area of radiotracer uptake is found in the region of the nidus and less in the reactive bone. This pattern, which is known as the double-density sign, is diagnostic of osteoid osteoma.\textsuperscript{32} The area of uptake may be wide. Historically, a pinhole collimator has been used to demonstrate the nidus because the reactive bone uptake may obscure it.\textsuperscript{14}

In children, increased uptake by active growth plates can obscure an adjacent osteoid osteoma. In this situation, comparison with the contralateral unaffected site is helpful to identify the tumor.\textsuperscript{13} In situations where radiofrequency ablation is not available, intraoperative radionuclide imaging may be used to confirm complete resection of the tumor.\textsuperscript{14,33}

**Single-photon Emission Computed Tomography**

Although in most cases a conventional bone scan followed by thin-section CT scan is sufficient, single-photon emission computed tomography (SPECT) can be helpful in diagnosing osteoid osteomas in cases in which bone scintigraphy uptake is subtle.\textsuperscript{34} A SPECT scan can detect smaller lesions by improved spatial resolution of overlying normal tissue uptake and has been advocated as helpful in depicting osteoid osteomas of the spine.\textsuperscript{14,35} Transaxial anatomic imaging of SPECT can further enhance its diagnostic ability in positioning suspicious lesions.\textsuperscript{36}

**Magnetic Resonance Imaging**

The appearance of osteoid osteoma is variable with magnetic resonance imaging...
A primarily cellular nidus will demonstrate low to intermediate signal intensity on T1-weighted images that increases on T2-weighted images (Figure 1B). A heavily calcified nidus appears as low to intermediate signal intensity on both T1- and T2-weighted images. A more striking finding is the presence of surrounding bone marrow edema or periostitis, best demonstrated on fluid-sensitive sequences (Figure 2B). Areas of densely sclerotic medullary or cortical bone may retain low signal intensity on all sequences. In some cases, the bone marrow and soft tissue edema is florid and can mimic an aggressive process, such as infection or malignancy. Reactive soft tissue mass with myxomatous change, cell-depleted juxtanidal bone marrow, and proteinaceous material may be confused with those of a malignant tumor or osteomyelitis.

Sonography
Historically, the use of preoperative Doppler duplex color localization of osteoid osteomas has been reported as a means of assessment of the vascularity of the nidus or the nidus’ feeding artery. Color Doppler sonography may show increased blood supply and demonstrate the entering vessel at the site of the lesion. Sonography is limited by its inability to penetrate bone and has been replaced by other imaging modalities.

Histopathology
Osteoid osteomas consist of a nidus that is surrounded by sclerotic bone, the density of which usually varies with time from the onset of the lesion. Macroscopically, the nidus is a distinct round or oval reddish area with little contact with its surrounding sclerotic bone. Depending on the degree of calcification, the nidus’ consistency may vary from soft and granular to hard and sclerotic. Older lesions demonstrate formation of defined trabeculae.

Intraoperatively, the tumor can be visualized protruding from the bone surface, or it may be hidden under a thick cortical layer of hyperostotic reactive bone. Intracortical and subperiosteal lesions are often associated with hyperemia and edema of the surrounding soft tissues. In tubular bones specifically, osteoid osteomas that present subperiosteally tend to become intracortical due to continuous bone remodeling and subperiosteal new bone apposition.

Histologically, the nidus appears as a small, well-defined area consisting of interlacing, irregular bone trabeculae of varying mineralization (Figure 5). Size, thickness, and mineralization diversity of trabeculae are evident among different lesions, as well as in different areas of the same lesion. The nidus may demonstrate a zonal arrangement of trabecular architecture, with the central part being more sclerotic and the periphery less mineralized and with more cells. Osteoid trabeculae are surrounded mainly by osteoblasts. Osteoclast-like, multinucleated giant cells have also been reported to be pres-
Nidus osteoblasts also display strong diffuse staining for COX-2, a key enzyme in the production of prostaglandins and in particular of prostaglandin E2. This enzyme appears to be a major factor in osteoid osteoma pain, and inhibition of COX-2 production enables control of symptoms.

**DIFFERENTIAL DIAGNOSIS**

The differentiation of osteoid osteomas from other benign bone-forming lesions is based on the difference in size, location, pathology, and clinical symptoms, pathology, and clinical symptoms. In particular, osteoblastomas are larger in size (usually more than 1.5 to 2 cm) and tend to expand instead of regress. Osteoblastomas are also painful but generally without characteristic night exacerbation seen with osteoid osteomas, and pain does not respond dramatically to salicylates or NSAIDs. Osteoblastomas have a predilection for vertebral lesions and can be accompanied more frequently with neurological symptoms or paravertebral muscle spasms.

Instances of osteoid osteoma transition to osteoblastoma have been reported, although they are rare. Radiographically, osteoblastomas appear larger with less reactive sclerosis. Plain radiographs alone may not be distinctive enough to establish the diagnosis, and CT scans can give more information on the expansive nature of the lesion.

When small in size, a Brodie’s abscess may appear similar to an osteoid osteoma on plain radiographs. Imaging using MRI, CT, and scintigraphy can help differentiate between osteoid osteomas and osteomyelitis, as well as other types of tumors, including nonossifying fibromas, chondroblastomas, enchondromas, eosinophilic granulomas, and malignant bone tumors.

In children, infantile cortical hyperostosis, osteomyelitis, Perthes’ disease, leg-length discrepancy, healing stress fractures, tuberculosis, and neuromuscular conditions should be considered. Imaging using CT, bone, and SPECT scans are useful in delineating the nature of the lesion. Patients with unexplained low-back pain and sciatic pain in the second decade of life should be carefully examined to rule out osteoid osteoma.

**TREATMENT**

Moberg suggested that the natural history of osteoid osteoma is that of spontaneous healing. In various studies, it has been noted that if the osteoid osteoma is not excised, complete resolution of symptoms occurs within 6 to 15 years. Administering aspirin or other NSAIDs can reduce this time period to 2 to 3 years. Kneisl and Simon reported permanent relief of symptoms and regression of the nidus after prolonged NSAIDs treatment for 30 to 40 months. Strict selection criteria should be applied if nonoperative treatment is considered, given the potential side effects of prolonged NSAIDs administration. Nonoperative management should be considered in patients where osteoid osteoma is not easily accessible by surgery.

Various techniques have been described for the preoperative localization of osteoid osteomas, such as angiography and placing wires and needles dipped in methylene blue over the nidus while under CT guidance. Radioisotope imaging with scintimetric guidance for intraoperative localization and excision has been reported. Historically, in cases of intracortical lesions, preoperative oral tetracycline administration and examination of nidus’ fluorescence under ultraviolet light has been used to demonstrate the lesion and verify excision, but such techniques are not currently considered practical.

Osteoid ostema was traditionally treated with excision of the nidus. Although the nidus needs to be removed completely to achieve symptomatic relief, complete removal of the sclerotic bone is not necessary. A well-planned surgical approach is essential. Radiographs or CT scans confirm identification of the nidus.
before and after en bloc removal, and then the nidus undergoes histological examination for confirmation. En bloc resection has the disadvantages of a large surgical exposure and excision of a large part of sclerotic bone. Bone grafting or internal fixation may be necessary, depending on the size of the bone defect left by the resection. Unroofing and curettage has a role in structurally critical locations, such as the neck of femur because the central sclerotic structure is not disrupted. Multiple articles report arthroscopic removal of intra-articular osteoid osteomas.

Several methods have been described whereby osteoid osteomas may be treated percutaneously using CT guidance. These include trephine excision, cryoablation, radiofrequency ablation, and laser thermocoagulation. The use of 3-dimensional C-arm radiographs during percutaneous excision in the long bones of children has also been reported. However, most patients in the literature undergoing percutaneous ablation or resection required general anesthesia for pain control. The need for a general anesthetic increases the invasive nature and the cost of these procedures and reduces the advantages of percutaneous treatment over surgical resection. Furthermore, these techniques require equipment not commonly available in all hospitals.

Fine drills, bone trephine, or Tru-Cut needles (Medline Industries, Inc, Mundelein, Illinois) have been described for use in precise and bone-sparing resection. With smaller instruments, the need for a general anesthetic increases, and the procedure can be performed in the outpatient setting, reducing the overall cost. Roger et al reported 16 patients who were treated using percutaneous CT-guided excision and had satisfactory results in 14 patients. The 2 failures were attributed to the proximity of the lesion to the articul margin and excessive periosteal reaction preventing access. The authors concluded that intraoperative CT guidance and immediate postoperative scintigraphy were effective in localizing and confirming removal of the nidus in an outpatient setting. In a series of 38 patients, Sans et al reported a cure rate of 84% at 3.7 years postoperatively and 2 instances of femoral fracture at 2 months. Muscolo et al reported superior outcomes of CT-guided minimally invasive surgery rather than open surgery. Overall, percutaneous CT-guided procedures have profoundly modified the treatment of osteoid osteoma. Rosenthal et al reported a statistically significant reduction in hospital stay over the past 20 years by using more conservative and intralesional procedures.

Gangi et al reported laser interstitial photocoagulation as a successful minimally invasive procedure. In their case series of 114 patients, 112 patients had a visual analog score of 0 at 1 week postoperatively. Six patients had recurrence and were successfully treated at the second attempt. A recent retrospective study reported 26 patients treated by percutaneous trephine resection and 100 by percutaneous interstitial laser ablation. Percutaneous trephine resection had a success rate of 95% at 24 months. Two patients sustained skin burns and 1 reported meralgia. Interstitial laser ablation had a success rate of 94% at 24 months, with complications including infection, tendonitis, hematoma, and common peroneal nerve injury. The outcome was worse regardless of treatment method in patients younger than 18 years and in instances where the nidus was 12 mm or larger.

Percutaneous thermocoagulation of the nidus has been used by de Berg et al, who reported 17 patients treated successfully with this method. Percutaneous radiofrequency ablation has been proposed as an alternative to the operative treatment of osteoid osteomas. The newer technology radiofrequency probes allow thermocoagulation of a region as large as 5 cm using a single probe (Figure 1C). Generally, osteoid osteoma nidus size is up to 1 cm; consequently, the conventional monopolar radio frequency probe is adequate. A series of 21 patients with osteoid osteoma in atypical locations (eg, hip, radioulnar joint, phalanx) showed radiofrequency ablation to be successful, albeit with only short-term follow-up data available. A 5-year review of radiofrequency ablation confirmed cure in 38 of 39 patients, with 1 case of a broken drill and 1 of infection as the only reported complications. Similarly, a 5-year case series of 21 patients confirmed a primary cure rate of 89.6% that increased to 93% if a second treatment was required.

With osteoid osteoma affecting the spine, the efficacy and safety of this procedure has been assessed, especially considering the effect of increased temperature in the spinal canal. Dupuy et al reported that this technique has no cytotoxic effects into the spinal canal, especially with internally cooled radiofrequency probes. Recently, Peyser et al and Neumann et al also concluded that CT-guided percutaneous radiofrequency ablation of osteoid osteomas is safe, effective, and minimally invasive procedure with a high success rate and no recurrence. Rimondi et al reported a series of 557 patients and recommended modifications to electrode parameters, duration of ablation with regard to the size, and morphology of the lesion.

Recently, bipolar radiofrequency technology has gained interest in the management of osteoid osteoma. Some drawbacks of monopolar radiofrequency ablation include skin burns at the site of neutral electrode and aberrant currents causing irregular areas of necrosis or inducing heat at metallic implants. Another innovative approach with promising results, particularly for inaccessible lesions, has been described by Mylona et al who successfully performed radiofrequency ablation using a probe needle with expandable electrodes. A retrospective review of 81 patients treated either by conventional surgery or minimally invasive techniques for osteoid osteoma of the spine found no difference in outcome.
In its 2004 issue, the National Institute of Clinical Excellence stated that “Current evidence on the safety and efficacy of CT-guided thermocoagulation of osteoid osteoma appears adequate to support its use, provided that the normal arrangements are in place for consent, audit and clinical governance.”

Regardless of the technique used, it is imperative that a biopsy be taken at the time of intervention to confirm the diagnosis. Various methods have been used to determine the complete removal of the nidus. These include immediate radiographs of the patient, tomogram or bone scan of the resected specimen, preoperative tetracycline labeling and use of intraoperative ultraviolet light, microradiography, specimen autoimaging on underdeveloped film, intraoperative use of bone scintigraphy, and immediate postoperative scintigraphy.

**CONCLUSION**

Osteoid osteomas are the third most common benign bone tumor and have a wide variation in presentation. They tend to present in the second decade of life with pain that is worse at night and is relieved by salicylates. Plain radiographs and CT are the mainstays of imaging. Osteoid osteomas consist of a nidus with surrounding sclerotic bone. The natural history of an untreated osteoid osteoma is natural regression, which occurs within 6 to 15 years but can be reduced to 2 to 3 years with treatment with aspirin or NSAIDs.

Various surgical techniques have been discussed in the literature. With the advancement of radiological techniques, percutaneous procedures with less morbidity have been introduced. Surgery is still performed in instances where the location of the lesion precludes percutaneous techniques. If a complete excision or ablation of the nidus is achieved, the reactive bone sclerosis regresses and patients become asymptomatic. In the future, identification of factors that control the local production of prostaglandins may lead to further treatment modalities.

**REFERENCES**


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