Osteoid osteoma is a rare, generally small benign tumor of unknown etiology. Jaffe is credited with the initial description of osteoid osteoma, distinguishing it from the sterile Brodie's abscess and Garré osteomyelitis. The lesion is composed of osteoid and woven bone and is usually smaller than 1.5 cm in diameter. It represents 12% of all benign bone tumors. Osteoid osteomas are more common in males than females (2-3:1), and although 75% occur between the age of 5 and 25 years, they may occur in the mature skeleton up to 70 years of age. Osteoid osteomas are uncommon in Afro-Americans. They can occur in any bone, but in approximately two thirds of patients, the appendicular skeleton is involved. In over 50% of the cases they are centered on the cortex of the diaphysis of the femur or tibia. The skull and facial bones are exceptionally involved.

Histologically they are composed of a small nidus of osteoblasts and osteoid that are arranged in a haphazard fashion over several millimetres, margined by a peripheral neural and arterial supply.
Presentation

The natural history of osteoid osteoma appears to be of growth followed by eventual regression in a variable period of up to 15 years, but many patients present for treatment before this. The mean duration of symptoms prior to presentation is around 16 months.

The hallmark of classical presentation is unremitting, sharp, boring pain which worsens at night and increases with activity, and it is dramatically relieved with small doses of salicylates (aspirin, 20-30 minutes, 75–90%). The lesion produces prostaglandins (PGE2 and 6-keto-PGF1α) in excess, causing local inflammatory effects and vasodilatation which in turn generate pain. The blockade of arachidonic acid pathway with non-steroidal anti-inflammatory drugs (NSAIDs) reduce this prostaglandin burden and hence reduce the associated induced pain. The site of involvement may be tender to the touch or the pressure. The effect of salicylates is so profound that in cases where the pain does not subside after salicylate ingestion, diagnosis of osteoid osteoma should be doubted.

When the spinal column is involved, muscle spasms may cause abnormal alignment. A painful scoliosis may be concave toward the lesion. Kyphoscoliosis, torticollis, and exaggerated lordosis may also be seen. The onset of scoliosis may be acute and is frequently initiated by physical exertion. Osteoid osteoma has been called the most common cause of painful scoliosis.

Definite neurologic abnormalities are seen in 6.5% of patients with spinal osteoid osteoma. An osteoid osteoma affecting the hip may cause referred pain, simulating nerve root compression by an intervertebral disc lesion. An intracapsular lesion often provokes a considerable intra-articular inflammatory response, mimicking erosive arthropathy, crystal arthropathy, or infective arthritis. Approximately one half of patients with intra-articular lesions may have complications of osteoarthrosis 1.5–22 years after the onset of symptoms. Rarely, marked weakness associated with muscular atrophy may affect the involved limb, particularly when the tumor is long-standing.

Features of the Tumor

The tumor consists of an ovoid or spherical nidus of osteoid-rich tissue and interconnected bone trabeculae superimposed on a background of highly vascularized connective tissue containing large dilated vascular channels. The amount of osseous and osteoid tissue varies within the nidus and is reflected in its radiologic opacity. The average size of the nidus is approximately 1.5 cm, but its size can be 0.5–2 cm. Generally, the amount of osteoid tissue exceeds that of mineralized bone.

Multinucleated giant cells and osteoclasts are frequently observed. The degree of bone sclerosis varies around the central nidus, but such reactions may be minimal and sometimes absent. The sclerosis and the osteoblastic rimming are indistinguishable from findings in osteoblastoma. Unlike in osteoblastoma, neural staining techniques reveal many axons throughout an osteoid osteoma, which probably accounts for the pain. Levels of prostaglandin E2 are markedly elevated in the nidus; this is presumably the cause of pain and vasodilatation.

The tumors may regress spontaneously (as seen clinically and radiologically), though the exact mechanism of action is not known (tumor infarction postulated). Yet, on occasions surgical excision or nidus ablation may be required. Though minimal, malignant transformation has been reported.

Classification

Cortical osteoid osteoma is the most common with the nidus within the cortex. It demonstrates solid/laminated periosteal reaction with fusiform sclerotic cortical thickening in shaft of long bones. There is a radiolucent area within the center of the osteosclerosis (Figures 1., 2.).

Cancellous osteoid osteoma is localized intramedullary. It is of great importance in cases of intra-articular osteoid osteoma as it is difficult to diagnose, a four month to five year diagnostic lag has been seen. It is seen juxta-/intraarticularly at the femoral neck, vertebral posterior elements and small bones of the hands and feet. The sclerotic cortex is distant from the nidus, the joint spaces are widened with effusion.

Subperiosteal osteoid osteoma is comparatively rare, round soft-tissue mass besides the bone. Most frequently seen juxta-/intraarticularly at the medial aspect of femoral neck, hands, feet (neck of talus). Typified by the juxtacortical mass excavating the cortex (bony pressure atrophy) with almost no reactive sclerosis (Figure 3.).
DIFFERENTIAL DIAGNOSIS

Cortical osteoid osteoma: Brodie abscess, sclerosing osteomyelitis, syphilis, bone-island, stress fracture, osteosarcoma, Ewing sarcoma, osteoblastic metastasis, lymphoma, subperiosteal aneurysmal bone cyst, osteoblastoma.

Intraarticular osteoid osteoma: Inflammatory (septic, tuberculous, rheumatoid) arthritis, nonspecific synovitis, Legg–Calvé–Perthes disease.

IMAGING

Radiography (plain X-ray) – This is the initial examination of choice and may be the only that is required. A plain radiograph of osteoid osteoma demonstrates dense reactive bone which is diagnostic (Figure 1). The nidus is radiolucent (75%), round/oval and <1.5 cm in size. The lesion initially appears as a small sclerotic bone island within a circular lucent defect. This central nidus is seldom larger than 1.5 cm in diameter, and it may be associated with considerable overlying cortical and endosteal bone sclerosis, with or without central calcification. Roentgenographs are usually enough, however some areas of the skeleton are difficult to assess by using plain X-ray in patients with a suspected osteoid osteoma. These areas include the spine, the femoral neck, and the small bones of the hands and the feet. In the spine the overlapping shadows of the vertebral column can obscure the tumor. In cases where we have spinal involvement, there might be abnormalities of alignment, such as scoliosis, kyphosis or hyperlordosis. In children with a long-standing tumor the involved bone may demonstrate overgrowth.

Particular attention should be devoted to differentiating osteoid osteoma from a Brodie’s abscess.

Figure 1. Sclerotic cortical thickening of the diaphysis of the tibia on plain film a) and CT scan b). The scan showed the nidus of the lesion.

Figure 2. AP and lateral views of the left tibia operated for osteoid osteoma. The nidus along with the affected bone section was resected and titanium elastic nails were placed to stabilise the extremity.
and a tumor in the long bones of children where overgrowth may occur. Also, some confusion may occur in differentiating osteoid osteoma from osteoblastoma as both have a propensity for the posterior elements of the spine and both are osteoblastic tumors. The two can be differentiated on the basis of their sizes, since osteoblastomas are considerably larger than osteoid osteoma and are better depicted on plain radiographs.

*Nuclear scan* – Radionuclide scanning for tech-
netium Tc 99m diphosphonate uptake shows fairly intense activity at the tumor site (increased blood flow and new bone formation). This examination may also be used to localize the tumor preoperatively and to establish complete removal of the nidus by using a hand-held radioactivity detector. Radionuclide scanning is a sensitive technique, and findings may be positive before radiographic changes appear.

**Computed tomography** – It has gained widespread popularity. It is ideal for the detection and precise localization of the nidus and has recently been also employed for guiding percutaneous ablation. On the CT scan the nidus is seen to be well-defined round to oval shape and surrounded by variable amounts of sclerosis. The nidus enhances on dynamic scan following intravenous administration of contrast medium. The nidus is seen with variable amounts of mineralization (it may be punctate, amorphous, ringlike or dense). CT is particularly effective in areas with complex anatomy such as the spinal pedicles, laminae, and femoral neck. Occasionally, osteoid osteoma can be mistaken for Brodie’s abscess.

**Magnetic resonance imaging** – On MRI there is reduced enhancement of the lesion as compared to CT. On T1W1 weighted scans, the nidus is isointense to muscle. This signal intensity increases to that between muscle and fat on T2W1. Perinidal inflammation of bone marrow is observed in 63% and perinidal soft-tissue edema (inflammation, specially in young patients) seen in 47%. In cases where the joints are involved, synovitis and joint effusion are seen intraarticularly. MRI reliably demonstrates the nidus, yet, CT appears superior for precise nidal localization. Also, marrow edema may be erroneously taken for malignancy or stress fracture. In cases of cancellous osteoid osteoma, MRI is better.

**Ultrasonography** – The roles of conventional and Doppler ultrasonography have not been established yet. The duplex color Doppler ultrasonography can be used to identify the feeding vessels to the nidus. Also, it can be used to guide percutaneous localization and biopsy of the lesion.

Ultrasonography has been avail to aid in the diagnosis of intra-articular osteoid ostemias. Sonographic findings of a cortical irregularity and focal synovitis may refer to the possibility of intra-articular osteoid osteoma.

**Angiography** – The need for angiography should only very rarely arise in the presence of other less invasive diagnostic modalities. On angiography the nidus is highly vascularised with an intense circumscribed blush appearing in the early arterial phase and persisting late into venous phase – diagnostic of osteoid osteoma. Care should be taken to rule out Brodie’s abscess since it may also show hypervascularity (but blush not seen lasting into venous phase).

**Word of caution:** Osteoid osteoma occurs in many different locations differently. Therefore it is imperative to have imaging that documents the changes clearly. But, on occasions these changes may not be so well documented using a particular examination technique. For example, the nidus in the spine may be difficult to detect by using plain radiographs. Intra-articular tumors are difficult to detect on plain radiographs because of the absent or limited sclerosis around the nidus. Also CT, even though ideal to detect the nidus, has the disadvantage of ionizing radiation. On MRIs the tumor is not as obvious as on CT scans. Angiography is an invasive procedure, and a minor overlap of angiographic features occurs with a Brodie abscess. Finally, the specificity of radionuclide bone scanning is low.

**TREATMENT**

Despite its small size, osteoid osteoma may have an unpredictable course. It may resolve spontaneously or it may require treatment to overcome the intense, continuous pain. Initially medical therapy with NSAIDs may be employed. Cases where the pain is severe and unrelenting, surgical excision has been the treatment of choice for many years. Recently, owing to difficulty in access to deep sites (hip joint), higher risk of complications, and prolonged postoperative recovery, less invasive techniques have been proposed, such as CT-guided percutaneous resection, drill trepanation combined with or without ethanol injections, cryoablation, and laser or radiofrequency (RF) thermoablation. In spinal tumors, complete ablation or resection of the tumor is desirable but not always feasible.

Coming back to surgical mode of treatment, en-bloc excision of the nidus used to be the first-choice treatment, but intraoperative localization may be very difficult and large bone resection might be necessary, resulting in bone weakness and risk of fractures.
Percutaneous radiofrequency ablation (RFA) of tumor

The first report in the literature of technical and clinical success with radiofrequency thermal ablation in the treatment of osteoid osteoma by Rosenthal et al.\(^1\) appeared in 1992. Fifteen years following that report, CT-guided radiofrequency thermal ablation has been proven to be an accepted, safe, minimally invasive, and cost-effective treatment for osteoid osteoma.\(^3\) The radiologist’s role in the management of this condition has evolved from simply confirming the diagnosis of osteoid osteoma to curing the abnormality.

A very thorough description of the technique is available in the paper from Pinto et al.\(^2\). The technical details are summarized below for the readers’ interest. The authors of the above mentioned report divided their procedural details into eight points (steps), having a success rate of 92%.\(^2\)

The principle of thermocoagulation

Radiofrequency thermal ablation is a form of electrosurgery in which an alternating current of high-frequency radio waves (>10 kHz) passes from an electrode tip in body tissue and dissipates its energy as heat. A radiofrequency generator forms an electric current that flows from the generator, through the electrode into the patient, and out through a grounding electrode or pad back to the generator. Resistance of biologic structures causes local ions to vibrate. This ionic agitation results in friction around the electrode tip as ions attempt to pursue changes in direction of the alternating current and create heat to the point of dessication – hence, the term “thermal ablation.”\(^2\) Radiofrequency thermal ablation differs from electrocautery in that the tissue around the electrode, rather than the electrode itself, is the primary source of heat.

Indications

CT-guided radiofrequency thermal ablation should be attempted when a nidus is identified on CT in a patient with an appropriate history suggestive of osteoid osteoma.\(^3\) The target tissue is the nidus. Strict criteria comprising visualization of a distinct radiolucent, round, or oval nidus with variable internal calcification on fine-section CT (slice thickness 1-3 mm) should be applied. This will avoid the risk of ablating lesions that may mimic an osteoid osteoma, such as a Brodie’s abscess, for which an alternative therapy or no treatment is required.\(^3\)

Equipment

Helical CT with low-dose, “quick-check” CT fluoroscopy results in savings of time and dose for the patient. A general anesthetic allows a pain-free procedure and absolutely stable patient position, although a spinal anesthetic is an option for patients with lower limb lesions. Entering the nidus elicits extreme pain in most cases resulting in patient movement and loss of position. The time required for the procedure is around 90 min, including the time until the patient is stable under anesthesia.

Patient should be placed supine in cases of limb lesions. The limbs can be rotated internally or externally in order to give the best access. The limbs can then be secured with tape or straps to allow good skin access, easier needle placement, and avoidance of neurovascular structures. Spinal lesions are treated with the patient lying prone with a padded ring beneath the chest for easier ventilation.

In most of the publications available the Bonopty coaxial bone biopsy system (Radi Medical Systems, Uppsala, Sweden) has been used for bone access. The system’s small-caliber needles and multi-capability components such as drill and biopsy cannula make it ideally suited for radiofrequency thermal ablation. The system comprises a 95-mm-long 14-gauge (2.1-mm) Bonopty Penetration cannula, a 100-mm-long 15-gauge (1.7-mm) Bonopty Drill, a 16-mm-long 15-gauge (1.7-mm) Bonopty Extended Drill, and the 160-mm-long 15-gauge (1.7-mm) Bonopty Biopsy cannula. The radiofrequency thermal ablation probe, such as the SMK-TC15 (Radionics, Burlington, MA) is a 15-cm-long, straight, rigid electrode with a diameter of 1 mm. An incorporated temperature-measuring device (thermistor) allows precise monitoring of the probe-tip temperature. The probe is introduced using a 145-mm-long dedicated Sluyter-Mehta 20-gauge thermal ablation cannula with a 5-mm-long
noninsulated tip (Radionics). The 20-gauge thermal ablation cannula is placed through the bone-penetration cannula at the time of treatment.

The radiofrequency thermal ablation probe is connected to a radiofrequency generator which supplies the monopolar radiofrequency current. The device delivers an AC of approximately 500 kHz in a continuous unmodulated sinusoidal waveform when in “lesion” mode.

Grounding

Grounding consists of a dispersive electrode placed close to the lesion site to draw current back to the radiofrequency unit. A large-area adhesive gel grounding pad like that used in the operating room has the advantages of no skin penetration and reduced current density, resulting in less heating at the dispersive electrode to avoid tissue burns at this site.

Contraindications

Patients with cardiac pacemakers.

Steps of the technique

1. Localization of lesion – to localize and plan from a specimen block of 3-4 cm which is broken down into 1 mm-thick slices.
2. Grounding pad – placed close to skin entry point allowing the shortest current path through the patient. The area is then sterilized and draped.
3. Superficial bone entry with use of tenting – A 2-mm skin incision is made, and the penetration cannula with stylet is then inserted through the soft tissues and into the bone surface.
4. Drilling – the inner stylet is exchanged for the drill (when needed for deeper lesions), and drilling to the edge of the nidus is performed. During drilling, position and direction are verified with further scans. The anchored penetration cannula now serves as a fixed pathway for biopsy and radiofrequency thermal ablation.
5. Biopsy – histology helpful in case the lesion recurs. The biopsy cannula is inserted through the penetration cannula, and the biopsy specimen is removed using gentle suction. Tissue material fixed in formalin is sent for histology. Appropriate decalcification is mandatory before embedding and cutting slides.
6. Cannula-probe placement – thermal ablation cannula with a stylet is inserted through the bone-penetration cannula, and a check scan is made.
7. Electrode connection.
8. Radiofrequency thermal ablation – 90 °C for 4 min. The automatic temperature override control is set to 93 °C (the maximal desired temperature). Built-in circuitry will prevent the lesion temperature from exceeding the set value. Radiofrequency thermal ablation is performed by smoothly turning the output control knob for 30-60 sec until the desired temperature of 90 °C is displayed. The lesion time control is set to its maximum of 2 min, then repeated (total time 4 min).

Potential complications

Bleeding, nerve injury, soft-tissue burns, higher risk of skin necrosis in osteoid osteoma in superficially located bone, in which extra care is required. This complication is avoided by withdrawing the outer cannula to approximately 1 cm above the noninsulated tip of the coagulation cannula.

Physiologic reaction to radiofrequency thermal ablation

During general anesthesia, in about 50% of patients physiologic reactions are observed upon entering the nidus or during ablation. These reactions consist of variable increases in blood pressure, heart rate, and respiratory rate. The patient may even move and cause a loss of position. The reaction subsequently normalizes when the lesion is completely destroyed and seems compatible with theories suggesting a neurogenic origin for the pain associated with an osteoid osteoma. These reactions inform the operator that they have entered the nidus.

Postprocedure periode, bone healing

Pain is variable after radiofrequency thermal ablation. Pain may last for up to one or two days after the procedure. This typically settles quickly, and analgesia is rarely required. Patients may bear weight immediately and return to normal activi-
ties (including sports). Follow-up clinical assessment is made at two weeks. At this time, patients with persistent pain requiring a second thermal ablation can be identified. Ultimately, resolution of pain is the primary parameter used to define a successful treatment. Radiographically, partial or complete infilling of the nidus with sclerotic bone is expected over 2–27 months, although little or no change in lesion appearance is also possible. Eventually the nidus site can become indistinguishable from surrounding bone, and reactive changes in adjacent bone and periosteum also tend to diminish.

**Special considerations about osteoid osteoma**

**Spinal lesions** – Spinal lesions compose 10% of cases of osteoid osteoma. Most lesions seen in the lumbar spine (59%), followed by the cervical (27%), thoracic (12%), and sacral regions (2%)²³. Lesions are almost always in the posterior elements and are located in the pedicles (75%), laminae, articular processes, and only uncommonly in the vertebral body. More important for this form of treatment that lesions do not usually involve the spinal canal or paraspinal tissues.

**Large lesions** – For osteoid osteoma larger than 1 cm in any dimension, radiofrequency thermal ablation must be performed at more than one probe position, preferably with overlap of the treatment zones.

**Lesions close to joints** – The hip joint is involved much more commonly than the elbow, wrist, knee, and foot. Avoiding a transarticular approach will minimize the small risk of introducing infection, negate cooling effects from any associated joint effusion, and also reduce the chance of inadvertent ablation of articular cartilage. For acetabular lesions, needle passage through the hip joint is usually not required. For lesions of the anterior proximal femoral neck, joint passage is occasionally required. Internally rotating the lower limb provides easier access to lesions of the anterior proximal femoral neck by an anterior approach. The femoral neurovascular bundle is usually easy to avoid.

**Lesions close to open growth plates** – A cranially or caudally angulated approach in these rare cases reduces the risk of damaging the undulating growth plate.

**Residual and recurrent symptoms** – Residual symptoms are defined as pain or impaired function or both, identical to or resembling the presenting complaints, that persist for more than two weeks after radiofrequency thermal ablation. Patients with residual and recurrent symptoms will usually benefit from a second ablation of the apparently incompletely treated nidus.

Two or more probe placements may be required for the follow-up radiofrequency thermal ablation, which can be expected to result in a cure. If symptoms persist but the lesion continues to look like an osteoid osteoma, a third ablation can be attempted. However, surgical excision is probably warranted when feasible²³.

**Conclusion**

Osteoid osteoma is a painful benign tumor. Initial treatment usually consists in medical therapy using NSAIDs. Patients not responding to medical therapy or unable to bear long-term therapy require nidus excision. Surgery used to be the first treatment option for osteoid osteoma, but has several disadvantages, such as difficult preoperative localization and need for wide excisions causing bone weakness and the need for internal fixation, bone grafts, and postoperative immobilization.

Percutaneous treatments for osteoid osteoma have gained popularity worldwide, and the reported high success rates with low incidence of complications have extended its indications, confining surgical treatment to specific cases. Radiofrequency ablation represents one option whose safety and efficacy has been proven²³, 26–30.

**References**


