

Management of Osteoid Osteoma by Radiofrequency Ablation

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Abstract

Case Report

Osteoid osteoma is a benign bone tumor commonly affecting young adults, characterized by severe nocturnal pain relieved by nonsteroidal anti-inflammatory drugs. Computed tomography (CT)-guided radiofrequency ablation (RFA) has emerged as a minimally invasive and highly effective alternative to surgical excision. We report the case of a 20-year-old patient presenting with progressive thigh pain. CT imaging revealed a 10 mm cortical nidus in the femoral metaphysis. The patient underwent CT-guided RFA under spinal anesthesia, achieving complete nidus ablation with immediate pain relief and no complications. RFA induces localized thermal coagulation, ensuring precise nidus destruction while preserving surrounding bone integrity. Clinical success rates exceed 90%, with rapid recovery and minimal recurrence. This case highlights CT-guided RFA as the treatment of choice for osteoid osteoma, combining safety, efficacy, and cost-effectiveness.

Keywords: Osteoid osteoma, Radiofrequency ablation, CT-guided procedure, Minimally invasive treatment, Bone tumor.

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INTRODUCTION

Osteoid osteoma is a benign bone tumor, accounting for about 5% of all bone tumors [4] typically small, primarily located in the diaphyseal cortex of the femur and tibia, but it can affect any skeletal region [2].

This lesion causes intense nocturnal pain, relieved by nonsteroidal anti-inflammatory drugs. Historically, surgical excision was the standard treatment, but its drawbacks, such as prolonged recovery and postoperative complications, have led to the development of minimally invasive techniques like radiofrequency ablation [3].

CASE STUDY

A 20-year-old patient reporting localized, dull aching pain in the upper left thigh, progressively worsening over the past 6 months.

The pain is characteristically more severe at night and shows marked relief with non-steroidal anti-inflammatory drugs.

The patient has shown no history of trauma, systemic symptoms (fever, weight loss, night sweats), or neurological complaints.

The imaging results were as such:

X-ray (AP and lateral femur): Small, radiolucent focus with surrounding sclerosis, no sign of fracture were noted.

CT Scan:

- Well-defined round lucent nidus (~10 mm) with central mineralized focus, located in the anterior cortex of the left femoral metaphysis. (figure A-B)
- Surrounding cortical thickening and reactive sclerosis.
- No cortical breakthrough or periosteal reaction beyond expected changes.

The patient was diagnosed with Osteoid osteoma, and was considered a good candidate for radiofrequency ablation of the tumor.

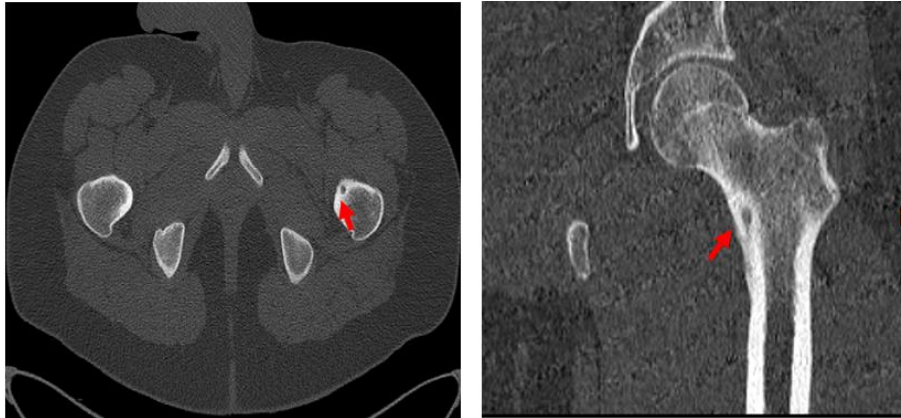
After running standard blood tests and obtaining consent from the patient, the procedure was scheduled.

The patient underwent spinal anesthesia while being thoroughly monitored, then was installed in the CT

room, additional local anesthesia was added, and the procedure following these steps:

The nidus must be located thoroughly and precisely, using a grid and 3x1 mm collimation (Figure

C) sequences to minimize irradiation, if the nidus lies within 10 mm of vital structures, the needle trajectory must be modified or alternative treatment considered.



Figures A-B: Nidus of the osteoid osteoma (red arrows) in axial (figure A) and Sagittal (figure B) reconstructions showing as well defined round lucencies surrounded by cortical thickening and reactive sclerosis



Figure C: Precise location of the nidus using (1x3) collimation

The aim of such adjustments is to maximize the safety margin by increasing the distance from critical anatomy before proceeding with the treatment.

The procedure begins with placement of a spinal needle through the predetermined skin entry site to the cortical surface overlying the lesion.

After confirming its correct position on imaging, an insulated introducer needle of larger gauge (17 G in our case) is advanced along the trajectory of the spinal needle, which functions as a guide.

The introducer is then secured against the cortex using gentle hammering, and the spinal needle is

subsequently withdrawn while maintaining the introducer in situ.

A follow-up scan is performed to verify accurate introducer positioning. This approach minimizes repeated trajectory corrections, thereby reducing soft tissue trauma and shortening overall procedure time.

Then RF probe is advanced through the introducer until its unopened tip is aligned with the introducer tip.

The probe is then deployed within the nidus, followed by imaging to confirm accurate positioning (figure D) and to delineate the ablation zone while ensuring that no vital structures are encompassed within the predicted treatment zone.



Figure D: Confirmation of the accurate positioning of the probe within the nidus

Radiofrequency is applied starting at 2 W, increasing by 1 W every 3 minutes up to a maximum of 5 W. Automatic stop if a resistance limit of 900 ohms is reached.

After the completion of the RF ablation, the electrode is retracted into the insulated introducer, and both are removed together as a single unit to minimize the risk of thermal injury to surrounding tissues.

A small volume of local analgesic is then infiltrated along the needle tract to reduce immediate postoperative pain.

Technical success is defined by complete nidus ablation, confirmed by a control scan (figure G)

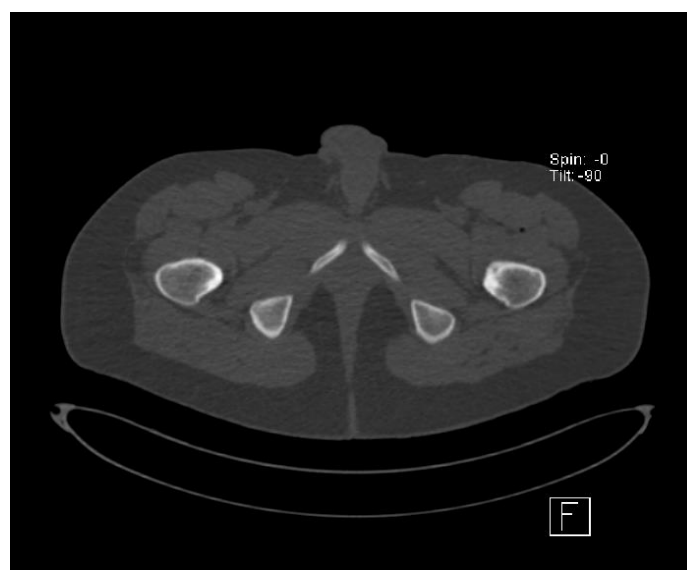


Figure G: Control scan after thermoablation of osteoid osteoma. The figure shows a complete ablation of the nidus

DISCUSSION

Introduction

Osteoid osteoma is a benign bone tumor of unknown etiology, first described by Jaffe in 1935 accounting 2–3% of all primary bone tumors and 10–12% of benign skeletal neoplasms [1].

This tumor occurs predominantly in male adolescents and young adults, with half of the patients aged between 10 and 20 years, a male-to-female ratio of 4:1 [7].

Clinically, it presents with localized, progressive, nocturnal pain relieved by NSAIDs, sometimes associated with swelling or erythema in superficial lesions.

Although Osteoid osteoma can arise in any skeletal site, the most frequent locations are in the diaphysis or metaphysis of long bones, especially the femur and tibia.

Histologically it is categorized into cortical, medullary, and subperiosteal types. Cortical lesions are most common, showing a central nidus with peripheral sclerosis; medullary lesions occur in the femoral neck, small bones, or spine, and subperiosteal lesions typically involve intra-articular surfaces. [8]

Imaging of Osteoid Osteoma

On plain radiographs, osteoid osteoma typically appears as a small (<2 cm) cortical lucency within dense cortical bone, surrounded by thickening and sclerosis which might hide the nidus if important [9].

CT is the modality of choice, reliably identifying the nidus as a round or oval low-attenuating lesion, sometimes with punctate, amorphous, or ring-like mineralization [10].

Reactive sclerosis can range from minimal to extensive. Nidus mineralization correlates positively with pain duration, serving as a marker of lesion age, though not with nidus size; diaphyseal lesions show lower mineralization ratios compared to epiphyseal and metaphyseal sites.

MRI is more sensitive for detecting reactive changes in soft tissue and bone marrow edema, but less specific than CT for nidus visualization. Signal characteristics vary with mineralization and vascularity: the nidus appears iso- to hyperintense on T1, heterogeneously hyperintense on T2/STIR, and variably enhancing. Osteosclerosis manifests as low signal on both T1- and T2-weighted images. The “half-moon sign” of marrow edema in the femoral neck has been reported as highly sensitive and specific for osteoid osteoma 94.7% and 100%, respectively. [8]

Treatment

Although osteoid osteomas may spontaneously regress over the course of 2 to 6 years [11] surgical excision was historically considered the standard therapy for patients with persistent pain or NSAID intolerance achieving success rates of 88–100%, but carries disadvantages including difficulty in lesion localization, need for wide bone removal with risk of weakness or fracture, and recurrence rates of 4.5–25% due to incomplete nidus excision [8].

Excessive bone removal during surgical excision may result in significant weakening, sometimes requiring bone grafting and increasing morbidity.

Percutaneous image-guided procedures, performed under CT or MRI guidance, allow precise nidus localization and effective pain relief with minimal morbidity while preserving bone integrity. Nidus destruction can be achieved by mechanical methods (trephine needle or bone drill), chemical ablation (ethanol), or thermal ablation. Among thermal techniques, radiofrequency ablation (RFA), microwave ablation, and laser ablation are the most commonly employed. [12]

Principle [8] et [12]:

Image-guided radiofrequency thermal ablation (RFTA) relies on thermal coagulation induced by alternating electromagnetic currents in the 375–500 kHz range.

Energy delivery occurs via monopolar systems, consisting of a single active electrode and a dispersive grounding pad, or via bipolar systems, which utilize two adjacent active electrodes.

The passage of current induces ionic agitation and frictional heating within the surrounding tissue, resulting in coagulative necrosis confined to the treatment zone.

The extent and morphology of this zone are determined by electrode design, active tip length, degree of tissue charring, perfusion-related heat sink, power output, and ablation duration.

Several electrode types are available: expandable multi-tine electrodes that enlarge and homogenize the ablation zone, internally cooled electrodes that limit collateral thermal damage, and perfusion electrodes that enhance electrical conductivity through saline infusion.

Multi-tined systems generally generate broader and variably shaped ablation zones compared with single-tip electrodes.

Experimental data indicate that non-cooled probes with an active tip of 5–8 mm, operated at 90 °C for 4–6 minutes, consistently produce ablation zones of approximately 10–13 mm in diameter. This dimension is adequate for complete nidus destruction while minimizing unintended thermal spread, provided that accurate intranidal probe positioning is achieved.

Advantages:

Thermal ablation, including radiofrequency, provides a minimally invasive alternative to conventional surgical excision. It allows precise destruction of the nidus under image guidance (CT or MRI), preserving surrounding bone and soft tissues and thereby minimizing the risk of structural compromise or the need for grafting and fixation. [12]

Clinical success rates consistently exceed 90%, with low recurrence rates, and retreatment further improves outcomes in persistent cases[13].

Procedures are typically performed under local or regional anesthesia, with brief operative time and rapid post-procedural recovery, enabling same-day discharge and early return to normal activities. Complication rates are low and generally minor, including transient nerve irritation, hematoma, or superficial skin injury.

Thermal ablation is particularly advantageous for lesions in anatomically challenging locations, such as the spine, hip, or intra-articular sites, where conventional surgery carries higher morbidity.

The combination of high efficacy, safety, and reduced hospitalization renders thermal ablation a cost-effective first-line intervention for symptomatic osteoid osteoma [14,15].

Indications [5]

Thermoablation is indicated when the nidus is clearly identified on CT and the patient's clinical history is compatible with osteoid osteoma. Strict adherence to diagnostic criteria is essential to avoid misdiagnosis, particularly in cases that may mimic other conditions such as Brodie's abscess or geode formation.

Contraindications and Complications

Absolute contraindications are rare but include patients with implanted pacemakers. Potential complications are generally minor and may include superficial bleeding or skin burns, particularly when the lesion is subcutaneous. Proper technical expertise and careful consideration of local anatomy are critical for minimizing these risks.

Healing and Postoperative Follow-up

Clinical success of thermal ablation is defined by a significant reduction in pain, typically measured by the Visual Analog Scale (VAS), and the complete

absence of pain up to two years post-procedure. Radiological indicators of successful ablation include resolution of bone marrow edema and perilesional synovial reaction, evidence of bone remodeling, and the presence of the "ring sign." Bone edema and perilesional synovial reaction generally resolve within one year, whereas complete bone remodeling may take up to two years.

Persistence of radiolucency on radiographs or CT, combined with residual nidus enhancement on dynamic imaging and ongoing clinical pain, is indicative of incomplete ablation. [12]

CONCLUSION

Osteoid osteoma is a common benign lesion in young patients, causing severe pain and functional impairment. CT-guided radiofrequency ablation is a safe, minimally invasive, and effective alternative to surgery, allowing rapid recovery and reducing healthcare costs.

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