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INVITED COMMENTARY

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Percutaneous radiofrequency treatment of osteoid osteoma

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Abstract Osteoid osteoma is a small osteogenic tumor usually found in the lower extremity of children and young adults. Although these lesions are benign and rarely progress, they present distinctive pain symptoms that frequently require medical intervention. This article reviews surgical, medical, and percutaneous techniques for treatment of osteoid osteoma, emphasizing the value of percutaneous radiofrequency treatment.

Keywords Bone neoplasms · Computed tomography (CT) · Radiofrequency (RF) ablation · Osteoma

Treatment options

Proper treatment of osteoid osteoma has been the subject of some controversy, as several treatment options are currently available [1, 2, 3, 4, 5].

Surgical treatment

Surgical treatment has been the standard of care for many years. An appropriate operative approach must balance three competing issues:

1. Visual identification of the tumor margins can be difficult because of surrounding bone formation and reactive tissue. This may lead to wide resection margins to ensure a successful treatment.
2. Tumor resection in weight-bearing bones requires a fairly long recovery period to avoid the risk of fracture, frequently necessitating internal fixation and/or bone grafting [6].
3. Subtotal resection of the lesion can lead to recurrence, although there is a small amount of evidence to the contrary [7].

To limit the operative procedure and spare as much bone as possible, a number of sophisticated techniques combining imaging and surgery have been developed. Radioisotope scanning can be used intraoperatively to localize the lesion [8] and to ensure removal of the tumor. Computed tomography (CT) scanning also has been extremely effective at finding the tumor nidus and can be used to guide placement of needles, Kirschner (K) wires, or methylene blue to assist with surgical identification [9].

Medical treatment

There are reports in which lesions with clinical and radiological features of osteoid osteoma spontaneously became asymptomatic after a period of 2–8 years, with or without radiological regression. This has led to the belief that the tumors can be treated non-operatively with non-steroidal anti-inflammatory drugs [3]. In our experience, most patients are unwilling to tolerate the pain and also wish to avoid the long-term use of such medications.

Percutaneous techniques

During the past decade, percutaneous techniques have been developed in an attempt to match the extent of iatrogenic tissue damage to the small size of the lesion. These procedures may be divided into two groups: those that attempt to remove the lesion physically, and those that aim at in-situ destruction (ablation).

In the first group, the prototypical procedure is percutaneous excision using large-caliber hollow needles and drills. This technique has been pioneered chiefly in Europe and has the merit of simplicity. It does not require elaborate or sophisticated equipment and, like surgical approaches, it results in immediate relief of symptoms [4]. However, we have observed that the average osteoid osteoma has a diameter of 7–8 mm, and lesions measuring 10 mm or slightly more are not unusual. The removal of such lesions requires either large-caliber drills (9–10 mm) or multiple passes, which appears to obviate some of the benefit of the minimally invasive approach. Indeed, advocates of this technique acknowledge difficulty in removing large lesions owing to increased risk of fractures [4]. Other disadvantages include the need for hospitalization ranging between 2 and 21 days [4, 10] and complications such as skin burns, osteomyelitis, muscular hematomas, and fractures [4].

Ablative techniques include ethanol injection, laser photocoagulation, and radiofrequency treatment [2, 11]. Alcohol injection has been used as a salvage technique after failed surgery and as an adjunct to percutaneous excision [11]. However, alcohol injection is not anatomically selective and extravasation may affect the surrounding tissues.

Interstitial laser photocoagulation through an optical fiber is similar to radiofrequency treatment in that both techniques result in thermal destruction of the tumor [5]. With both methods, the extent of necrosis is limited by the thermal properties of the tissues. Experimental and clinical studies indicate that a maximal thermal lesion of approximately 10 mm can be created, with minimal influence to tissue immediately adjacent to that area. Excellent results have been achieved with laser photocoagulation, which can be performed with extremely small optical fibers [5]. However, in our view, this advantage is outweighed by the fact that biopsy cannot be performed through such small devices. Although we agree with published opinions that diagnosis by clinical and imaging methods is highly accurate [1], in our experience occasional errors occur, and patients find that histological proof is comforting. In addition, the thermal rise during laser treatment is uncontrolled and not monitored, reaching peak temperatures that vary between 100 and 240°C. Although complications have not been reported as the result of osteoid osteoma treatment, rapid temperature rise with the use of lasers has been reported to injure bone as the result of a shock wave induced in the tissue [12].

Radiofrequency ablation of osteoid osteomas was first introduced in 1992 [2] and since then several studies have reported excellent results [13, 14, 15]. The technique consists of drilling a small hole and placing an RF electrode within the tumor, causing thermal necrosis (Fig. 1). As a result of the diameter of the hole (2 mm) it is possible to obtain biopsy specimens using a 16-G needle.

Experience with RF ablation of osteoid osteoma

Beginning in July 1990, we have treated over 250 patients with osteoid osteoma by CT-guided radiofrequency (RF) coagulation. We believe this approach has numerous advantages. There are three simple requirements for a patient to qualify for the procedure:

1. The tumor should have a high probability of being an osteoid osteoma based upon clinical and imaging evidence.
2. There must be safe access for a 16-G needle, permitting placement such that no part of the tumor is more than 5 mm from the needle. More than one placement may be needed.
3. No vital structures should be within 1 cm of the tip of the electrode.

Because of the third requirement, we generally decline to treat the rare tumors of the hand and posterior elements of the spine. However, virtually all other lesions are appropriate, and in our institution, operative treatment for these tumors has been essentially eliminated.

Our technique has been fully described elsewhere [16]. Although we use general anesthesia, the procedure is performed on outpatients. Patients are advised to resume all daily activities immediately, and follow-up requirements are minimal. No cast, splints or other external supports are provided. Patients with lesions of the weight-bearing bones are advised to avoid strenuous sports that require prolonged running and jumping for 3 months after the procedure. Physical therapy is not employed.

All procedures have been completed successfully (electrode introduced into the lesion in a satisfactory location). None has had to be abandoned for any reason. Biopsies obtained at the time of the procedure are diagnostic in approximately 75%.

Complications have been minimal. One case of probable cellulitis was successfully treated with oral

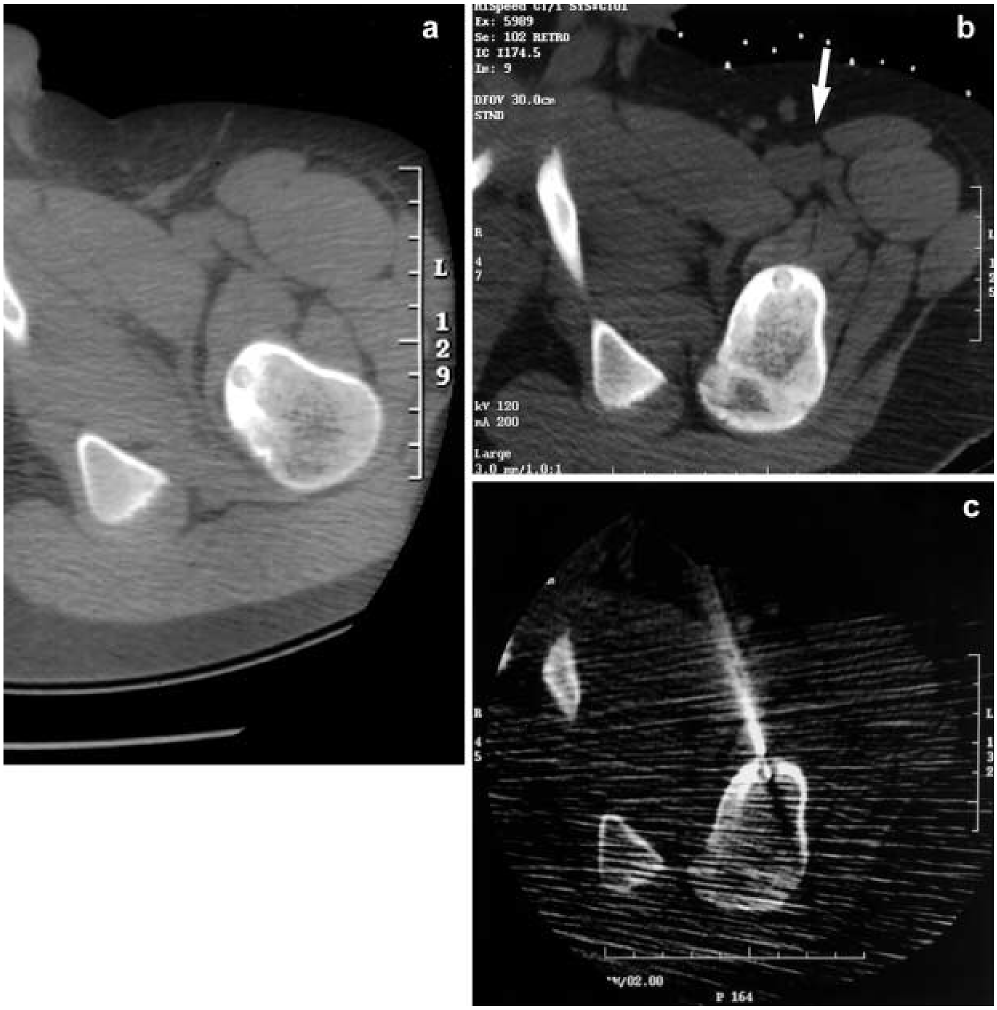

Fig. 1. **a** CT scan of the left hip shows an osteoid osteoma in the postero-medial cortex of the proximal femur. **b** Images obtained with the patient in the "frog-lateral" position. This rotates the lesion anteriorly, allowing it to be safely approached medial to the femoral triangle (*arrow*). The lesion measures 5 mm in diameter, contains central ossification, and is surrounded by thickened cortex. **c** The radiofrequency electrode is seen within the tumor. Notice that no portion of the tumor is more than 5 mm from the exposed tip of the electrode. The image contains a large amount of "streak" artifact as a result of the low-dose scanning technique we employ for needle placement. This reduces radiation exposures by factors of up to 10

antibiotics, and one case of a peculiar vascular instability resolved spontaneously. Interestingly, despite concerns about appropriate activity levels following the procedure, no fractures or other delayed complications were observed.

Others have adopted our methods with slight variations in technique. Primary clinical success rates have varied between 73% and 95% after follow-up periods of 3–23 months [13, 14, 15]. Recurrences can be treated by RF with equal success. In our practice, the primary and secondary success rates are 91% and 60%, respectively.

In summary, our experience strongly supports the current trend in minimally invasive treatment of osteoid osteoma. We believe CT-guided RF ablation of these lesions is a simple, safe, and highly effective technique, and can be considered the modality of choice for most lesions located in the appendicular skeleton and pelvis.

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