CLINICAL STUDY

Microwave Ablation of Osteoid Osteomas Using Dynamic MR Imaging for Early Treatment Assessment: Preliminary Experience

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ABSTRACT

Purpose: To evaluate the efficacy of microwave ablation for osteoid osteomas by using dynamic contrast-enhanced magnetic resonance (MR) imaging in early treatment assessment.

Materials and Methods: Ten patients (two female, eight male; mean age, 28 y; range, 16–47 y) presenting with osteoid osteomas were treated between June 2010 and December 2012 with the use of computed tomography (CT)–guided microwave ablation. Osteoid osteomas were found at the femoral neck (n = 4), tibia (n = 3), calcaneus (n = 1), navicular bone (n = 1), and dorsal rib (n = 1). Dynamic contrast-enhanced MR imaging at 3.0 T was performed 1 day before microwave ablation and again after ablation. The procedure was considered successful if the signal intensity (SI) of the lesion on MR imaging decreased by at least 50% and the patient was pain-free within 1 week of intervention.

Results: All patients were pain-free within 1 week after microwave ablation and remained so during the 6 months of follow-up. No major or minor complications developed. On average, SI of the lesions decreased by 75% (range, 55.5%–89.1%) after treatment. The difference in lesion SI before versus after ablation was significant by *t* test ($P < .0001$; confidence interval, 120.26–174.96) and Wilcoxon test ($P = .0020$).

Conclusions: Microwave ablation treatment of osteoid osteoma was highly successful, without any complications observed. Dynamic contrast-enhanced MR imaging is a useful tool for diagnosing osteoid osteoma and evaluating treatment.

ABBREVIATIONS

NSAID = nonsteroidal antiinflammatory drug, PG = prostaglandin, RF = radiofrequency, SI = signal intensity, 3D = three-dimensional, TWIST = time-resolved imaging with stochastic trajectories

Osteoid osteomas account for approximately 13.5% of all benign bone tumors, mostly affecting young men in their third decade of life (male-to-female incidence ratio of 4:1) (1). Typically, they are located in the long bones of the lower extremity, with other common locations being the hands, feet, and spine (2). Histologically, osteoid osteomas present with a nidus of woven bone and osteoid, surrounded by osteoblasts and a reactive zone of thickened cortical bone and fibrovascular tissue (2). The nidus itself essentially contains only capillary channels and some peripheral nerve fibers (3). It could be shown that osteoid osteomas express high levels of prostaglandins (PGs), especially PGE2 and PGI2, which are thought to cause the dull bone pain experienced by these patients, which is commonly worse at night (4,5). This may explain why, typically, nonsteroidal antiinflammatory drugs (NSAIDs) are so effective in relieving this pain (6).

Routinely, osteoid osteomas are diagnosed with the use of computed tomography (CT), which can precisely localize the lesion within the bone. Dynamic contrast-enhanced magnetic resonance (MR) imaging with fast three-dimensional (3D) gradient-echo sequences with parallel imaging and view sharing offers the advantage of functionally depicting the vascularization of the

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osteoid osteoma; treatment can therefore be monitored by assessing vascular coagulation.

CT-guided radiofrequency (RF) ablation can be considered the new gold standard for osteoid osteoma treatment, as it is safe and effective (7–10). However, in general, the use of microwaves for thermal ablation may present certain advantages versus the use of RF: (i) higher intratumoral temperatures, resulting in faster ablation times and larger possible ablation volumes with the use of a single needle; (ii) less prominent heat-sink effect; (iii) no need to directly, internally cool the needle tip; and (iv) a lower risk of skin burns because no grounding pads are needed (11,12).

The currently available literature on microwave ablation of osteoid osteoma mainly reports on thermal ablative treatment of bone, lung, liver, or kidney metastases or malignancies in a general context (13,14). The aim of the present study was to evaluate the efficacy of microwave ablation in the treatment of osteoid osteomas with the use of 3D dynamic contrast-enhanced MR imaging.

MATERIALS AND METHODS

The study was approved by the institutional review board, and written informed consent was obtained from all patients before treatment.

Microwave ablation was performed under general anesthesia in all patients. Patients were placed on the CT table (SOMATOM Definition; Siemens, Erlangen, Germany) on a vacuum mattress to eliminate movement during the procedure. First, a nonenhanced CT scan (slice thickness, 3 mm; 120 kV, 50 mA, B60f reconstruction kernel [Siemens]) was performed. After locating the osteoid osteoma, the overlying compact bone was fenestrated by using a 11-gauge Jamshidi needle (CareFusion, McGaw Park, Illinois). Then, a 16-gauge ablation needle (Medwaves, San Diego, California) was introduced into the lesion. Microwave ablation was performed at 16 W, 915 MHz, and 80°C for 60 seconds. In one case, the ablation time was 160 seconds because of a large lesion diameter (9 mm; Table 1). After ablation, the needle was withdrawn and a sterile dressing was applied to the puncture site. After the intervention, pain medication was given liberally (intravenous paracetamol and piritramide). The procedure was considered successful if the patient was free of pain within 7 days after the intervention and remained so during the 6 months of follow-up (Figs 1 and 2).

Three-dimensional MR imaging was performed at 3.0 T (32 × 102; MAGNETOM Tim Trio; Siemens) before microwave ablation and within 2 days after ablation. A 3D gradient-echo sequence with parallel imaging and stochastic data sampling with the time-resolved imaging with stochastic trajectories (TWIST) scheme was applied with the following parameters: repetition/echo times, 2.98/1.14 ms; flip angle, 25°; voxel size, 0.94 mm^3, parallel imaging 3; and temporal resolution, 3.8 seconds, as previously described (15–17). As contrast medium, the macrocyclic gadolinium chelate Gd-1,4,7,10-tetraazacyclododecane-1,4,7,10-tetraacetic acid (0.5 M Dotarem; Guerbet, Roissy, France) was administered at a dose of 0.03 mmol/kg. Contrast medium was injected at a rate of 1.5 mL/s, followed by 30 mL of saline solution, via a 18-gauge needle in the left or right cubital vein with the use of an automated power injector (Spectris Solaris EP; Medrad, Indianola, Pennsylvania).

Signal intensities (SIs) of the lesions were measured in the TWIST source data before and after microwave ablation. The SI of adjacent muscle tissue was taken as background signal for each measurement, and the ratios of lesion to muscle tissue SI were calculated. The *t* test and Wilcoxon test for two paired samples were applied to the differences between pre- and postablation SIs of the lesions and muscle.

Study outcome measures were pain relief and SI decrease on postablation dynamic contrast-enhanced MR imaging.

Table 1. Characteristics of Treated Patients and Osteoid Osteomas

Pt. No.	Age (y)/Sex	Localization	Maximum Diameter (mm)	Ablation Time (s)
1	47/F	Fourth left dorsal rib	3	60
2	23/M	Right femoral neck	6	60
3	16/M	Right femoral neck	4	60
4	18/M	Left calcaneus	4	60
5	18/M	Left proximal tibia	3	60
6	18/M	Left femoral neck	5	60
7	32/M	Right distal tibia	3	60
8	28/M	Right navicular bone	3	60
9	44/M	Left femoral neck	3	60
10	34/F	Right distal tibia	9	160
Mean	27.8	–	4.3	70

Maximum lesion diameter was measured on CT scan. All lesions were ablated at 16 W.