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Osteoid osteoma treated with percutaneous radiofrequency ablation: MR imaging follow-up

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Abstract

Purpose: We evaluated follow-up magnetic resonance (MR) images for osteoid osteoma treated with percutaneous radiofrequency ablation (RFA).
Materials and methods: Sixteen patients with osteoid osteoma treated with RFA underwent follow-up MR imaging. The protocol included T1, T2 and contrast-enhanced (CE) T1-weighted images with fat saturation at each visit immediately for 17 months after the treatment. MR images were jointly reviewed by two radiologists, regarding the appearance of treated areas, presence of complications, and the best sequence for visualization of signal intensity (SI) changes. The therapeutic response was evaluated to be a clinical success with the relief of pain.
Results: The treated areas had a target-like appearance on MR images: a central ablated zone (Z1) surrounded by a band (Z2), and a peripheral area (Z3). Z1 was a non-enhancing, hypointense core on T1, T2WI. Z2 was a well-enhancing, hyperintense rim on T2WI. Z3 was less hyperintense and less enhanced than Z2. All nidi were within Z1. This appearance became evident from 1 week to 1 and 2 months. Following up after 2 months, Z2 showed progressive inward enhancement from the periphery, resulting in almost complete enhancement of Z1 and Z2 with a diminishing size. Z3 gradually showed a decrease in signal change and enhancement. No complications were found. CE-T1WI was the best for visualizing SI changes. The clinical success was achieved in all patients except for one patient with a recurrence at 17 months following treatment that had a second ablation.
Conclusion: MR imaging demonstrated a characteristic appearance and subsequent changes of treated areas for osteoid osteoma following RFA.

Keywords: Bone; Magnetic resonance (MR) imaging; Osteoma; Radiofrequency ablation

1. Introduction

Osteoid osteoma is a small painful benign tumor that is relatively common, composing approximately 10% of all benign bone tumors. Localized pain is the hallmark of its clinical presentation, and is dramatically relieved by aspirin or non-steroidal anti-inflammatory drugs. However, such long-term medical therapy may not be unacceptable because of the complications from chronic use of anti-inflammatory agents. Surgical excision has been the treatment of choice, yet minimally invasive therapies, such as percutaneous excision followed by alcoholization, percutaneous radiofrequency (RF) ablation and laser ablation, have recently been developed [1–3].

Percutaneous image-guided RF ablation has been effectively applied to treat selected tumors of the various organs [4–7]. For bone as the target organ, Rosenthal et al. [1,8] have reported the use of RF ablation for treating osteoid osteoma;

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the success rate was comparatively high, the recovery was brief and the complication rate was satisfactorily low. This therapy is now commonly used for primary treatment of osteoid osteoma.

Among the imaging modalities, computed tomography (CT) guidance is the imaging technique of choice for performing osseous RF ablation as this modality is readily available and clearly demonstrates the bony lesions that should be treated and also the relationship with the adjacent anatomic structures. However, magnetic resonance (MR) imaging appears to be superior to CT for monitoring the effects of RF ablation treatments by allowing detection of bone marrow signal change [9–12]. MR imaging would be expected to be helpful for the evaluation of treatment efficacy, although the imaging may have a limited role in assessing recurrence of osteoid osteoma. The purpose of our study was to evaluate the appearances of treated areas on follow-up MR images for osteoid osteoma that were treated with RF ablation.

2. Materials and methods

2.1. Patients

During 4-year period, 25 consecutive patients underwent 27 CT-guided percutaneous RF ablations for osteoid osteoma. Of these, 16 patients (11 male patients and 5 female patients; mean age, 23.2 years) were prospectively examined with MR imaging following treatment, participated in our study. The lesions were located in the femur ($n = 12$), pelvis ($n = 2$), tibia ($n = 1$) and humerus ($n = 1$). The mean diameter of the nidus was 7 mm. Each patient had CT, or MR imaging, or both, as well as radiography in two orthogonal directions of the lesions presented with clinical and radiologic features of osteoid osteoma. The clinical criteria included local pain that was not related to physical activity and was relieved by administration of salicylates or other non-steroidal anti-inflammatory agents. The radiologic criteria included the typical findings of presence of a radiolucent nidus that was smaller than 1.5 cm in maximum diameter on radiographs, CT and/or MR images. Histological confirmation of osteoid osteoma was made in six patients at needle biopsy performed at the time of RF ablation. However, patients were not excluded if biopsy results were non-diagnostic and inclusion of patients without histologically proven lesions was permitted since we considered previous reports in which clinical and imaging features are so accurate that biopsy may not be required [13], and non-diagnostic biopsy findings are common in osteoid osteoma even after surgery [14].

2.2. Procedures

An informed consent was obtained from all the patients. All the procedures were performed by radiologists under CT guidance and general or regional anesthesia; general anesthesia was preferred in most cases. CT scans with a section thickness of 2.5 mm (LightSpeed Qx/i; GE Medical Systems, Milwaukee, WI) were obtained for precise localization of the nidus. As reported by Rosenthal et al. [1], the shortest distance through the bone was selected for access except for cases in which such an approach was unsafe or technically difficult.

After a small incision of skin was made at the puncture site, the nidus was engaged with a biopsy needle system (Bonopty Penetration Set-REF 10-1072 and Bonopty Biopsy Set-REF 10-1073, and, if necessary, Bonopty Extended Drill-REF 10-1074; RadiMedical Systems, Uppsala, Sweden) with a 14-gauge needle. Accurate positioning of the needle tip was confirmed with additional CT scans before needle biopsy was performed.

Subsequently, RF ablation was performed by introducing an RF electrode (Fig. 1A and B). We used a 50-W monopolar RF generator (model 500 Series; Radiofrequency Interstitial Thermal Ablation Medical Systems, Mountain View, CA) and an active expandable RF needle electrode with four retractable lateral prongs in initial five cases. The diameter of the deployed prongs varied about 1 cm, more or less, depending on the size of the lesion. We also used a different device (Cool-tip; Radion-

Table 1
Clinical and technical data of patients

Patient no.	Sex/age	Location of lesion	Total ablated time per procedure (min)	Result	Follow-up frequency	Follow-up period (months)	RF generator
1	M/3	Femur	4	Clinical success	1	2	RITA
2	M/19	Femur	5	Clinical success	2	4	RITA
3	M/20	Tibia	7	Clinical success	4	7	RITA
4	M/14	Femur	7	Clinical success	3	5.5	RITA
5	M/40	Femur	7	Clinical success	3	5	Radionics
6	F/51	Femur	6	Clinical success	2	4	Radionics
7	F/12	Femur	6	Clinical success	2	2	Radionics
8	M/13	Femur	7	Clinical success	2	2	RITA
9	F/29	Femur	6	Clinical Success	2	3	Radionics
10	M/28	Ilium	5	Clinical success	3	6	Radionics
11	M/12	Femur	6	Clinical success	2	4	Radionics
12	F/30	Humerus	7	Clinical success	4	15	Radionics
13	M/24	Femur	6	Recurred	3	17	Radionics
14	M/31	Femur	7	Clinical success	2	3	Radionics
15	F/26	Sacrum	4	Clinical success	1	2	Radionics
16	M/20	Femur	7	Clinical success	2	4	Radionics