Treatment of Bone Metastases with Microwave Thermal Ablation

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ABSTRACT

Purpose: To retrospectively evaluate the feasibility, safety, and effectiveness of computed tomography (CT)–guided percutaneous microwave ablation (MWA) in patients with bone metastases.

Materials and Methods: Twenty-one patients with metastatic bone lesions were treated in 18 MWA sessions. In patients whose lesions contained fractures, or who had a high risk for fracture (48%; n = 10), MWA was followed by cementoplasty with polymethylmethacrylate injection. The positioning of the MWA antenna into the tumor was guided by CT. Treatments were performed under conscious sedation. All patients underwent clinical (self-reported Brief Pain Inventory [BPI]; scale from 0 to 10) and radiologic evaluation at baseline and 1 month after the procedure. The reported results are data from baseline to a follow-up period of 3 months.

Results: There were no complications. A reduction of pain and improvement in quality of life was observed in all patients as measured by BPI score. On average, the mean BPI score during the 3-month follow-up period was reduced by 92% (41%–100%). Thirteen of 18 patients (72%) were symptom-free, four patients (22%) were still symptomatic but with 85% lower average BPI scores (41%–95%), and one patient (6%) experienced a recurrence of symptoms.

Conclusions: Preliminary results suggest that MWA of bone metastases is a well tolerated, safe, and effective procedure. However, its efficacy still remains to be determined by medium- and long-term studies.

ABBREVIATIONS

BPI = Brief Pain Inventory, MWA = microwave ablation, NSAID = nonsteroidal antiinflammatory drug, PMMA = polymethylmethacrylate

Skeletal metastases are the most common cause of severe pain among patients with cancer. Bone pain remarkably compromises the patient's quality of life. This type of pain can be caused by periosteal stretching secondary to tumor growth, release of chemical mediators by tumoral cells, osteolysis, micro- and macrofractures, spinal cord compression, entrapment and nerve root infiltration, and/or compression caused by weakening of bone by tumor growth (1). The treatment options currently available to patients with bone pain from metastases are primarily palliative, in addition to systemic therapy for the underlying malignancy. These palliative treatments include the use of bisphosphonates, systemic analgesic agents, steroids, external-beam radiation therapy, and local surgery (2). A number of patients do not benefit from these conventional therapies, and pain relief may only be achieved 4–12 weeks after the initiation of treatment (3). Because of these patients' short life expectancy and poor quality of life, a minimally invasive approach is desirable. During the past decade, percutaneous ablation has emerged as an effective minimally invasive local treatment alternative to the aforementioned conventional therapies (4). As a wide range of pain treatment options are available to patients with skeletal and soft-tissue metastases, the selection of the most appropriate ablative technology requires proper patient and lesion selection, knowledge of relevant anatomy, and an understanding of the advantages and limitations of the specific technique.

The principal indication of image-guided musculoskeletal tumor ablation is for the palliative treatment of painful metastases secondary to advanced cancer disease. Microwave energy radiates into the tissue through an interstitial antenna

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None of the authors have identified a conflict of interest.

J Vasc Interv Radiol 2013; 24:229–233

http://dx.doi.org/10.1016/j.jvir.2012.10.009

that functions to couple energy from the generator power source to the tissue. As a result of the radiation energy emitted from the antenna, direct heating occurs in the adjacent tissue volume. Bone tissue exhibits low conductivity and high impedance, and, therefore, microwaves, which are relatively insensitive to high impedance, may present a relative advantage in the treatment of musculoskeletal tumors. Additionally, multiple microwave antennas can be powered simultaneously to take advantage of the thermal synergy that occurs when these antennas are placed in close proximity (5,6). Thermal ablation can destroy the tumor but may also further weaken the bone involved. If this bone is weight-bearing and there is a risk of pathologic fracture, consolidation with cementoplasty or surgery is needed. Percutaneous injection of polymethylmethacrylate (PMMA) provides pain relief and strengthens the bones in patients with malignant bone tumors (7). Because of its mechanical properties, this cement is suitable for the treatment of fractures involving weight-bearing bones, such as the vertebral body and acetabulum, and in any bones subject to compression forces. Although the use of microwave ablation (MWA) has been reported to help surgical resection of osteosarcomas (8), no data are available about its percutaneous use in musculoskeletal tumors. The aim of the present study is to evaluate the technical success, effectiveness, and possible complications of MWA treatments in patients with painful bone metastases.

MATERIALS AND METHODS

Institutional review board approval is not required at the authors' hospital for retrospective case studies such as the present study, and informed consent to perform MWA of bone cancer, alone or with osteoplasty, was obtained from all patients.

From July 2011 to January 2012, 18 consecutive patients with skeletal metastatic lesions (eight men and 10 women; mean age, 63 y) underwent computed tomography (CT)–guided percutaneous MWA of bone symptomatic metastases. Seven patients had previously been treated with radiation therapy, three patients with radiation therapy and chemotherapy, and seven with chemotherapy alone. In all these patients, pain had proven refractory to conventional approaches.

Before the ablation treatment, all patients received analgesic therapy consisting of opioid agents or a combination of opioid and nonsteroidal antiinflammatory drugs (NSAIDs), and analgesic agent use was monitored before treatment and at 1, 4, and 12 weeks thereafter for all patients.

Patients were selected based on the following criteria: Brief Pain Inventory (BPI) score greater than 4, lesions not responding to chemotherapy and/or radiation therapy at least 3 weeks before the ablation session, chemotherapy-associated complications that required cessation of treatment, lesions adjacent to structure sensitive to irradiation, life expectancy greater than 2 months, and ineligibility for surgical treatment.

Table. Bone Metastasis Classification with Regard to Primary Malignant Lesion and Site of Skeleton Involved

Site/Primary Neoplasm	n	Site of Metastasis	n
Penis	1	Acetabulum	1
NSCLC	8	Scapula	1
		Spine	1
		Pelvis	4
		Ribs	3
Thyroid	2	Spine	1
		Pelvis	1
Breast	7	Pelvis	8
		Spine	1
Total	18	–	21

NSCLC = non–small-cell lung cancer.

Fifteen patients had single lesions and three had two lesions each, resulting in a total of 21 metastases. The topographic distribution of the lesions and their originating primary malignancies are summarized in the **Table**. Lesion diameters ranged between 2.2 cm and 12 cm (mean ± standard deviation, 5.3 cm ± 3.2).

All treated lesions were osteolytic, with a combination of bone destruction and soft-tissue masses. All patients underwent a preliminary contrast-enhanced magnetic resonance (MR)-imaging study and/or CT scan to properly assess the site, size, and radiologic aspects of the lesion(s).

We considered patients to be at a high risk for fractures if their lesions involved just one of these criteria: bones subjected to load (eg, vertebrae, head and neck of femur, and acetabulum), disrupted the cortical bone with tumor tissue extending from the bone, and were extensively osteolytic.

The oncologist and radiologist who administered MWA also performed physical examination of the patients. Pain assessment was obtained through the BPI (9) and monitored at baseline and in the following weeks (1, 4, and 12 weeks after the procedure), for a total follow-up time of 3 months. The BPI score was obtained through the Pain Severity Score Questionnaire, which rated pain on a scale from 0 to 10 to indicate the intensity of pain. In all patients, drug therapy (eg, NSAIDs and opioid agents) was interrupted after 1 week. If symptoms persisted or worsened, drug therapy was resumed.

Radiologic follow-up consisted of contrast-enhanced CT or MR imaging 1 month after the procedure. No further radiologic evaluations were performed in the absence of new symptoms. In all patients, radiological imaging was performed 1 month after treatment, primarily to highlight the presence of any residual untreated tumor that may present focal contrast enhancement rather than to assess the recurrence of disease (in view of the short time since treatment).

MWA TECHNIQUE

Percutaneous MWA was performed by using a 2.45-GHz microwave generator (AMICA-GEN; HS Hospital Service,