



Microwave Ablation for Palliation of Bone Metastases

Leigh Kinczewski, MSN, AGNP-BC

Bone metastases are the most common source of pain for patients with cancer. For pain that is refractory to conventional measures, microwave ablation (MWA) is an emerging alternative therapy. Studies show that MWA is effective in reducing pain and analgesic requirements while improving function. This article describes studies of MWA that include patients with bone metastases to a variety of locations from a range of primary malignancies. Although studies are limited, MWA has proven to be well tolerated with impressive efficacy.

At a Glance

- Microwave ablation (MWA) is a promising option for patients with metastatic disease to bone that is resistant to traditional treatments.
- MWA reduces pain almost immediately in many patients, with relief lasting as long as a year.
- MWA is well tolerated, with the most common complications including increased pain, infections, and postablation syndrome.

Leigh Kinczewski, MSN, AGNP-BC, is a nurse practitioner in the Pain and Palliative Care Program at Fox Chase Cancer Center in Philadelphia, PA. The author takes full responsibility for the content of the article. The author did not receive honoraria for this work. No financial relationships relevant to the content of this article have been disclosed by the author or editorial staff. Kinczewski can be reached at leighkin@gmail.com, with copy to editor at CJONEditor@ons.org.

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Bone metastases are the most common source of pain in patients with cancer (Brescia et al., 1990). This condition affects 47%–75% of patients with metastatic breast cancer and 90% of patients with metastatic prostate cancer (Bubendorf et al., 2000; Coleman, 2001; Hess et al., 2006). Patients with metastatic lung, thyroid, or kidney cancer have a 33% chance of their disease spreading to the bone (American Cancer Society, 2014). In addition to inducing severe pain, bone metastases can cause impaired mobility, fractures, and decreased quality of life (Puscchedu, Sotgia, Fele, & Melis, 2013). Methods of palliation include treatment tar-

geted at lesions and systemic anticancer therapies. These approaches include radiotherapy, hormonal therapy, bisphosphonates, chemotherapy, analgesics, surgery, and radiopharmaceutical therapy. However, for patients whose pain is refractory to these modalities or are ineligible for certain methods, ablative techniques are emerging as a promising option (Kastler et al., 2013). These methods include cryotherapy, radiofrequency ablation, ethanol ablation, high-intensity focused ultrasound, laser ablation, and microwave ablation (MWA), with this modality having potential advantages over other methods (Simon, Dupuy, & Mayo-Smith, 2005).

Although methods and equipment vary, one example of performing delivering MWA is using 14.5-gauge needles to deliver electromagnetic waves to lesions. Patients receive conscious sedation and are closely monitored with pulse oximetry, electrocardiography, and blood pressure checks. After sterile draping and local injection with lidocaine, a transducer is placed over the tumor using either ultrasound or computed tomography. An antenna is threaded through the transducer to reach the lesion (Simon et al., 2005). The antenna delivers as much as 60 watts of microwave power at a frequency of 900 MHz. The microwaves concuss the water in tumor cells, causing friction and heat and leading to cell death. After the treatment, the antenna is removed, followed by the transducer (Simon et al., 2005). The procedure lasts from 1–13 minutes (Botsa, Mylona, Koutsogiannis, Koundouraki, & Thanos, 2014; Kastler et al., 2013; Kastler, Alnassan, Aubrey, & Kastler, 2014; Wei et al., 2015).

Current Research

MWA can be widely applied in patients with a variety of primary malignancies. Of the six studies published that assess the efficacy of MWA in palliating symptomatic bone metastases, all show a significant improvement in pain scores (see Table 1). Kastler et al. (2013) found that 93% of patients experienced immediate relief that was maintained for an average of 5.5 months. In 8 of 15 patients, analgesic medications were discontinued, and, in 5 of 15 patients, opioids were replaced with nonsteroidal anti-inflammatory drugs (NSAIDs).

For tumors posing a high risk of fracture, providing cementoplasty (in the form of kyphoplasty, osteoplasty, vertebroplasty, or sacroplasty, depending on the affected area) with MWA is advantageous. Cementoplasty entails injecting liquid cement into the fracture to stabilize the bone (Gangi, Guth, Imbert, Marin, & Dietemann, 2003). An initial study by Pusceddu et al. (2013) used this dual method. One week after the procedure, patients experienced a 77% reduction in pain, with a 92% reduction 12 weeks after the procedure. Seventy-two percent of patients were symptom free after 12 weeks. Three months after cementoplasty, no patients had subsequent fractures from their bone metastases.

In a follow-up study using MWA and cementoplasty, 83% of patients were pain free after four weeks, with the remaining 17% reporting a pain reduction of 45% (Pusceddu, Sotgia, Fele, & Melis, 2015). This improvement occurred after patients ceased taking analgesics. One month after the procedure, ambulatory progress was noted in all patients and was sustained in 98% of patients at six months. Three months after MWA, no patients experienced fractures. One year after the procedure, 88% of patients were symptom free and had a mean visual analog scale pain score of 0.2 (range = 0–10) (Pusceddu et al., 2015).

Of the six studies, only one included multiple methods to compare the effectiveness of MWA with radiofrequency ablation. Outcomes measuring

pain reduction were equivocal between the two groups; however, MWA was a shorter procedure (Botsa et al., 2014).

Pain control can be quantified by measuring analgesic requirements. Wei et al. (2015) found that patients receiving combined MWA with cementoplasty had preprocedure daily morphine doses averaging 47.7 mg. At 48 hours postprocedure, the daily dosage dropped to 29.6 mg and further decreased to 16.1 mg at one week, to 10.8 mg at one month, and to 9.2 mg at six months postprocedure.

In the past, ablative methods were not used to treat tumors on or near the spine because of concern for damaging surrounding structures. However, Kastler et al.'s (2014) study showed efficacy and safety using MWA to treat spinal metastases. Sixteen of 17 patients experienced immediate pain relief that lasted six months. In 11 of 17 patients, pain relief was significant enough that analgesics were discontinued, and, in the remaining six patients, opioids were replaced by NSAIDs (Kastler et al., 2014).

Reported complications from MWA from all six studies were rare and not severe (see Table 2). Pain was the most common complication. Postablation syndrome has been reported. In this syndrome, necrotic material is systemically absorbed after the procedure, initiating an inflammatory cascade and causing fever, malaise, nausea, and vomiting that lasts from three to five days. Wei et al. (2015) found that one-third of patients experienced some degree of this

syndrome. It has not been reported in other studies.

Comparison With Other Techniques

Radiotherapy, often considered the gold standard for palliating bone metastases, can take one to nine weeks to achieve an effect (Kastler et al., 2014; Meeuse et al., 2010). As many as 30% of patients do not get relief, and only 56% get relief greater than two increments on the visual analog scale (Dennis et al., 2011; Gaze et al., 1997). In comparison, 7% of patients receiving MWA did not get relief (Kastler et al., 2013, 2014; Pusceddu et al., 2013, 2015). Radiation can also cause significant side effects from damaging surrounding tissues (Frassica, 2003).

Opioids play an important role in managing pain for patients with bone metastases. Unfortunately, the analgesic requirements can cause patients to experience side effects, including nausea, constipation, and sedation that affect quality of life and limit dosing (Rosenthal & Callstrom, 2012). MWA can provide relief to ameliorate opioid requirements (Botsa et al., 2014; Wei et al., 2015).

Compared to other ablative techniques, MWA allows for more effective heating with less damage to surrounding tissues than radiofrequency ablation and achieves higher temperatures more quickly, allowing for larger tumors to be ablated and procedures to be faster (Lubner, Brace, Hinshaw, & Lee, 2010). Compared to radiofrequency ablation, MWA is believed to be more effective on tissues with high impedance, which includes the bone (Ahmed, Brace, Lee, & Goldberg, 2011). In addition, MWA allows for cementoplasty, which is available with radiofrequency ablation, but must be delayed with cryotherapy to allow for ice melting (Gangi, Tsoumakidou, Buy, & Quoi, 2010). The equipment required for MWA is considered less cumbersome than for radiofrequency or cryotherapy (Kastler et al., 2013).

Limitations

All studies had small samples and were conducted by few researchers

TABLE 1. Mean Visual Analog Scale Results for Pain From Literature Review Studies

Study	N	Preprocedure		One Day Postprocedure		One Month Postprocedure		Six Months Postprocedure	
		\bar{X}	SD	\bar{X}	SD	\bar{X}	SD	\bar{X}	SD
Botsa et al., 2014	15	6.7	–	4.4	–	2	–	–	–
Kastler et al., 2013	19	7.2	0.97	1.64	1.86	2.05	2.03	1.8	1.8
Kastler et al., 2014	20	7.4	1.2	1.3	1.8	1.9	1.6	2.3	1.4
Pusceddu et al., 2013	18	5.6	1.2	–	–	0.45	0.7	–	–
Pusceddu et al., 2015	35	6.8	1.4	–	–	0.7	1.4	0.6	1.6
Wei et al., 2015	26	7.4	1.6	1.7	1.2	1.5	0.9	1.2	0.8

Note. The visual analog scale ranges from 1–10, with higher scores indicating more pain.

TABLE 2. Complications Experienced by Patients From Literature Review Studies

Study	N	Complications
Botsa et al., 2014	15	No patients experienced complications.
Kastler et al., 2013	19	Three patients experienced "painful" complications, and one experienced "very painful" complications. One was because of axillar abscess, which was drained without complication.
Kastler et al., 2014	20	No patients experienced complications.
Pusceddu et al., 2013	18	No patients experienced complications.
Pusceddu et al., 2015	35	Seven patients experienced cement leak, and four experienced increased pain.
Wei et al., 2015	26	One patient experienced clavicle infection, one experienced incomplete ilium fracture, nine experienced postablation syndrome, 26 experienced moderate pain, and six experienced severe pain. All recovered.

in select settings, limiting generalizability. Pusceddu et al. (2015) followed patients' pain scores for one year, but no other studies gathered data beyond six months. Larger studies that include additional researchers and healthcare centers and a longer follow-up period are needed. The average lesion ranged from 2.6–5.3 cm, but lesions as large as 12 cm were included. Additional research would guide decision making about MWA for larger populations. Five of six studies were retrospective. Only two studies included combined modality treatment. In addition, only one study compared multiple ablative techniques (MWA and radiofrequency ablation). This study yielded equivocal results; therefore, although theoretical advantages exist for various procedures, the method that has superior outcomes is unclear. As techniques continue to emerge, evidence regarding which methods are most likely to be successful would assist in decision making for patients and healthcare providers.

Conclusion

MWA is a technique with potential to palliate bone metastases. Patients

likely to benefit most from MWA include those with bone metastases refractory to conventional treatments, patients whose tumors pose a high risk for fracture or extension into critical structures, and patients with limited disease who are not surgical candidates (Rosenthal & Callstrom, 2012). Survival for patients with breast cancer with bone metastases is 59% at one year and 22% at three years (Yong et al., 2011). In patients with metastatic prostate cancer, survival is 47% at one year and 9% at three years (Norgaard et al., 2010). Although bone metastases often indicate poor survival and need for expedited palliation, a subset of patients exist

who survive for years and will likely require multiple treatment modalities for palliation. MWA can serve both populations.

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