CT Guided Microwave Ablation of Osteoid Osteoma – Efficacy in Alleviation of Symptoms

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ABSTRACT

BACKGROUND

Osteoid osteoma is a benign bone tumour which eventually undergoes spontaneous resolution but causes distress due to severe inflammatory pain and sleep loss. Major goal of ablative procedure is alleviation of symptoms. Long term follow up studies on pain remission and complications are less commonly available for microwave ablation. We wanted to assess alleviation of symptoms and long term complications in CT guided microwave ablation of osteoid osteoma.

METHODS

CT (Computed tomography) guided microwave ablation was performed on 10 patients referred with clinicoradiological diagnosis of osteoid osteoma and their preoperative and 6 month postoperative numerical pain scale, frequency of pain, disability and analgesic uses were compared. Subjects were between 13 and 30 years of age.

RESULTS

Pain scale dropped to 0 in 9 out of 10 patients. The single remaining patient had partial remission at 6 month follow up. The only complication encountered was wound site infection. All patients were free of analgesic use, disability due to pain, and sleep loss, on follow up.

CONCLUSIONS

Microwave ablation as an ablative procedure offers many potential benefits and appears to have good treatment response rate with minimal complications.

KEY WORDS

Osteoid Osteoma, Microwave Ablation, Bone, Interventional Radiology

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BACKGROUND

Osteoid osteoma is a benign bone tumour that most frequently occurs in first and second decades of life with male predilection.¹ Characteristic symptom is severe inflammatory pain which worsens at night and is promptly relieved by salicylates.² Osteoid osteoma can be subperiosteal, intracortical, endosteal or intramedullary on cross-sectional imaging.³ Osteoid osteoma is classically seen as a radiolucent focus called a nidus which shows variable mineralization surrounded by reactive sclerosis.⁴ Periosteal reaction may obscure the nidus. Other accompanying features include cortical thickening and decreased bone density because of disuse owing to pain.⁵

Differentials of osteoid osteoma include small Brodie abscess with radiolucent centre and surrounding reactive sclerosis, Chondroblastoma in epiphyseal location of children with extensive marrow edema and periosteal reactions, cortical lesions in pediatric age groups like osteofibrous dysplasia, adamantinoma and stress fractures that produce cortical thickening and proliferation. Other considerable differentials include non-ossifying fibromas, enchondromas, eosinophilic granulomas, perthe's disease, tuberculosis and malignant bone tumours.

In intracortical Brodie abscess, sequestrum is irregular and inner margin of the lucency is not smooth whereas in osteoid osteoma the inner margins are usually smooth. Epiphyseal and intramedullary location is more characteristic for Chondroblastoma whereas osteoid osteoma is usually diaphyseal and intracortical. In stress fractures reactive woven bone is well oriented around the trabeculae of fractured bone in comparison to haphazard arrangement in osteoid osteoma.

CT is the modality of choice for diagnosis and specifying location of the lesion. Nidus can show mineralization which maybe punctate, amorphous or ring like. Mineralization ratio of osteoid osteoma increases significantly with pain duration. Dynamic Contrast-enhanced computed tomography (CECT) helps to differentiate osteoid osteoma from bone cyst and chronic osteomyelitis, specifically Brodie's abscess which is avascular. The tumor nidus show early arterial enhancement and appears hypervascular. Tc⁹⁹ labelled scintigraphy has high sensitivity for confirming diagnosis of osteoid osteoma with a sensitivity of approximately 100 %.

On MRI (magnetic resonance imaging), nidus shows low to intermediate signal intensity on T1WI with 18 signal on T2WI depending on mineralization and post contrast enhancement.⁶ Other imaging features like edema in adjacent bone marrow, soft tissue and joint effusion may be seen.⁷ Intra articular osteoid osteoma is another rare entity which occurs within or near a joint.⁸

With technological evolution at fast pace, there has been a drastic development of minimally invasive percutaneous ablative procedures in treatment of both benign and malignant bone lesions. Considered to be a safe and efficacious modality of treatment, ablative procedure is quite an attractive alternative or adjunct to conservative treatment. These include ethanol ablation, laser ablation, RFA (Radiofrequency ablation), microwave ablation, cryoablation and irreversible electroporation.

Microwave ablation is usually performed under some kind of anaesthesia and under uncompromised local sterility measures. Percutaneously placed antennae deliver electromagnetic microwaves with resultant frictional heat that produce protein denaturation and coagulation necrosis. Among the ablative procedures, high success rates are well documented for radiofrequency ablation in osteoid osteoma with some studies reporting success rate as high as 98 % with very few patients requiring secondary intervention.⁹

Microwave ablation is a relatively new alternative to RFA as a method of percutaneous guided ablation of osteoid osteoma. Microwave ablation offers many potential benefits over other modalities in that it applies electromagnetic field, heating it to more than 150 deg via dielectric polarization and is most effective in tissues with high water content.¹⁰ Other potential benefits of microwave ablation over RFA include faster ablation, higher temperature without limitations related to electric impedance, less sensitivity to tissue types, more consistent results and relative insensitivity to heat sinks and ability to create much larger ablation zones if needed.¹¹ Larger and more uniform ablation is another advantage.¹²

Although MWA and RFA both destroy tissue via thermally induced coagulative necrosis and frequencies of microwaves used in MWA are from radiofrequency spectrum; the two ablative modalities differ in their mechanism of energy deposition. RFA has limited effectiveness in tissues with low electrical conductivity like adipose tissue since it requires an electrically conductive route to transfer resistive heat. RFA applies frequencies from 450 to 500 kHz to destroy tissue in the proximity of the electrode by causing friction that results in heating.

The heating produced by RFA is maintained at 50 to 100 degree celsius to avoid charring the tissue and rendering it electrically nonconductive. In contrast MWA applies an electromagnetic field of either 915 or 2450 MHz to the tissue surrounding antennae, heating it to > 150 degree celsius via dielectric polarization and is most effective in tissues with high water content.

Reported complications of the procedure include second degree burns, superficial skin infections, intramuscular hematoma, neuropraxia, synovitis in intra articular osteoid osteoma. Other expected complications include osteomyelitis and injury to adjacent neurovascular structures, soft tissue abscesses and fractures at the sites.

Although the natural history of osteoid osteoma is that of spontaneous healing, it causes severe pain and disability resulting in significant distress.¹ Hence the major goal of ablative therapy is alleviation of symptoms. With such potential benefits of microwave ablation over other ablative procedures, need to prove efficacy of microwave ablation and study long term complications remain. However studies giving long term follow up to demonstrate efficacy and success rates in alleviation of symptoms of osteoid osteoma are much less available.

Objectives

- To assess the efficacy of microwave ablation in alleviation of symptoms in osteoid osteoma
- To assess long term complications and residual or recurrent symptoms on long term follow up.

METHODS

This study was conducted from September 2018 to August 2020 with approval from ethical committee and written informed consent of patients. Patients with clinicoradiological diagnosis of osteoid osteoma referred for treatment with CT guided microwave ablation and consenting for the study were included in the study. Patients incapable of subjective evaluation of pain like those with mental retardation and those contraindicated for percutaneous invasive procedure like those with sepsis, pregnancy and coagulation disorders were excluded from the study. Our sample size was 10 and convenience sampling was used. Osteoid osteoma being a relatively uncommon neoplastic lesion, our study with a sample size of 10 patients was one of the largest studies conducted on the efficacy of microwave ablation so far.

Detailed history regarding duration of illness, pain severity using numerical scoring, any associated disability, NSAID (non-steroidal anti-inflammatory drug) intake and frequency was taken. Patients were asked to assign their pain a score between 0 and 10 that fits best to their pain intensity. 0 stands for no pain at all and 10 for worst pain possible. The feasibility and good compliance of this method is proven.¹³

Preprocedural work up included pre aesthetic work up, clinical examination, routine blood exam. Plain radiograph and NCCT (Non contrast computed tomography) of bone lesions were performed in all cases with additional imaging options including bone scintigraphy and MRI used for diagnostic aid. All procedures were performed by an interventional radiologist with over 10 years of experience in image guided interventions. CT guided procedure was done using Somatom emotion 16 slice CT scanner (Siemens, Erlanger, Germany). Thin axial sections of 1.5 mm thickness were acquired and lesion localized for planning entry point and approach. Lesion was preferably approached from the opposite cortex and caution was taken to avoid neurovascular structures. Procedure was done under general or spinal anaesthesia.

Murphy 16 G bone biopsy needle set was used to gain access to the site under strict aseptic precautions. Bone drill was used to aid the same. We used solid state microwave generator (Mima Pro, Innovous meditech, Chennai, India) and hence grounding pads were not needed. Once the needle was placed on the farthest margin of the lesion, inner stylet was removed and metal applicator was inserted through the cannula which was then withdrawn to the cortex of the affected bone. Bone ablation occurs from the tip of the applicator in a backward direction in an umbrella configuration as shown in Figure 6.

Metal applicators were inserted through the formed track in the bone to the farthest margin of the lesion. 18 G metal applicators used were 10 cm in length and active tip measured 0.9 cm as all lesions were less than 1 cm in maximum dimension. The ablation was done with power set at 40 W and target temperature set between 25 and 30 degree Celsius. Cold saline at temperature between 1 and 10 degree Celsius helped maintain the temperature. Ablation was done for 2 minutes. Local compression was given post procedure. Procedure time varied from patient to patient.

The patients were given adequate analgesia for the first 3 days with wound care and antibiotics and they were

discharged on 3rd post-operative day. Close follow up was done to assess residual pain, disability or signs of infection and other complications on days 3, 7, 30 and 180. Any history of analgesic intake was duly noted. Numerical pain scoring was done on post-operative follow up as well.

Statistical Analysis

Statistical analysis was performed using statistical package for social science software version 15.5 which consisted computing the frequency counts and percentages for qualitative variables and mean for the quantitative variables. t-test was used to analyse mean reduction in pain score and its association with other variables in the study and the p value below 0.05 was considered significant.

RESULTS

A total of 10 patients between the age of 13 and 30 (median age 16.5 years) were studied out of which 9 were men. Maximum number of lesions were in femur accounting for 4 out of 10 lesions and the remaining in tibia and humerus. All the lesions were subcentimetric in size with a mean of 0.63 cm (standard deviation 0.14 cm). Numeric pain score dropped from a mean of 6.8 preoperatively, to 1.7 by 5.1 points on post-operative day 7, to 0.9 by 5.9 points by post-operative day 30 and to 0.3 by 6 months. The reduction in pain by 5.1 scores from a mean preoperative score of 6.8 by day 7 was found to be significant with all patients reporting remission out of which 5 patients reported complete remission. One patient was found to have developed wound site infection on follow up 3 weeks after procedure and had a pain score of 6 on day 30; however he achieved complete remission after conservative management with antibiotics.

On 6 months follow up, only 1 patient had residual pain and his numeric pain score had fallen from preoperative score of 7 to 3. This was taken to be partial remission. 9 out of 10 patients had complete remission at 6 months. 5 out of 10 patients had continuous pain requiring analgesics for remission at the time of presentation, 4 of them had night pains on most days of a week and 1 patient had only occasional pain. All the 10 patients took analgesics on a regular basis for pain remission of which 60 % required analgesics on a daily basis. On follow up, all patients were free of analgesic use. 5 out of 10 patients had some kind of disability due to pain preoperatively and 6 out 10 patients had sleep loss due to pain. Post operatively none of the patients had residual disability or sleep loss at 6 month follow up.

There was no significant correlation in drop in pain score with size of the lesion, P value of 0.34. Similarly no significant correlation was found between drop in pain score and site of lesion; P value 0.28. 10 patients took analgesics on a regular basis for pain remission of which 60% required analgesics on a daily basis. On follow up all patients were free of analgesic use. 60% patients had continuous pain requiring analgesics for remission at the time of presentation. 60% patients had some kind of disability due to pain preoperatively. Post operatively none of the patients had residual disability or sleep loss at 6 month follow up.

Graph 1. Frequency Distribution of Age of the Study Population

Graph 2. Gender Distribution of Study Population

Graph 3. Correlation between Drop in Pain Score and Site of Lesion

1 Femur; 2 Tibia; 3 Humerus

Graph 4. Frequency of Patients with Sleep Loss at the Time of Presentation

Graph 5. Disability

DISCUSSION

Major goal of ablative therapy in osteoid osteoma is alleviation of symptoms, considering the natural history of spontaneous healing, significant pain and distress caused by the lesion. In microwave heating, polar molecules (primarily water) realign with oscillating microwave field effectively increasing tissue temperature. In contrast to electric currents, microwaves radiate through all tissues including bone and charred tissue which show high impedance to current, thus continuously generating heat in larger volumes of tissue surrounding the applicator. Radiofrequency ablation has limited effectiveness in tissues with lower conductivity like adipose tissue.¹⁰

Percutaneous CT guided RFA in treatment of osteoid osteoma has showed up to 98 % success rate.³ Our study demonstrates 100 % success in alleviation of symptoms with 90 % of subjects attaining complete relief of symptoms with no recurrence / residual pain at 6 month follow up and partial remission in the remaining. Only complication encountered was wound site infection.

Adequate caution was employed to prevent neurovascular injury. Another study assessing microwave ablation of osteoid osteoma using dynamic MR imaging for treatment assessment showed all patients to be pain free¹⁴ on follow up in close agreement to our observations and 75 % decrease in signal intensity of lesions on MR after treatment. A different prospective pilot study of CT guided microwave ablation in treatment of osteoid osteoma showed a success rate of 92.3 %.⁴ In our study all patients had remission, partial or complete by post-operative day 7 and 9 out of 10 patients had complete remission at 6 month follow up. Complete remission in terms

of disability associated with pain and sleep loss due to pain was noted. All patients were completely off analgesic use.

Main limitations of our study were that all the lesions were in relatively accessible locations and none were intra articular. Although pain scoring gives good comparison between preoperative and post-operative severity of the same patient, interpatient comparison cannot be relied upon.

CONCLUSIONS

Considering the many potential benefits of microwave ablation over other ablative procedures, good treatment response elicited in our study with no major complications suggests that microwave ablation maybe a better alternative to other ablative procedures in the management of osteoid osteoma. The procedure seems to be minimally invasive and feasible with less complications and provides excellent treatment response. In our experience microwave ablation has proven to be extremely beneficial to the patients in terms of better quality of life and reduced morbidity.

Limitations

The limitations of our study were that all the lesions were in relatively accessible locations and none were intra articular. Although pain scoring gives good comparison between preoperative and post-operative severity of the same patient, interpatient comparison cannot be relied upon.

Data sharing statement provided by the authors is available with the full text of this article at jemds.com.

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REFERENCES

- [1] Noordin S, Allana S, Hilal K, et al. Osteoid osteoma: contemporary management. *Orthop Rev (Pavia)* 2018;10(3):7496.
- [2] Cerase A, Priolo F. Skeletal benign bone-forming lesions. *Eur J Radiol* 1998;27(Suppl 1):S91-7.
- [3] Kayser F, Resnick D, Haghighi P, et al. Evidence of the subperiosteal origin of osteoid osteomas in tubular bones: analysis by CT and MR imaging. *AJR Am J Roentgenol* 1998;170(3):609-14.
- [4] Chai JW, Hong SH, Choi JY, et al. Radiologic diagnosis of osteoid osteoma: from simple to challenging findings. *Radiographics* 2010;30(3):737-49.
- [5] Swee RG, McLeod RA, Beabout JW. Osteoid osteoma. Detection, diagnosis and localization. *Radiology* 1979;130(1):117-23.
- [6] Zampa V, Bargellini I, Ortori S, et al. Osteoid osteoma in atypical locations: the added value of dynamic gadolinium-enhanced MR imaging. *Eur J Radiol* 2009;71(3):527-35.
- [7] Davies M, Cassar-Pullicino VN, Davies AM, et al. The diagnostic accuracy of MR imaging in osteoid osteoma. *Skeletal Radiol* 2002;31(10):559-69.
- [8] Kattapuram SV, Kushner DC, Phillips WC, et al. Osteoid osteoma: an unusual cause of articular pain. *Radiology* 1983;147(2):383-7.
- [9] Upadhyay AR, Desai NC, Vaghela DU. Role of percutaneous computed tomography-guided radiofrequency ablation in treatment of osteoid osteoma. *South Asian J Cancer* 2017;6(4):139-40.
- [10] Poulou LS, Botsa E, Thanou I, et al. Percutaneous microwave ablation vs radiofrequency ablation in the treatment of hepatocellular carcinoma. *World J Hepatol* 2015;7(8):1054-63.
- [11] Prud'homme C, Nueffer JP, Runge M, et al. Prospective pilot study of CT-guided microwave ablation in the treatment of osteoid osteomas. *Skeletal Radiol* 2017;3546(3):315-23.
- [12] Yu NC, Raman SS, Kim YJ, et al. Microwave liver ablation: influence of 38 hepatic vein size on heat-sink effect in a porcine model. *J Vasc Interv Radiol* 2008;19(7):1087-92.
- [13] Farrar JT, Young JP Jr, Lamoreaux L, et al. Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. *Pain* 2001;94(2):149-58.
- [14] Kostrzewa M, Diezler P, Michaely H, et al. Microwave ablation of osteoid osteomas using dynamic MR imaging for early treatment assessment: preliminary experience. *J Vasc Interv Radiol* 2014;25(1):106-11.