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ORIGINAL ARTICLE

Role of Percutaneous Microwave Ablation in Treatment of Osteoid Osteoma

Mohamed M.A. Zaitoun1, Ayman FathyZeid[1], Dina Abdelhamid Ali Mohamed[1*], Ibrahim M. Eladl[1]
[1]Radiodiagnosis Department, Faculty of Medicine, Zagazig University, Egypt.

Corresponding author*:
Dina Abdelhamid Ali Mohamed
Email:
abdelhamiddina5@gmail.com

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ABSTRACT

Background: Percutaneous microwave ablation is a recent validated management line which is less invasive treatment option, with highly effective results and could be utilized efficiently in management of osteoid osteoma. This study aimed for assessment of the safety and efficacy of microwave ablation in managing osteoid osteoma.

Methods: We enrolled 18 patients with osteoid osteoma who underwent microwave ablation at Zagazig University Hospitals followed by post-procedure computed tomography (CT) follow up in this clinical trial. The collected data included the severity of pain, use of pain medication after ablation and any post-procedure complications.

Results: There was statistically significant improvement in VAS one week postoperatively as compared to preoperative value where all patients had preoperative pain score from 8 to 9 ($p<0.001$). One month and 6 months postoperatively, all patients had no pain (pain score 0). Larger percentage of patients passed uncomplicated (88.9%), one patient developed superficial infection and another one had skin numbness. Both patients with complications needed postoperative pain medications as they had postoperative pain score 2 which indicated use of pain medications. A statistically significant positive correlation was revealed between cycles of ablation and preoperative pain scores ($p=0.036$).

Conclusions: Percutaneous CT guided microwave ablation may be used as an efficient safe treatment line among osteoid osteoma patients, contrary to surgery, with no major complications (infection or neurovascular injury) that have been reported after microwave ablation for osteoid osteoma.

Key Words: Percutaneous; Microwave Ablation; OsteoidOsteoma.

INTRODUCTION

About 3% of primary bone tumors are osteoid osteomas, which are benign, painful neoplasms. Typically, they manifest between the ages of 5 and 25. Although it can manifest anywhere in the axial and peripheral skeleton, the most common places it manifests are the long bones of the lower limbs. The thigh and femur, which are part of the appendicular bones, are the most common sites. It is also conceivable for a location to be unusual, or rare [1]. When patients with osteoid osteoma use nonsteroidal anti-inflammatory medications (NSAIDs), their nighttime pain goes away. When the lesion is painful, it might impede a person's ability to do daily tasks [2].

Both clinical and radiographic evidence, such as an intracortical radiolucent nidus, cortical thickening, and reactive sclerosis, can be used to confirm a diagnosis of osteoid osteoma [3]. A CT scan of an osteoid osteoma usually shows a clearly defined low-attenuation area with what may be a central high-attenuation focal point, which represents mineralized osteoid [4]. Complications such as scoliosis, contractures, and limb length disparities, especially for juxta-articular lesions, can arise in patients with osteoid osteoma [5].

Surgical options for treating osteoid osteoma include operative excision and curettage. Surgical excision, on the other hand, requires removing a large amount of bone during the procedure owing to the difficulty in localizing the nidus, and the patient may need to stay in the hospital for a long time after the procedure, which increases the risk of complications and morbidity [6].

Nowadays, the gold standard for minimally invasive, extremely successful, and safe treatments is percutaneous thermal ablation, which includes radiofrequency and microwave ablation [7].Resistive heating is used to provide the energy of RFA, and then conduction is used to disseminate it throughout the surrounding tissue. Microwave ablation, on the other hand, generates heat by the constantly agitating water molecules in its field [8]. Microwave ablation has several benefits over RFA, such as less heat loss, shorter ablation periods, more ablation volume, and the elimination of the need for a grounding pad [9]. Percutaneous thermal ablation associated with some complications as superficial infection at the probe access site, skin numbness around the access site, skin burns, tendonitis, and hematoma [10].

This research was performed for assessment of the safety and efficacy of microwave ablation in managing osteoid osteoma.

Patients and methods

This study was a clinical trial study conducted on 18 patients, the included study population were patients diagnosed with osteoid ostomies have been admitted to Radiology Department, Zagazig University Hospitals and underwent microwave ablation from October 2022 till November 2023 followed by post-procedure computed tomography (CT) follow up.

Written informed consent was obtained from patients or the parents in pediatric age group and the study protocol was approved by the institution's medical ethics committee, faculty of medicine (with reference number ZU-IRB#10651/29-3-2023). The Declaration of Helsinki, issued by the World Medical Association to ensure the protection of people participating in medical research, was strictly followed during this study.

We included patients aged from 6 to 26 years who were diagnosed with osteoid osteoma either by clinical presentation or imaging with from different age group, patients who had nidus size of osteoid osteoma less than 1.5 cm, and those with failed previous conservative management.

All patients who had any of the following were excluded from the study: Patients who had lesions neighboring articular surfaces or not amenable for safe percutaneous access like spine lesions, patients with lesions that were present near neurovascular structures, as well as cases who were unfit for surgery were excluded from the study.

All patients are subjected to the following: History was taken from the patients or the parents in pediatric age group including the date of onset of the pain, coarse of the disease and if any previous surgical interventions were done. All patients undergone the 10 points numerical pain scale assessment for their symptom level before performing the ablation.

Pre-operative routine laboratory investigations were collected including complete blood count (CBC), Bleeding profile, liver and kidney functions.The patient has undergone the following radiological examination: Plain X ray, CT; for the CT examination, (16 and 128 slice Lightspeed, Toshiba and Philips CT scanners were used), and Magnetic Resonance imaging (MRI) especially of long bones denoting typical imaging appearances with nidus less than 1.5 cm +/- surrounding sclerosis.

Operative procedure: General anesthesia was done to all patients prior to do the procedure,the Microwave system used was mono-axial (Amica HA). Computed tomography guidance (with a slice thickness of 3 mm, 120 kV, and 50 mA) was utilized to perform microwave ablations and determine the lesion site, as well as to guide the needle trajectory. After passing through the bone cortex using a coring co-axial bone biopsy 16G needle, the old one was pulled out and replaced with a 16G microwave antenna just beyond the lesion's distal edge. This allowed the new antenna to cover the whole nidus within its ablation zone. Under the patient's general anesthesia, we placed the 16-G MWA antenna needle into the distal region of the nidus, making sure to leave a margin of 1 cm between the ablation zone and any untargeted body parts, like nerves and skin. The majority of patients required three sessions.

A drill was used in some patients to provide facilitated access to the osteoid osteoma nidus. At least three 30-watt ablation cycles were carried out, with a 30-second cooling interval between each, to achieve a target temperature of 90 degrees Celsius. The ablation cycle time was around thirty seconds. Ablation time could have been increased if we were dealing with large lesion and ablation time lasted for 5-10 minutes for most patients.

After the ablation procedure, the next steps involved withdrawing the needle and applying a sterile bandage to the puncture site. Pain medication was freely administered following the intervention.

A successful procedure was defined as one in which the patient reported no pain at 7 days post-intervention and persisted in reporting no pain at 6 months at the follow up.

Outcome measures: Patients were able able to return to high-impact sports between 4 and 12 weeks following the treatment; crutches were distributed to all patients for usage until their 1-week follow-up appointment. The regular follow up interval was at 1 week. 1 month, 3months and 6 months. The collected data included the severity of pain, use of analgesics after ablation and incidence of any post-procedure complications.

Both before and after the surgery, pain was measured using a numerical scale with ten points. According to the standards set by the Society of Interventional Radiology (SIR), the frequency and seriousness of complications were documented [11].

Data of clinical symptoms and findings in computed tomographic before and after microwave ablation were collected. The good response was marked as disappearance of the symptoms manifested before MWA of Osteoid Osteoma. The Data of clinical and radiological follow up was collected within 1 weeks to 6 months after the procedure.

STATISTICAL ANALYSIS

SPSS (Statistical Package for the Social Sciences) version 26 was used to analyse the data. Absolute frequencies were used to characterize categorical variables. The chi-square for trend test was performed to examine the relationship between the two sets of ordinal data. Wilcoxon signed rank and Monte Carlo tests also were used. Depending on the data type, quantitative variables were described using mean values, standard deviations, median values, and interquartile ranges. The Spearman rank correlation coefficient was employed to measure the degree to which two continuous variables were correlated with one another and in what direction.

RESULTS

Larger percentage of patients were males (13/18; 72.7%) with age range from 6 to 26 years and mean age 11.72 years, concerning site of lesion, seven patients (38.9%) had lesions in proximal femur, six patients had affection in distal femur, mid tibia and distal tibia with an equal distribution (two in each group). All patients had night pain and all used NSAIDs as pain killer. Size of nidus ranged from 5 to 14 mm with mean 9.83 mm. Preoperative pain scores were ranging from 8 to 9 with mean 8.44 (Table 1).

Concerning cycles of ablation, fifteen patients (83.3%) needed three cycles, remaining three patients needed from four to six cycles. Time of ablation ranged from 1.5 to 3 minutes with mean 1.67 minutes.

There was statistically significant improvement in VAS one week postoperatively as compared to preoperative value where all patients had preoperative pain score from 8 to 9 while one week postoperatively, two patients had score 2 (11.1%). One month postoperatively, all patients had no pain (pain score 0) which showed non-significant change when compared with value one week postoperatively. Also, six months postoperatively, all patients had no pain (pain score 0) (Table 2).

Larger percentage of patients passed uncomplicated (88.9%), one patient developed superficial infection and another one had skin numbness, both patients with complications needed postoperative pain medications as they had postoperative pain score 2 which indicated use of pain medications. In both patients, pain score at one and 6 months became zero with no pain recurrence. Both were males, needed 5 to 6 cycles of ablation (Table 3).

A statistically significant positive correlation was revealed between cycles of ablation and preoperative pain scores ($p=0.036$) (Table 4). A statistically significant relation was found between preoperative pain score and duration of preoperative pain ($p=0.016$) (duration was significantly lower in patients with pain score 9), also a statistically significant positive correlation was found between postoperative pain score and ablation time and number of ablation cycles ($p<0.001$) (Table 5).

A 10-year-old male patient with left upper femur osteoid Osteoma underwent CT guided MWA. Post procedure clinical follow up revealed subsidence of pre-operative pain (successful MVA). (Figure 1).

A 13-year-old male patient with left upper tibial osteoid Osteoma underwent CT guided MWA. Post procedure clinical follow up revealed subsidence of pre-operative pain (successful MVA) (Figure 2).

Table (1): Distribution of studied patients according to demographic and preoperative data:

	N=18	%
Gender: Female Male	 5 13	 27.8% 72.7%
	Mean ± SD	Range
Age (year)	11.72 ± 4.43	6 – 26
Site of lesion Distal femur Proximal femur Proximal tibia Mid tibia Distal tibia Proximal fibula Distal fibula Glenoid Humerous	 2 7 1 2 2 1 1 1 1	 11.1% 38.9% 5.6% 11.1% 11.1% 5.6% 5.6% 5.6% 5.6%
Symptoms: Night pain	 18	 100%
NSAIDs use	18	100%
	Mean ± SD	Range
Size of nidus (mm)	10.72 ± 4.27	5 – 20
Preoperative pain score	8.44 ± 0.51	8 – 9
Duration of preoperative pain	7.17 ± 3.05	2 – 11

Table (2): Pain scores pre and postoperatively among studied patients:

	N=18 (%)	Wx	p
Preoperatively 8 9 Median (IQR)	 10 (55.6%) 8 (44.4%) 8(8 – 9)	 -	
1 week postoperatively 0 2 Median (IQR)	 16 (88.9%) 2 (11.1%) 0(0 – 0)	 -3.816	 <0.001**
1 month postoperatively 0	 18 (100%)	 -1.414	 0.157
6 months postoperatively 0	 18 (100%)	 0	 >0.999

WxWilcoxon signed rank test **p≤0.001 is statistically highly significant

Table (3): Distribution of studied patients according to postoperative complications, and Characteristics of patients who developed postoperative complications:

	N=18	%
Complications		
Superficial infection	1	5.6%
Skin numbness	1	5.6%
Pain recurrence	0	0%
Non-complicated	16	88.9%
Characteristics of patients who developed postoperative complications		
Parameter	N=2 (%)	
Male gender	2 (100%)	
Age	One 26 years, other 11 years	
Duration of symptoms	5 months for one patient and 3 months for the other	
Site of lesion	Mid tibia (50%), proximal femur (50%)	
Size of nidus	10 mm in one , 15 mm in the other	
Preoperative pain score	9 in both	
Postoperative pain score (1 week)	2 in both	
Ablation cycle	5 in one, six in the other	
Time of ablation	2.5 minute in one, 3 minutes in the other	

Table (4): Correlation between cycles of ablation and studied parameters:

	r	p
Age (year)	0.405	0.094
Size of nidus (mm)	0.29	0.243
Duration of preoperative pain	-0.117	0.644
Preoperative pain score	0.498	0.036*

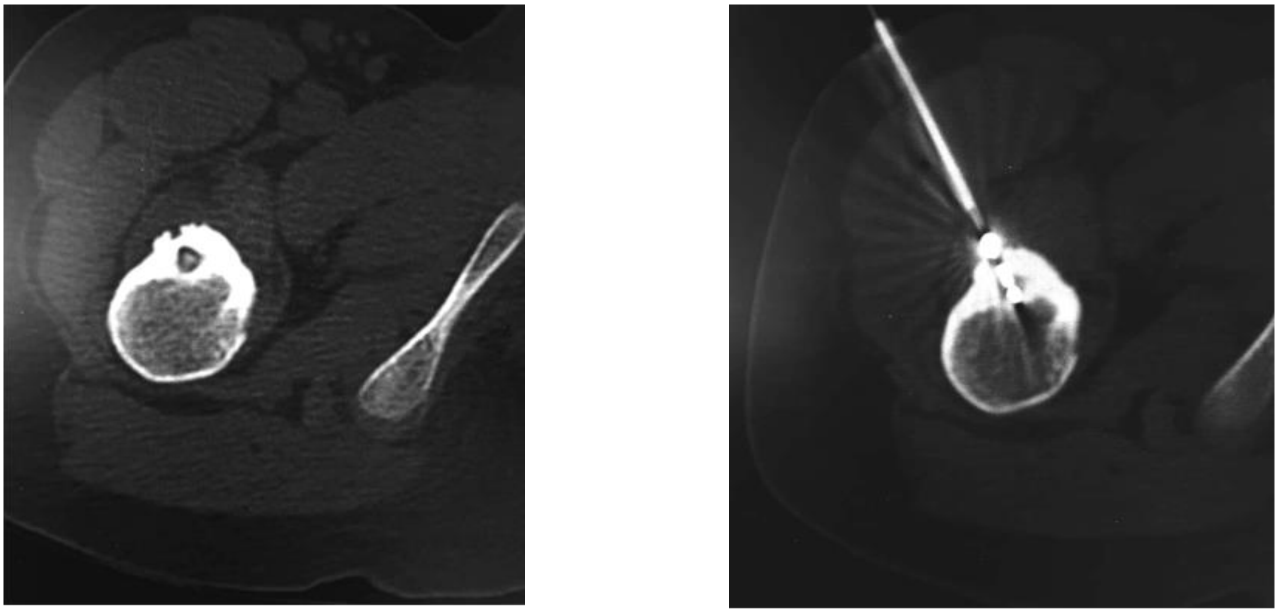
r Spearman rank correlation coefficient *p<0.05 is statistically significant

Table (5): Relation between preoperative pain score and studied parameters:

	Pain score 8 N=10 (%)	Pain score 9 N=8 (^%)	χ^2	p
Gender:				
Female	3 (30%)	2 (25%)	Fisher	>0.999
Male	7 (70%)	6 (75%)		
Site of lesion				
Distal femur	1 (10%)	1 (12.5%)		
Proximal femur	3 (30%)	4 (50%)		
Proximal tibia	1 (10%)	0 (0%)		
Mid tibia	1 (10%)	1 (12.5%)		
Distal tibia	0 (0%)	2 (25%)	MC	0.833
Proximal fibula	1 (10%)	0 (0%)		
Distal fibula	1 (10%)	0 (0%)		
Glenoid	1 (10%)	0 (0%)		
Humerous	1 (10%)	0 (0%)		
Cycles of ablation				
Three	10 (100%)	5 (62.5%)		
Four	0 (0%)	1 (12.5%)	$3.542^{¥}$	0.06
Five	0 (0%)	1 (12.5%)		
Six	0 (0%)	1 (12.5%)		
	Mean ± SD	Mean ± SD	t	p

	Pain score 8 N=10 (%)	Pain score 9 N=8 (^%)	χ^2	p
Age (year)	10.9 ± 1.6	12.75 ± 6.5	-0.787	0.455
Duration (month)	11.4 ± 5.42	9.88 ± 2.23	2.906	0.016*
Size of nidus	8.8 ± 1.62	5.13 ± 3.27	0.808	0.434
Time of ablation	1.5 ± 0	1.88 ± 0.58	-1.821	0.111
Correlation between postoperative pain and studied parameters				
	r	p		
Age (year)	0.257	0.302		
Size of nidus	0.276	0.267		
Preoperative pain score	0.395	0.104		
Duration of preoperative pain	-0.361	0.142		
Number of ablation cycles	0.839	<0.001**		
Ablation time	0.839	<0.001**		

χ^2Chi square test t independent sample t test, r Spearman rank correlation coefficient **p≤0.001 is statistically highly significant
*p<0.05 is statistically significant MC Monte Carlo test ¥Chi square for trend test

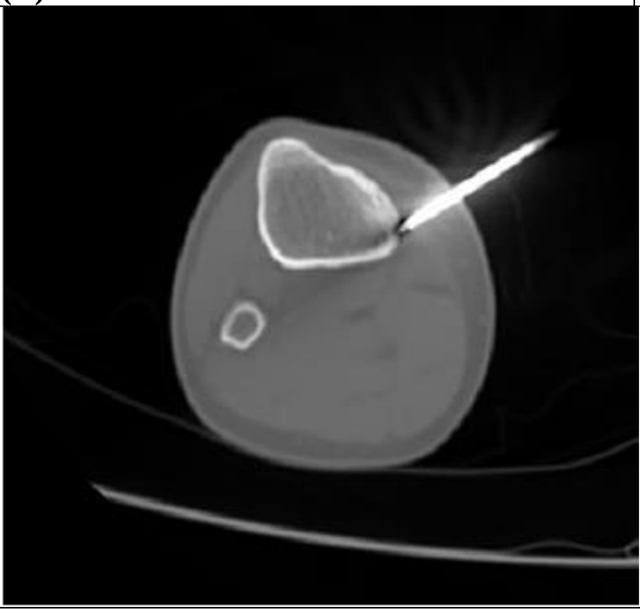


(A) (B)

Figure 1: (A) Axial CT image showing osteoid osteoma before MWA.
(B) CT image during needle direction

(A)

(B)



(C)

Figure 2: (A) Plain x ray showing proximal tibial osteoid osteoma**.**
(B) Axial CT image showing osteoid osteoma before MWA**.**
(C) CT image during needle direction

DISCUSSION

Osteoid osteomas are benign but often painful neoplasms. They occur across the axial and appendicular skeleton, but they're most prevalent in the long bones of the lower limbs [12]. Osteoid osteomas make for 12% of all benign bone tumors and are quite prevalent. They prevail in men during their second decade of life and are most found in the long bones' cortex (incidence among males is four folds the incidence among females) [13].

Surgical excision or curettage are two options for treating osteoid osteomas. The safety, efficacy, and minimally invasive nature of percutaneous ablation have made it the treatment of choice [2]. These tumors can be treated using microwave ablation, a more recent technology. A probe is inserted under the skin to expose the water molecules in tissues to an alternating electromagnetic field. The result is elevated temperatures that trigger cellular death and coagulation necrosis [14].

There may be certain benefits to using microwaves instead of RF for thermal ablation: first it increase intratumorally temperatures enable faster ablation times and larger potential ablation volumes with a single needle; secondly it reduce heat-sink effect; then it helps for elimination of the necessity to directly cool the needle tip internally; and lastly it decrease risk of skin burns due to the elimination of the need for grounding pads [15].

The present study included 18 patients 13 male by percentage (72.7%) and 5 females by percentage (27.3%) were treated at for symptomatic osteoid osteoma, they were managed by NSAIDS drugs and with no history of surgical or minimal invasive intervention. Kostrzewa et al. [7] revealed that the age of patients ranged from 16 to 47 years and their mean age was 28± 3.38 years, but in our study the age of patients ranged from 6 to 26 having a mean age 11.72± 4.43 years.

Regarding site of nidus, the present study results agreed with Prud’homme et al. [16] since they stated that most cases found in femur as in our study, we had 50% of our patient osteoid osteomas in femur.

Regarding size of nidus, the present study results agreed with Yildirim et al. [17] who found that the mean size of niduses was 6.86±2.05 (4.1–10.2) mm, that was mostly approximate to size of niduses in our study that ranged between (5 to 14) mm with mean size about 9.83 mm.

In our study, Duration of preoperative pain ranged from 2 to 11 months with mean 7.17 months in contrary to Rinzler et al. [18] who found that, before ablation, symptoms persisted for an average of eleven months, with a range of one to thirty-seven months.

Using CT guidance for MWA in the present study was in line with previous research by Ji j et al. [19] while it contradicts the findings made by Cheng EY et al. [20] as they used c-arm-guided ablation to further decrease the radiation dosage associated with CT techniques.

While Kastler et al. [21] recommends regional anesthesia for microwave ablation, our study found included all patients who had the procedure under general anesthesia.

Regarding to MW antenna, as a precaution and because MW antennas don't have to be placed precisely in the center of the nidus for an effective treatment, we advise keeping a 1 cm space between the ablation zone and non-targeted tissues like skin and nerves. This will help with lesions that are hard to see or access as reported by Prud'homme et al. [16].

In the present study, a target temperature of 90 degrees Celsius and an average of 3.4 ablation cycles per antenna, the ablation process took 1.7 minutes on average. Three patients needed additional ablation cycles to completely cover their large lesions, that was in line with Rinzler et al. [18] findings.

In the present study, all of patients (18/18) were managed using single ablation antenna with no need of placement another ablation antenna in contrary with Rinzler et al. [18] who need second ablation antenna in three patients (3/24) for creation of an ablation zone that cover the entire lesion nidus.

In the present study, all patients were free of pain within 1 week after the intervention, with no need use NSAID over 6 months follow-up. These findings were consistent with Kostrzewa et al. [7] who revealed that all patients were free of pain within 1 week after intervention.

Consistent with Basile et al. [22], who similarly found no recurrence when assessing the efficacy of microwave ablation on osteoid osteomas, we did not see any symptomatic cases of osteoid osteoma recurrence throughout the average 6-month follow-up period. This was in contrary to Zheng et al. [23] who reported two patients had postoperative recurrence over a follow up interval 17.9 months

Regarding treatment outcome, in the present study During the 6-month follow-up period, we recorded a 100% technical and clinical success rate with no serious side effects. This was consistent with Rinzler et al. [18] findings since they reported also 100% clinical success while in contrary to Reis et al. [24] they reported 92% of clinical success.

In our study CT imaging was performed to evaluate ablation area and identify possible complications. In contrary to Potteche et al. [25], they described MR as better tool because it can assess changes in the surrounding soft tissues and edema in the bone marrow following a procedure.

The minimally invasive aspect of MVA is a significant advantage when compared to surgery. The fact that no serious problems could occur, and no patients experience any kind of morbidity—meaning they were all able to go home the same day the treatment was performed—is evidence of this. Furthermore, in the event of a local recurrence, MVA can be simply repeated without significant bone loss, in contrast to surgery.

Regarding complications, in our study, we have two patients of 18 (11.2%) with post procedure complications in the form of skin numbness and soft tissue infection surrounding the access site, all of which have either resolved or reached subclinical severity at subsequent follow-up. The reason of this high percentage of post-operative complications most probably due to small patient number As well as Rinzler et al. [18] 570 reported four of 24 patient (17%) treated with MWA for In the present study, a soft-tissue infection was detected at the access site in one patient, and three individuals experienced local cutaneous numbness in the area around the site. While MWA has shown promise in treating bone cancers, a recent study by Cazzato et al. [26] revealed that there is a lack of evidence about its safety. This could be attributed to the thermo-mediated problems, like secondary fractures, which could occur in bone tissue.

Also, the present study findings agreed with Parisot et al. [27] who demonstrated that minimally invasive CT-guided MWA effectively could manage osteoid osteoma without late recurrence and with few complications.

Limitations of this study is being with small patient number and not all patients have been followed up with CT and MR imaging .as well as While our mean follow-up time of 6 months is sufficient to evaluate the effectiveness of our treatment at the outset, it falls short when it comes to assess the late recurrences.

CONCLUSIONS

Percutaneous CT guided microwave ablation may be used as an efficient safe treatment line among osteoid osteoma patients, contrary to surgery, with no major complications (infection or neurovascular injury) that have been reported after microwave ablation for osteoid osteoma.

Long term studies with larger populations are needed to confirm the effectiveness of CT-guided MWA in treating OO of the appendicular skeleton. The procedure should always be conducted under general or epidural anesthesia. It appears that the success rate of CT-guided MWA of osteoid osteoma is about identical to that of laser or radiofrequency ablation; nevertheless, great caution is required to avoid nerve or skin injuries.

Conflict of interests: -The authors declare that they have no conflict of interests

Financial Disclosures: There were no any financial interests, relationships and affiliations relevant to the subject of the study

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