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The safety and the efficacy of computed tomography guided percutaneous radiofrequency ablation of osteoid osteoma

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ABSTRACT

Objective: The aim of this study was to investigate the efficacy and safety of Computed Tomography (CT) guided percutaneous Radiofrequency Ablation (RFA) in the treatment of osteoid osteoma (OO).
Methods: A total of 116 patients (82 male and 34 female patients; mean age of 17.7 years; age range 13-months-42 years) who had 118 CT guided RFA treatment between June 2015 and November 2018 (42 moths) with the diagnosis of OO were included in this study. All the patients had pre-procedural CT examinations. The clinical and technical success and the safety of the treatment were evaluated by assessing the clinical pain symptoms, complication rates and recovery of posture and gait.
Results: All the patients had a favorable immediate relief of the known pain caused by osteoid osteoma in 24 h after the procedure. Only in two patients (15-years-old boy with OO in right femoral neck and a 12 years old boy with OO in femur diaphysis) pain relapse was occurred in 3 months and 12 months after RFA and a second RFA was performed. During follow-up they had no pain. The technical success and efficacy-rates of the procedure were recorded as 100% and 98% respectively in this study. No significant complication was observed during treatment or recovery period. Seven minor complications were noted which were successfully treated.
Conclusion: The rapid relief of pain symptoms, low relapse rate and low complication rates demonstrate the efficacy and safety of RFA therapy. RFA is an out-patient procedure that patients can be mobilized immediately after the procedure. RFA can be safely used as a first choice of treatment method in OO therapy.
Level of evidence: Level IV, therapeutic study.

Introduction

Osteoid osteoma (OO) is a benign osteogenic tumor which is accounting for approximately 10–12% of all symptomatic benign bone tumors that predominantly affects males and seen in second or third-decades of life.[1]

Pain, that is specifically worse at night and relieved by aspirin is the main symptom of OO. Depending on location of nidus and patient's age, daily activity may be restricted, gait and posture deterioration may occur, prosthetic-support may be required because of disability due to pain. So, OO should be treated either medical, surgical or by percutaneous approach.

In surgical approach, flouroscopy-guided localization of nidus can be challenging and may result in possible failure of the nidus removal while percutaneous approach with Computed Tomography (CT)-guidance provides easier localization of nidus. Conventional surgery may require either large bone resection, en-block resection, graft transposition, instrumentation, arthrotomy, or joint

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dislocation while image-guided percutaneous approach requires only a small osseous access to insert a needle.[2–6] Rosenthal et al compared surgical treatment to Radiofrequency Ablation (RFA) in their study and suggested percutaneous RFA for treatment of extraspinal OO because it has short hospitalization, associated with less complications and a rapid convalescence.[2–4]

Recent studies have shown that CT-guided percutaneous RFA is beneficial and may be preferred for treatment of OO.[2–14] The purpose of this study is to report the efficacy and safety of RFA-treatment in OO in a cohort of large number of cases.

Method

The study was approved by our institution's ethical committee (Number:1879; Date: 23.01.2018). A total of 116 patients (82 males and 34 females; mean age of 17.7; age range 13 months–42 years) who had 118 CT-guided RFA-treatment between June 2015 and November 2018 (42 months), with the diagnosis of OO, were included in this retrospective study. Of the 116 patients, 79 were younger or equal to 18 years-old. Three orthogonal-diameters were measured to calculate volume of the niduses using volume-formula ($V = d_{cc} \times d_l \times d_{ap} \times \Pi/6$).

The lesions were diagnosed based on radiological and clinical features. All the patients were referred to our interventional-radiology-clinic after decision of multidisciplinary tumor board excluding differential diagnoses such as osteomyelitis or malignancy according to clinical and radiological features. Since, radiological and clinical features are enough for diagnosis of OO; routine biopsy was not performed before the ablation not to extend the procedure time.[15] Only 10 patients had biopsy because they had less perilesional sclerosis and 60% of them had benign diagnosis while 40% had non-diagnostic results. Also, 5 patients had biopsy proven OO history at external centers before being referred to our hospital.

Informed-patient-consent was obtained for all the patients. Also, for anesthesia applications, patient's (and parents' of pediatric patients) approval was obtained. All the interventions were performed by two interventional-radiologists in the same center. All patients' pre-procedural CT-images and serum blood-tests (hemogram and coagulation) were evaluated. All the interventions were performed under CT-guidance (Toshiba, Alexion, Japan and Siemens, Somotom, Emotion, Germany) and sterile conditions (Fig. 1).

Fifty-two patients underwent sedoanalgesia (Propofol and Fentanyl), 54 had spinal-anesthesia and 10 had peripheric-nerve-block by two anesthesiologists to avoid patient motion and to block the pain that ablation causes. The anesthesia types were chosen according to experience and preference of the anesthesiologists and preference of the patients.

Intravenous 20 mg/kg cephazolin was injected at the beginning of the procedure in all patients for prophylaxis.[16] The best position of the extremity and the best localization is decided to insert a bone-needle under CT-guidance. All the procedures were performed with 17 gauge internally cooled, monopolar, RFA-electrode (UniBlate, AngioDynamics, US). A grounding-pad was placed close to the nidus location in the same extremity.

If the nidus was placed close to a vessel, nerve or tendon, Ultrasound/Doppler-Ultrasound (US/DUS) (4–12 MHz linear-probe; Mindray, DC-6 Expert, China) was used for guidance to avoid complications. The safest and the shortest way was chosen to reach the nidus directly from the cortical side. To prevent infection and hemorrhage risks, we did not prefer trans-medullary approach from counter-cortex.

The bone-needle (11/14G; 6/10/12.5 cm; Matek, Geotek, Bard) was placed in the nidus by using a firm pressure or by using a hammer. In 3 cases a drill was used to enter the nidus because of highly sclerotic rims. The RFA-electrode is sent through a bone needle (Fig. 2). The treatment time and the applied temperature were the same in children and adults, except for a 13-month-old-child. The ablation time was 7 min and the temperature of the RFA-electrode was increased to a maximum of 90° in all the patients while time was 5 min and temperature was 80° in this 13-month-old-boy. We have published this youngest, 13-month-old, patient as a case report.[17]

Ice (wrapped in a sterile towel) application was done around the needle, on the skin to prevent skin burns. At the end of the procedure, it was checked whether the intra-nidus probe temperature was higher than 60°. All the patients had one-night hospital stay in orthopedics-clinic and reassessed for pain relief and complications on the first day after RFA in radiology-clinic.

Visual-analog-scale (VAS) was used to assess the pain relief before and after the RFA-procedures as Miyazaki et al reported in their study which is an important clinical trial for this treatment.[18] The treatment was classified as effective when VAS-score was <2 after RFA. The success was categorized as “technical-success” and “efficacy” according to Society of Interventional-Radiology (SIR)-guidelines.[19]

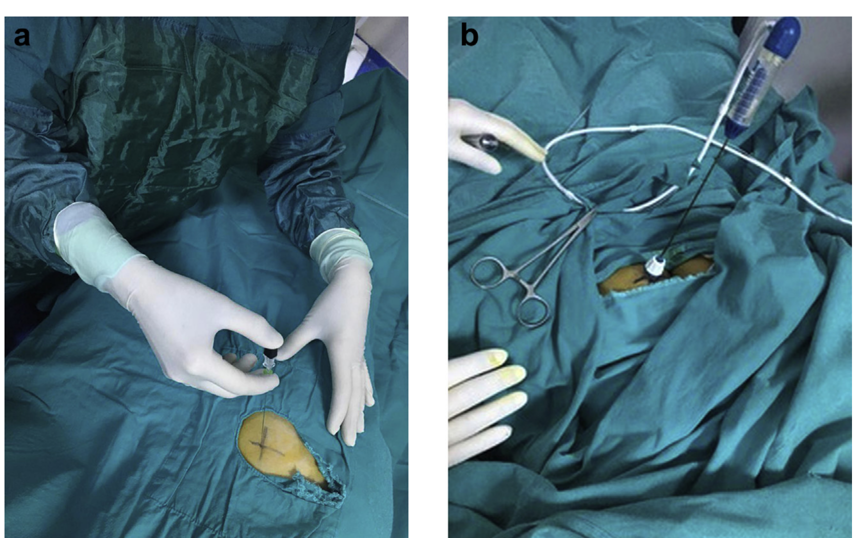

Fig. 1. a and b. All the interventions were performed under sterile conditions by two interventional radiologists in the same center.

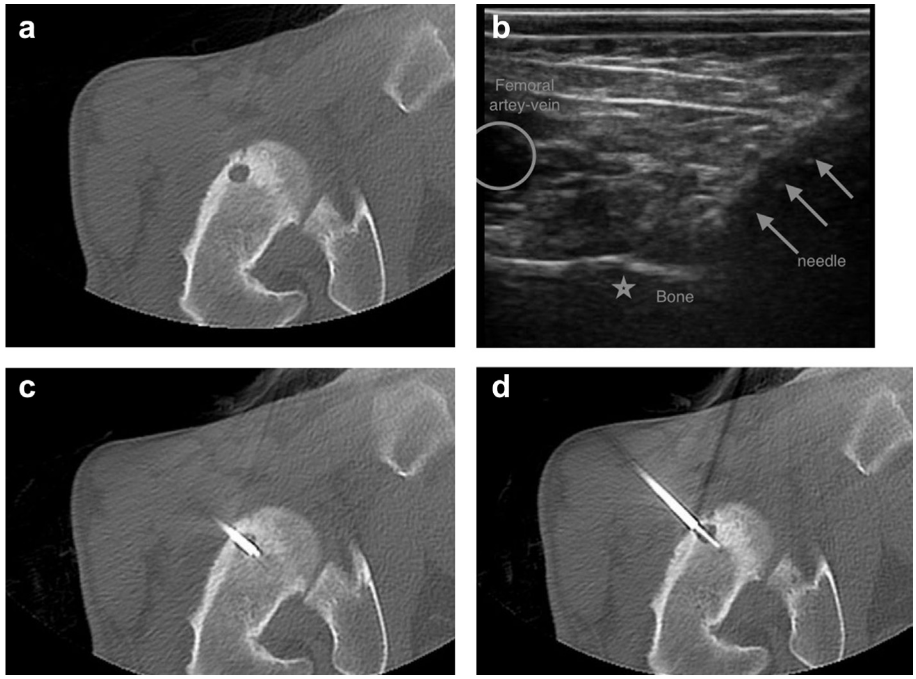

Fig. 2. a–d. Osteoid-osteoma with radiolucent nidus and peripheral sclerosis in right femur-neck of a 24-years-old male is seen **(a)**. Because the nidus was adjacent to vascular and neural structures, the leg was positioned in external-rotation and the needle was placed in the bone cortex with US **(b)** and CT guidance **(c)**. As the bone needle was inserted in the nidus, the tract opening needle in the bone needle is removed and the RFA probe is sent through the bone needle. The outer bone needle is slightly retracted approximately 1 cm (till the edge of the cortex) to enable the active end portion of the RFA probe to freely interact with the nidus **(d)**.

Primary-success is defined as technical-success; placement of RFA-electrode into nidus and to ablate nidus for a desired period. Efficacy is evaluated by assessing pain relief and defined as pain relief at least for 12 months after the first RFA-treatment. For efficacy assessment, all the patients were called for out-patient-clinic control on the 10th day, the 3rd, the 6th and the 12th months for follow-up. For some of the patients who live in far cities, assessment for pain relief is accepted contacting by phone, also.

For statistical analysis, Statistical Package for the Social Sciences (SPSS) for Windows (Version 15.0, Chicago, SPSS Inc.) program was used. Descriptive statistics were given as number and percentage for categorical variables and as mean, standard deviation, minimum, maximum and median for numerical variables.

Results

The median volume of the lesions was 185 mm^3 (min: 22 mm^3 (7 × 3 x 2 mm); max: 1123 mm^3 (15 × 12 × 12 mm)). The

Table 1
Localizations of the osteoid osteomas.

Localizations	Patient number (n = 116, 100%)
Femur (Femur neck/Femur)	62 (53.5%) (40/62)
Tibia	28 (24.1%)
Humerus	7 (6%)
Radius	2 (1.7%)
Fibula	2 (1.7%)
Metacarpal	2 (1.7%)
Iliac	2 (1.7%)
Ischium	2 (1.7%)
Talus	2 (1.7%)
Glenoid	1 (0.9%)
Cuboid	1 (0.9%)
Calcaneus	1 (0.9%)
Acetabulum	3 (%2.6)
Metatarsal	1 (0.9%)

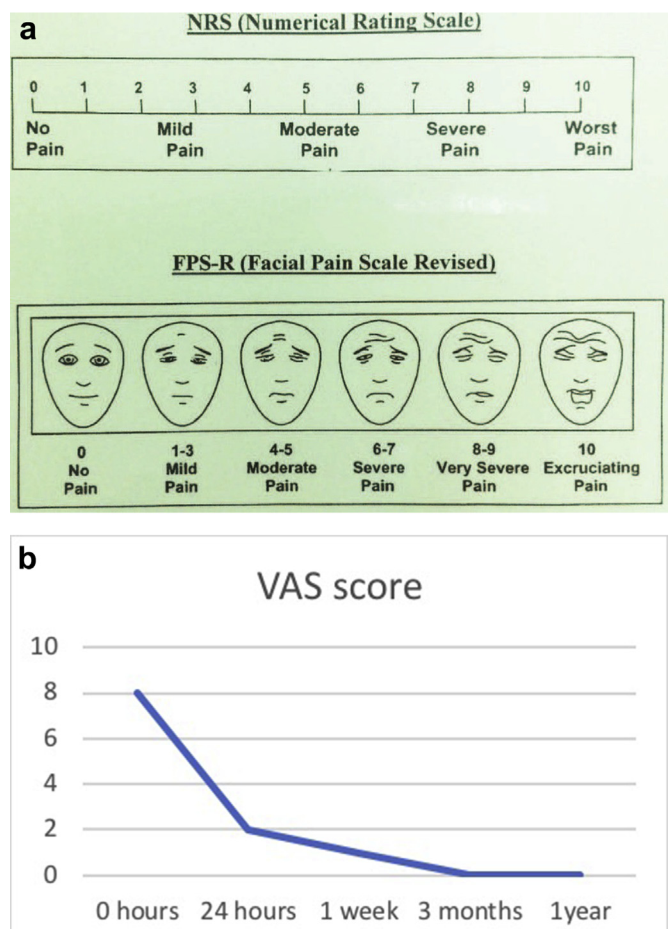

Fig. 3. a, b. Visual analog scale assessment schema **(a)**. The decrease in pain after RFA and change in VAS score is shown as a graph **(b)**.

localizations of OOs are shown in Table 1. We achieved a technical-success rate of %100 in 118 procedures of 116 patients. All the patients (including the patients with minor complications) had a favorable immediate relief of the known pain caused by OO in 24-h after the procedure and reported 0–1/10 points of VAS-score after RFA while all of them reported 6–10/10 points before RFA. The change in VAS-score is shown as a graph in Fig. 3.

Mean follow-up duration was 23 months (min: 3; max: 44 months) and 92 (79%) of the patients had more than 1-year follow-up. Eight patients were excluded due to missing clinical data for efficacy evaluation. So, 108 patients were included for efficacy evaluation. For follow-up, of the 108, 96 patients came to hospital and had physical-examination, 12 had contact by phone due to living in far-cities. Two patients (15-years-old boy with OO in right femoral-neck and a 12 years old boy with OO in femur diaphysis) had pain relapse on the 3rd and the 12th months after the procedure and a second RFA was performed in these patients. Of the two re-ablations, one case has been still pain-free for 24 months after the procedure. The other case underwent re-ablation just recently and has so far not reported relapse of pain. So, considering the patients who had recurrence in 3 months and 12 months, we achieved an efficacy-rate of 98% in this study.

Before the RFA, 4 patients (1 femur-neck, one cuboid and 2 talus) had crutches due to pain, 2 patients who had metacarpal lesions were unable to make a fist due to edema and pain, 4 children (with femur-neck lesions) had posture and gait deterioration due to gluteal-muscle atrophy and pain. After RFA, the patients with crutches left them in a week, the patients with metacarpal lesions were able to make fist in three months after resolving of edema, 3 children had postural recovery in three months also. Although pain was totally regressed in 24-h after RFA in a 12-year-old boy with femur neck lesion, postural deterioration was not regressed in 6 months. That child was referred to physical therapist for his gluteal muscle atrophy rehabilitation.

In 50 patients (43%) US/DUS was required for guidance in addition to CT. No significant complications were observed during treatment or recovery period according to SIR-complication-criterias.[15,19] Seven minor complications were noted which were successfully treated with conservative therapy. One of them was a broken needle-tip because of patient movement just at the end of the procedure due to insufficient sedation. The patient had benefit from the RFA. The lesion was in distal physis of tibia in this patient (Fig. 4). Because the patient did not have pain and did not want to have an operation to excise the broken needle-tip, he did not have any therapy for this complication. The other minor complications were; one intramuscular hematoma in femoral-region, four superficial skin burns on anterior tibial diaphysis and one skin erythema under the grounding pad which were also treated successfully with conservative therapy and did not require any plastic-surgery operation. There were no deaths or no bone fractures related to RFA-treatment. Also, there were no complications related to anesthesia procedures.

Discussion

Because OO is a benign tumor, the main purpose of the treatment is to relieve pain. It is not necessary to completely remove the nidus.[2–4] Medical treatment may be inadequate to relieve the pain. Also, patients may not be able to tolerate long-term nonsteroidal anti-inflammatory drug (NSAID) therapy that can cause peptic ulcer with very high dosages.[6] One of our patients had hospitalization history because of peptic-ulcer hemorrhage secondary to use of high dose of NSAID.

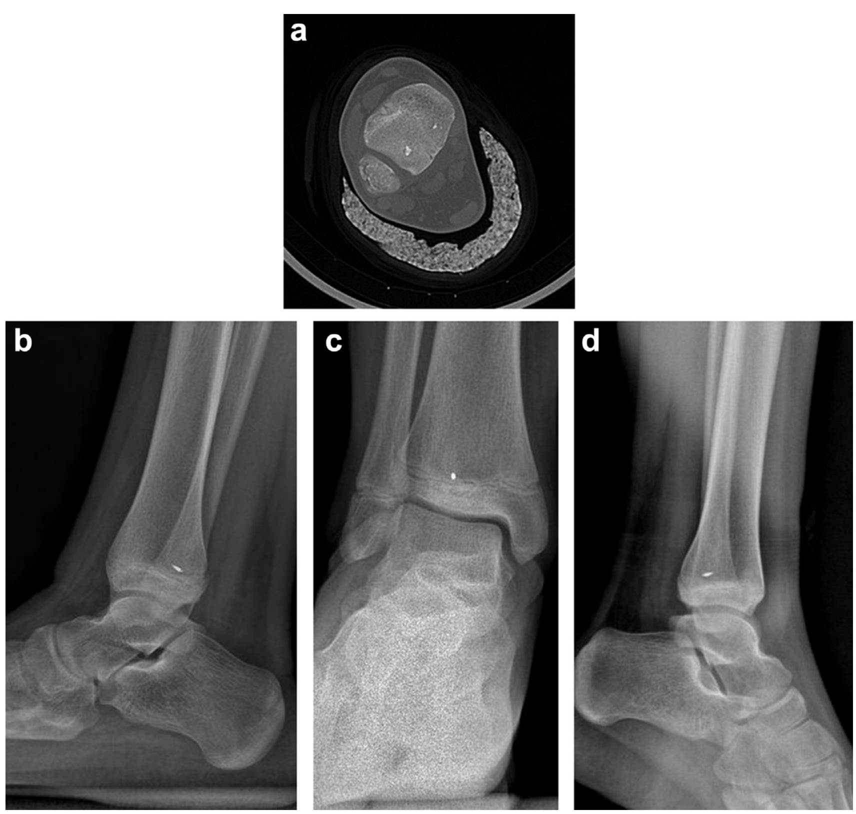

Fig. 4. a–d. A 12-years old boy with OO in the distal physis of tibia. The nidus is seen on pretreatment CT image **(a)**. The broken needle tip is seen in the epiphysis of tibia on post-treatment ((1st month) **(b, c)**; (9th month) **(d)**) follow-up radiographies.

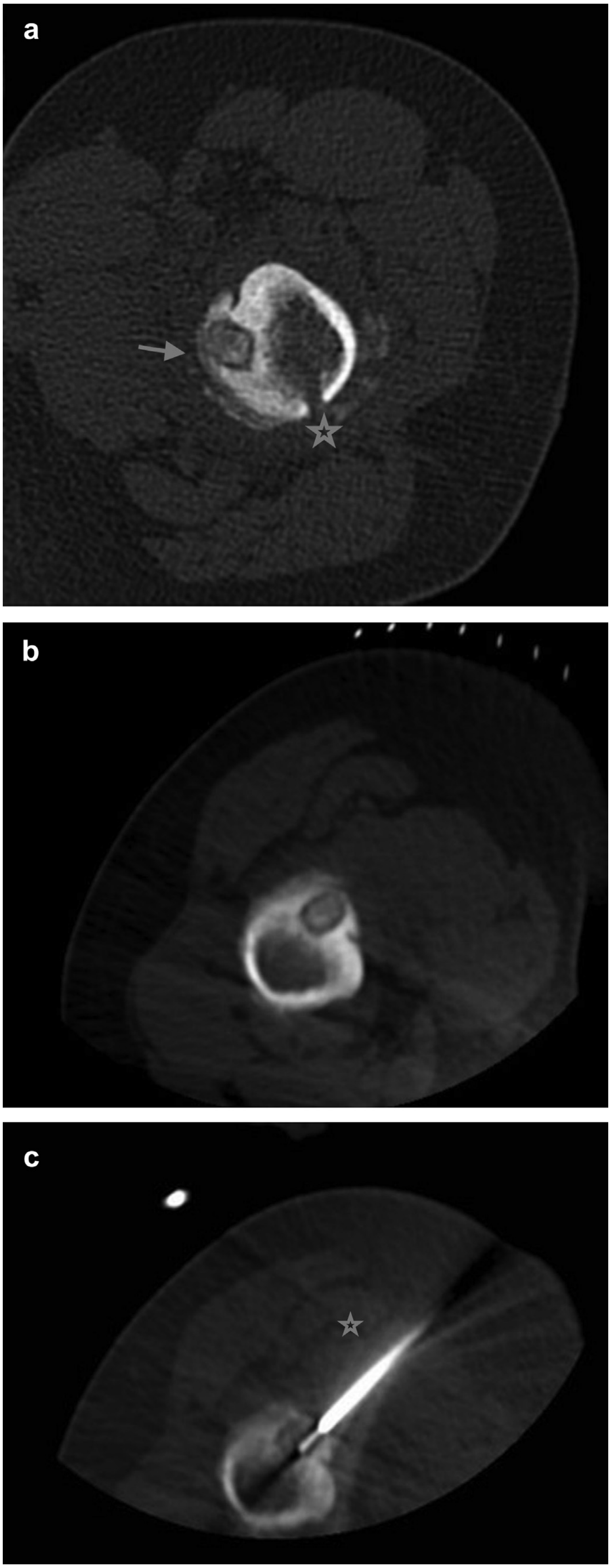

Fig. 5. a, b and c. A 9-years-old boy with the osteoid-osteoma (arrow) in left femur proximal diaphysis. The patient had fluoroscopy-guided RFA procedure in another hospital 3 months ago. Because the patient did not have pain relief he was referred for CT guided RFA. We see the cortical defect of previous intervention on posterior cortex of the femur on the same image (star) **(a)**. The procedure was performed on prone position **(b)**. RFA electrode was placed using the shortest and the safest way with medial approach concerning the sciatic nerve bundles (star) **(c)**.

Although surgical resection of OO nidus is a curative treatment option, it has disadvantages due to difficulty in detecting nidus during operation, necessity of wide bone excision, and long hospitalization requirements. Percutaneous RFA-treatment is an outpatient procedure that does not require large dissections or bone excisions. This makes percutaneous interventional treatments advantageous.[4–13,17,18,20,21] Since the most of our patients were admitted from far-cities, we hospitalised them for one night for close follow-up of possible complications. In this study, 5 patients had surgical or fluoroscopy-guided treatment history in different hospitals (Fig. 5). Because the treatments did not work, they were referred to our hospital for CT-guided percutaneous RFA-treatment. There were marked skin scars in 4 of these 5 cases. However, there was no scar in any patient after percutaneous RFA in our study. After RFA, patients were discharged only with a bandage.

All the RFA procedures were performed under CT-guidance due of its high resolution. In order to minimize the radiation dose received during the procedure, it was noted that the imaging area and the number of sections were restricted as much as possible. The treatment time and the applied temperature were the same in children and adults, except for a 13-month-old child.[16]

In 46 (40%) patients, size of the lesions was larger than 10 mm in diameter. The largest lesion was 15 × 12 × 12 mm in diameter. As osteoblastoma is in differential diagnoses, we considered the lesions that are equal or smaller than 15 mm in diameter as OO.[1] As far as we observed, all of the OOs were not round formed, some of them were elongated, we preferred to measure the volumes of the lesions. The median volume of the lesions was 185 mm^3 (min:22 mm^3 (7 × 3 x 2 mm); max:1123 mm^3 (15 × 12 × 12 mm)). In Pinto, Cagal and Vanderschueren's studies multiple probe usage was suggested for large lesions.[7,8,22] Since the active tip part of the RFA probe we used was adjustable to 1, 1.5 and 2 cm, we were able to treat lesions of any sizes with single intervention.

All the patients underwent anesthesia during the procedure. Spinal anesthesia and peripheral neural block reduced the duration of the procedure from ~90 min to ~40 min. In patients who underwent spinal-anesthesia and peripheral-block, shorter duration of procedure and extremity immobility was achieved more successfully. We think that spinal anesthesia and peripheral block is safe even in pediatric population and may be used more commonly in RFA procedures.

Since prophylactic antibiotherapy was ordered for all patients, no bone infection developed related to procedures. We were aware of all the minor complications because all the patients had one-night hospital stay and were checked the day after for complications. Although the RFA is a minimally invasive procedure, we advised the patients, to restrict heavy lifting and heavy sports for 3 months after RFA.

Seven minor complications were noted related to the procedure. This very few complication rates are attributed to using US-guidance besides to CT-guidance and pre-procedural good planning for the safest and the easiest approach.

There are some shortcomings in this study. A routine biopsy was not performed for all the lesions. According to SIR guidelines, tumors with characteristic clinical presentation and radiologic characteristics may be treated without biopsy proven diagnosis.[15] On the other hand, in 40% of the patients who had biopsy during the procedure had non-diagnostic histopathological results. Because all the patients clinically and radiologically diagnosed as OO, non-diagnostic histopathological results were common, an additional biopsy would require longer time and much more anesthesiologic drugs, we chose not to perform biopsy routinely. On the other hand, pre-RFA and post-RFA Musculoskletal Tumor Society Scores (MSTS) are lacking due to retrospective design of the study. Another limitation is that; some of the patients have less than 12 months of follow-up period in this study.

Although RFA is the first line method in OO, there are some other new methods in treatment of OO. High-intensity-focussed-US (HIFU) and MR-guided-HIFU are reported as efficient, noninvasive and radiation-free methods in treatment of OO.[23–25] However, the time duration of HIFU is 7 times longer than RFA because cooling periods are required between sonications. Microwave-ablation is another technique which is as efficient as RFA, has shorter time duration but larger ablation-necrosis area compared to RFA.[26] Also, Costanzo et al used multi-tined-expandable-electrode system which is a different type of RFA-electrode in treatment of OO and they suggested that expandable-needle-systems are not suitable for OOs located superficially.[27] When we compare CT-guided RFA to operation, time duration of procedure, hospitalization and recovery is much shorter and total cost is less.[28]

Finally, it may be concluded that rapid relief of pain symptoms, low relapse rate and clinical follow-up results demonstrate the efficacy, safety and success of CT-guided percutaneous RFA therapy. It is a reliable, micro-invasive and inexpensive method when compared to surgical excision. RFA-treatment in OO has satisfactory results and it has a rapid clinical response.

Conflict of interest

The authors have no conflict of interest.

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