ORIGINAL ARTICLE

Role of Interventional Radiology in the Management of Bone Tumors and Tumor like Lesions

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Abstract

Background: ***By providing novel minimally invasive options to radiation and surgery, interventional radiology has changed the game for local tumor care in the bone. In recent years, its use in treating both benign and malignant cancers has grown substantially.***

Aim and objective: ***To examine the various interventional radiology approaches for the treatment of bone tumors and tumor-like lesions, including their clinical feasibility, efficacy, short-term outcomes, and risks.***

Patients and methods: ***From March 2022 through September 2024, twenty patients with bone tumors or tumor-like lesions were admitted to the interventional radiology unit of the radiology department at Al-Azhar University hospitals for management. The study was a prospective cohort study.***

Results: ***The osteoid osteoma ablation had good outcomes, with high technical success, short procedures, and mild post-operative symptoms. This suggests that ablation techniques may be preferable for small lesions such as osteoid osteoma. However, endovascular embolization may have a role in the management of larger, hypervascular and more complex bone lesions.***

Conclusion: ***Osteoid osteomas can be effectively and safely treated with ablation. Larger, hypervascular, and more complicated bone lesions may be manageable with endovascular embolization.***

Keywords: Interventional radiology; Bone tumors; Lesions

1. Introduction

Many factors must be considered when managing patients with bone tumors. These include tumor histology, which distinguishes between benign and malignant tumors; a thorough assessment of the patient's overall health; knowledge of the disease process; an understanding of the extent of bone destruction; and an understanding of the treatment options that are currently available.[1]

By providing novel minimally invasive options to radiation and surgery, interventional radiology has changed the game for local tumor care in the bone. In recent years, its use for the treatment of benign and some malignant tumors has grown steadily, particularly in palliative care.[2]

Primary bone tumors are relatively rare compared with secondary (skeletal metastatic) disease. They represent less than 1% of all cancers in adults. Usually, Interventional radiology in this field is reserved for nonoperable patients or adjuvant treatments.[3]

Interventional radiology in malignant bone lesions is mainly aimed at the treatment of bone metastases due to the clear epidemiological prevalence compared to primary tumors.[3]

Compared to secondary (skeletal metastatic) illness, primary bone cancers are not very common. They make up a negligible fraction of the total adult cancer cases. Interventional radiology is typically used for patients who cannot undergo surgery or for patients undergoing adjuvant therapy in this discipline.[4]

This study aims to examine the clinical feasibility, effectiveness, and short-term outcomes and consequences of various interventional radiology procedures for the management of bone tumors and tumor-like lesions.

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2. Patients and methods

Twenty patients hospitalized in the interventional radiology unit of the radiology department at Al-Azhar University hospitals between March 2022 and September 2024 for the treatment of bone tumors or tumor-like lesions were the subjects of this prospective cohort study. They were classified into two groups: Group 1 (submitted for thermal ablation): Fourteen patients that underwent Interventional radiology technique through thermal ablation, and Group 2 (submitted for endovascular embolization): Six patients that underwent Interventional radiology technique through endovascular embolization.

Inclusion criteria:

Patients of any age group complaining of pain or vulnerable to pathological fracture as a result of the presence of benign or malignant bone tumors, or for pre-operative embolization.

Exclusion Criteria:

Patients with bleeding tendency, patients requiring yet not fit for general anesthesia, and systemic or localized infection.

Ethical Consideration

Informed consent was taken from all patients after detailed description of the procedure and before being enrolled to the study. Approval by the ethical committee was obtained before initiating this study.

All patients were subjected to full history taking, including age, sex, body mass index (BMI), and Physical examination. Decisions about overall strategy were discussed to permit accurate technique and device selection.

Laboratory investigations represented by: Hb (g/dl), WBCs (x109/L), platelets (x109/L), ALT (U/L), AST (U/L), creatinine (mg/dl), urea (mg/dl), PT (sec), PTT (sec), and finally the INR.

Techniques:

Anesthesia was discussed with the anesthesiologist based on the patient's clinical background, laboratory studies and the anesthesiologist's comfort and experience. Patients were subjected to general anesthesia with endotracheal intubation or conscious sedation, spinal analgesia or local anesthesia. A strict sterilization technique was employed at the site of entrance.

Different imaging modalities were used including CT and fluoroscopy guidance. - Different techniques were used according to each case including thermal ablation and/or transcatheter embolization.

All previous radiological investigations of the patients were reviewed. Intra-operative imaging studies were done to guide the procedure.

In thermal ablation group, patients underwent radiofrequency ablation or microwave ablation while in endovascular embolization group, all patients underwent selective trans-arterial catheterization.

Thermal ablation in osteoid osteoma:

A total of 14 patients were treated under the guidance of CT. Six-cases HS AMICA radiofrequency ablation system, and 8-cases canyon microwave ablation system were used.

Endovascular embolization:

All 6-cases were performed through trans-arterial catheterization using a standard right transfemoral approach under fluoroscopy guidance (Siemens Artis Interventional Angiography System was used), embolization was carried out using a microcatheter. Different embolic agents have been used according the target of embolization in each case including particulate embolic agents (PVA or embosphere), gel foam or absolute alcohol.

Anaesthesia:

Of the 20-patients performed in this study the choice of anesthesia was discussed with the attending anesthesiologist based on the patients' clinical background, laboratory studies and anesthesiologist's comfort and experience. All thermal ablation group patients underwent general anesthesia with endotracheal intubation. All TAE group patients received local anesthesia (lidocaine 1%) along the puncture site.

Sterilization:

A strict sterilization technique was employed, Application of povidone-iodine (Betadine 10%) at the planned site (s) of entry using sterile gauze. Application of sterile draping to cover the patient leaving a window at the site (s) of entry, the performing radiologist (s) scrubbed as by facility standards and wore proper surgical attire including over heads and surgical masks. The material used were sterile single use material.

CT guidance:

Using CT guidance were employed for co-axial needle placement. The drill was used in single case with hard access. Then the RFA or MWA needle was placed through the co-axial system, their tip is centered within the lesion. The active ablation time ranging between 5-10minutes.

Fluoroscopic Guidance:

Trans-arterial catheterization using a standard right transfemoral approach under fluoroscopy guidance was used, selective and super selective catheterization was performed through a selective catheter and microcatheter then embolization of the feeding vessels using micro particles has been performed.

Inpatients were observed for 1-hour following the procedure lying on their back. They were then sent to the ward and followed up.

Outpatients were observed for 3-hours following the procedure and then sent home and ordered not to weight bear for 24-hours and avoid strenuous activity for 3-days following the procedure.

Statistical analysis

We used SPSS v26 (IBM Inc., Armonk, NY, USA) to complete all of our statistical analyses. To determine if the data were normally distributed, the Shapiro-Wilks test and histograms were employed. The quantitative data were shown using the standard deviation (SD) and mean (Mean). Frequency and percentage were used to present the qualitative data.

3. Results

Table 1. Patient demographics used in the study.

		OSTEOID OSTEOMA ABLATION GROUP (N=14)	ENDOVASCULAR EMBOLIZATION GROUP (N=6)
AGE (YEARS)	Mean±SD	17.71±4.45	35.17±14.19
	Range	9-23	14-51
SEX	Male	11(78.57%)	3(50%)
	Female	3(21.43%)	3(50%)
BMI (KG/M^2)	Mean±SD	23.63±1.88	28.75±4.69
	Range	19.98-26.71	22.04-33.39

BMI: body mass index

In osteoid osteoma ablation group, the age ranged between 9-23 years with a mean ± SD of 17.71±4.45 years. There were 11(78.57%) males and 3(21.43%) females. The BMI ranged between 19.98-26.71 kg/m2 with a mean ± SD of 23.63±1.88 kg/m2. In endovascular embolization group, the age ranged between 14-51 years with a mean ± SD of 35.17±14.19 years. There were 3(50%) males and 3(50%) females. The BMI ranged between 22.04-33.39 kg/m2 with a mean ± SD of 28.75±4.69 kg/m2 (Table 1).

Table 2. Tumor type of endovascular embolization group.

	ENDOVASCULAR EMBOLIZATION GROUP (N=6)
GIANT CELL TUMOR	3(50%)
CHONDROSARCOMA	1(16.67%)
ANEURYSMAL BONE CYST	2(33.33%)

In ablation group, all 14(100%) patients had osteoid osteoma. In endovascular embolization group, 3(50%) patients had giant cell tumor, 1(16.67%) patient had chondrosarcoma, and 2(33.33%) patients had aneurysmal bone cyst (Table 2; Figure 1).

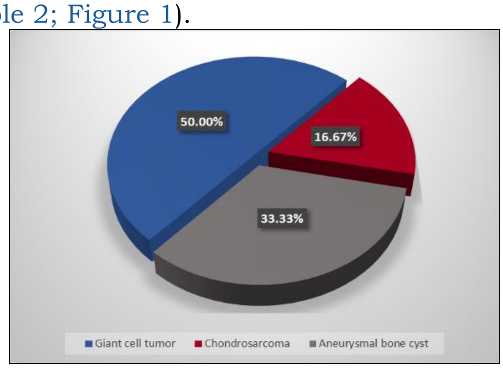

Figure 1. Tumor type of endovascular embolization group.

Table 3. Interventional radiology technique used in osteoid osteoma ablation.

	OSTEOID OSTEOMA ABLATION GROUP (N=14)
RADIOFREQUENCY ABLATION	6(42.86%)
MICROWAVE ABLATION	8(57.14%)

In osteoid osteoma ablation group, 6(42.86%) patients underwent radiofrequency ablation and 8(57.14%) patients underwent microwave ablation. In endovascular embolization group, all 6(100%) patients underwent endovascular embolization (table 3).

Table 4. Outcomes of the studied patients

	OSTEOID OSTEOMA ABLATION GROUP (N=14)	ENDOVASCULAR EMBOLIZATION GROUP (N=6)
BLOOD LOSS	0(0%)	0(0%)
TECHNICAL SUCCESS	14(100%)	4(66.67%)

The groups that underwent endovascular embolization and those that underwent osteoid osteoma ablation both saw no bleeding. All fourteen (100%) patients in the osteoid osteoma ablation group had their procedures successfully completed. One patient failed owing to insufficient embolization and one patient failed owing to lack of significant feeding arteries in the endovascular embolization group, with four patients (66.67%) achieving technical success (Table 4; Figure 2).

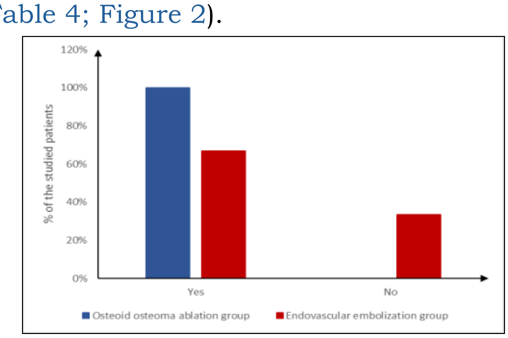

Figure 2. Technical success of the studied patients.

Table 5. Complications of osteoid osteoma ablation group.

	OSTEOID OSTEOMA ABLATION GROUP(N=14)
MILD RESPONSE TO THE TREATMENT	1(7.14%)
MILD LOCALIZED PAIN RELIEVED WITHIN A WEEK	12(85.71%)
RECURRENT PAIN AFTER 2 MONTHS	1(7.14%)

In osteoid osteoma ablation group, 1(7.14%) patient developed mild response to the treatment, 12(85.71%) patients developed mild localized pain relieved within a week, and 1(7.14%) patient developed recurrent pain after 2-months(Table 5;Figure 3).

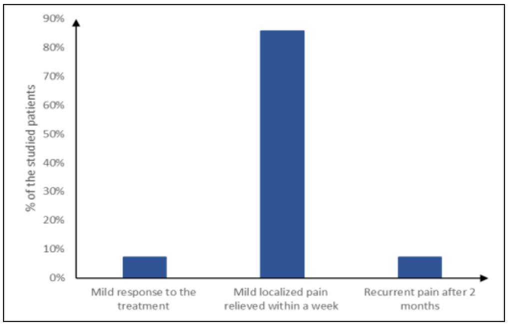

Figure 3. Complications of osteoid osteoma ablation group.

Table 6. Complications of endovascular embolization group.

	ENDOVASCULAR EMBOLIZATION GROUP (N=6)
MILD LOCALIZED PAIN RELIEVED WITHIN A WEEK	3(50%)
SEVERE LOCALIZED PAIN	1(16.67%)
PELVIC PAIN	1(16.67%)

In endovascular embolization group, 3(50%) patients developed mild localized pain relieved within a week, 1(16.67%) patient developed severe localized pain, 1(16.67%) patient developed pelvic pain, and 1(16.67%) patient achieved no complications (

Table 6, Figure 4).

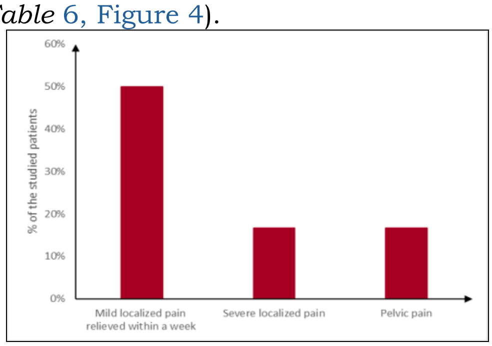

Figure 4. Complications of endovascular embolization group.

Case presentation:

Male 20-years old, left upper arm pain for 2.5-years specially at night reduced by aspirin, lesion: left humerus proximal shaft osteoid osteoma, procedure: radiofrequency ablation.

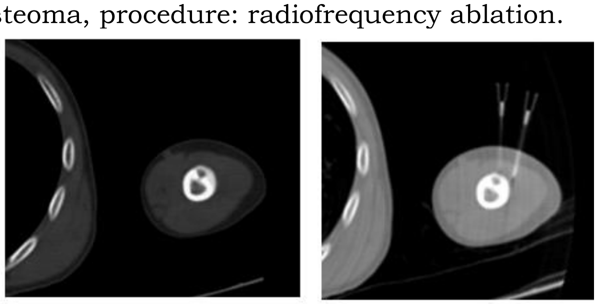

Figure 5. CT guided Localization of the lesion and local anesthesia injection.

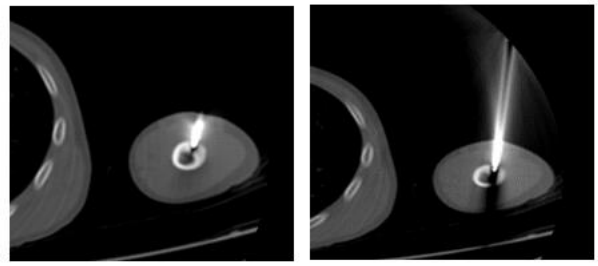

Figure 6. Insertion of co-axial needle.

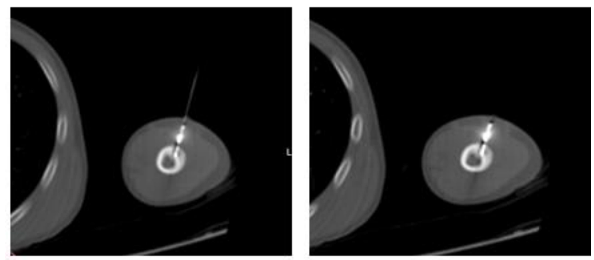

Figure 7. Tip of RFA needle inside the nidus.

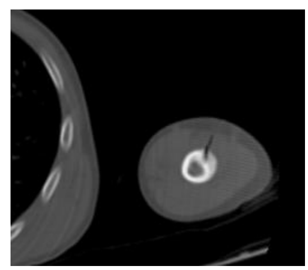

Figure 8. After removal of RFA needle.

4. Discussion

When it comes to radiodiagnostics, interventional radiology is all about the more intrusive diagnostic and therapeutic treatments rather than just running tests like CT and MRI. Due to the use of specialized needles and/or intravascular operations, it resembles surgery but has a less intrusive profile.

There are many roles of interventional radiology on benign bone tumors like Percutaneous CT guided biopsy for proper diagnosis as well as therapeutic roles as Radio-Frequency ablation, Microwave or Laser photocoagulation ablations, cryoablation, cementoplasty, selective transcatheter arterial embolization, direct Percutaneous intra-tumoral injections and adjuvants like(ethanol, Phenol injection, liquid nitrogen, poly-methylmethacrylate, irrigation with hydrogen peroxide or aqueous zinc chloride, calcitonoin and methylprednisolone injection).[5]

The obvious epidemiological frequency of bone metastases, as opposed to primary tumors, is the fundamental reason that IR in malignant bone diseases primarily targets their treatment.[6]

In our study, the osteoid osteoma ablation group, it was found that the age ranged between

9-23 years with a mean ± SD of 17.71±4.45 years. There were 11(78.57%) males and 3(21.43%) females. The BMI ranged between 19.98-26.71 kg/m2 with a mean ± SD of 23.63±1.88 kg/m2.

Kulkarni et al.,[7] collected data from 43 patients who underwent radiofrequency ablation (RFA) for symptomatic osteoid osteoma and analyzed it retrospectively. The results revealed that there was a higher proportion of males in the study compared to females. The average age of the participants was 18.1 years, with a range of 3-46 years.

Regarding tumor type, in the thermal ablation group, all 14(100%) patients had osteoid osteoma. Regarding tumor site of osteoid osteoma ablation group, it was found that L1 vertebral body, left femur neck, left femur proximal shaft, left femur supracondylar, proximal right femur shaft, right femur mid shaft, right femur neck, right femur subtrochanteric, left humerus, proximal right humerus shaft, right humerus proximal shaft, left tibial mid shaft, proximal right tibial shaft, and left iliac subarticular were the most common places.

Somma et al.,[6] showed that the most common sites for osteoid osteoma lesions were the trunk skeleton (21/102, 20.59%) and lower extremities (72/102, 70.59%). Among 25 patients (25 out of 102, or 24.51%), lesions were found in an unusual location.

In osteoid osteoma ablation group, it was found that tumor size ranged between 0.7-1.2cm with a mean ± SD of 0.91±0.16cm.

Rinzler et al.,[8] the lesions ranged in size from 5 to 22 millimeters, with an average size of 8.8 millimeters.

Six patients (42.86%) in the osteoid osteoma ablation group got radiofrequency ablation, while eight patients (57.14%) underwent microwave ablation.

Kulkarni et al.,[7] forty-three out of forty-three patients were first-time RFA users for osteoid osteoma, while three patients had previously undergone surgery and were undergoing RFA for local recurrence.

In the osteoid osteoma ablation group in our study, it was found that the procedure duration ranged between 30 and 60 minutes with a mean ± SD of 46±9.22min.

Reis et al.,[9] emphasizing the use of magnetic resonance imaging (MRI), computed tomography (CT), radiography, and, when necessary, bone scans as part of the pre-procedure imaging. The average duration between confirmatory imaging and treatment for RFA was 2.3 months (range 0.1–14.2) and for MWA it was 3.0 months (range 0.4–12.2), with no statistical significance between the two. After a non-confirmatory initial MR examination, 4 RFA and 9 MWA patients underwent both MR and CT scans. One patient had treatment after a confirmed femoral radiograph, while three patients whose diagnoses were still unclear after magnetic resonance imaging (MR) had bone scans.

The group that underwent osteoid osteoma ablation did not have any bleeding during the course of our trial. We were able to accomplish technical success with all fourteen patients, or 100%. One patient (7.14% of the total) in the osteoid osteoma ablation group experienced a minor response to therapy; twelve patients (85.71%) reported mild localized discomfort that resolved within a week; and one patient (7.14% of the total) reported recurrent pain two months after the initial treatment.

Kulkarni et al.,[7] determined that the pain scores of all 43 patients significantly improved. An intra-anodal electrode placement achieved a technical success rate of 100%. We had a 97.7 percent primary clinical success rate (42 out of 43 trials) and a 100 percent secondary clinical success rate in our research. The VAS scores of the participants in our study were 7.8 before the surgery and 0.4 after it. Patients were able to resume their full range of motion and avoid painkillers after just one week following ablation. Our study's follow-up time averaged 48 months, with a range of 4-129 months. Recurrence of pain occurred in one patient four years following therapy; subsequent sessions were effective in alleviating the discomfort. In three individuals, there were mild side effects that were conservatively handled: two cases of skin burns at the treatment location and two cases of RF pad burns. In this study, no patients experienced any kind of neurological abnormalities, either temporary or permanent, and no procedure-related deaths were recorded.

In our study, endovascular embolization group, it was found that age ranged between 14-51 years with a mean ± SD of 35.17±14.19 years. There were 3(50%) males and 3(50%) females. The BMI ranged between 22.04-33.39 kg/m2 with a mean ± SD of 28.75±4.69 kg/m2.

Jha et al.,[10] conducted a case control study that included Thirty-three patients underwent preoperative embolization of primary tumors of extremities, hip or vertebrae before resection and stabilization. The results showed that of twenty-six patients (15 men, 11 women, age range 14-82 years), who had surgical resection within 0-48 h of TAE.

Regarding tumor site of endovascular embolization group, it was found that left humerus head, right proximal humerus, left knee, Right knee, right superior pubic ramus, and sacrum were the most common places.

Jha et al.,[10] revealed that out of 26 patients who underwent TAE, the most prevalent histological form of tumor was GCT, which was found in 20 patients (77%), mostly in the lower limb. ABC and chondrosarcoma were the second most common types, with two patients (7%) each. The remaining patients included osteoblastoma and chondroblastoma. In five individuals, the axial skeleton was impacted.

In endovascular embolization group, the tumor size ranged from 12×7×6 to 21×20×17cm with a mean ± SD of 16±3.41×13.83±4.26×12.83±3.76cm. In endovascular embolization group, all 6(100%) patients underwent endovascular embolization. The procedure duration ranged between 65-110min with a mean ± SD of 83.33±15.38 min.

Reis et al.,[9] emphasizing the use of magnetic resonance imaging (MRI), computed tomography (CT), radiography, and, when necessary, bone scans as part of the pre-procedure imaging. It took an average of 2.3 months (range 0.1–14.2) for RFA and 3.0 months (range 0.4–12.2) for MWA to get from confirmation imaging to treatment, with no statistical significance between the two. After a non-confirmatory initial MR examination, 4 RFA and 9 MWA patients underwent both MR and CT scans. Three individuals had further bone scans because their diagnosis was still unclear after magnetic resonance imaging (MRI), and one patient had treatment after a confirmed femoral radiograph.

Limitation: Due to limited cases in special aspects of the study mainly in the aspect of endovascular embolization we have to continue study on larger sample size with multicenter cooperation to validate our results.

4. Conclusion

Osteoid osteomas can be effectively and safely treated with ablation. Larger, hypervascular, and more complicated bone lesions may be manageable with endovascular embolization. In our study there were few cases subjected to endovascular embolization and there were no cases of bone metastasis because we were limited to cases sent from the orthopedic oncology department.

Disclosure

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Authorship

All authors have a substantial contribution to the article

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Conflicts of interest

There are no conflicts of interest.

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