Orthopedics Rheumatology & sports medicine

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http://dx.doi.org/10.19104/jorm.2016.114

Case Report | Journal of Orthopedics, Rheumatology and Sports Medicine | Open Access

Percutaneous Radiofrequency Thermal Ablation Treatment of Recurrent Bone Giant Cell Tumor

Ignacio L. Franco [1]*, Angel B. Horcajadas[2], Jose Martel[1] and Eduardo Ortiz[3]

[1]*Department of Radiology, Hospital Universitario Fundacion de Alcorcon, Madrid, Spain*

[2]*Department of Musculoskeletal Radiology, Hospital Universitario Fundacion de Alcorcon, Madrid, Spain*

[3]*Department of Traumatology and Orthopedic Surgery, Hospital Universitario La Paz, Madrid, Spain*

Received Date: July 25, 2016, **Accepted Date:** October 28, 2016, **Published Date:** November 07, 2016.

***Corresponding author:** Ignacio Lopez-Vidaur Franco, Department of Radiology, Hospital Universitario Fundacion de Alcorcon, Madrid, Spain, E-mail: ilopezvidaur@gmail.com*

Abstract

Percutaneous Radiofrequency Thermal Ablation (PRFTA) is the method of choice to treat most of the cases of osteoid osteoma. The Good results on other benign bone tumors as osteoblastoma and chondroblastoma have been reported. The treatment for bone Giant Cell Tumor (GCT) is surgical resection. The PRFTA has not been previously described for recurrent GCT in the literature. We reported four recurrent GCTs from our institution, successfully treated with PRFTA (from 2009 to 2014), located in the lateral cuneiform bone, the distal epiphysis of tibia, the greater tuberosity of femur and the coxal bone involving the hip joint. The previous percutaneous CT guided 11G biopsy confirmed the diagnosis in all of the cases. The patients were under general anesthesia or deep sedation in the CT room. The radiofrequency electrode was inserted through a bone introducer needle and heated at 90°C for three to five minutes. There were no complications, with rapid recovery of the patients.

Introduction

Surgery remains as the primary treatment for the bone GCT. The GCT recurrence occurs in 2–25% of cases [1,2]. When surgery is not possible or could be associated with excessive morbidity, denosumab (a fully human monoclonal antibody to RANKL (Receptor activator of nuclear factor kappa-B ligand), a key mediator of osteoclast activity) is a good treatment option. The optimal length of treatment and schedule of denosumab is unknown, but recurrences after apparent complete responses have been observed after stopping denosumab, and long-term follow-up of denosumab treatment may reveal unrecognized effects [3].

On the other hand, recent advance in minimally invasive therapies are adding further tools for tumor management. For instance, percutaneous radiofrequency thermal ablation (PRFTA) has been reported in the literature as a successful treatment for hepatic tumor as well as for the treatment of benign bone tumors [4–6]. However, we have not found any reference in the literature to this treatment modality for recurrent GCT, and there are only a small number of case reports on GCT [6,7].

The Radiofrequency ablation is based on heating tumor cells to temperatures higher than 60°C until they are killed. It uses an electromagnetic 300 to 500 KHz frequency alternating current, carried by an image guided electrode which is introduced into the tumor. The current phase changes induce local ionic agitation, which triggers molecular friction movements responsible for a rise in temperature. The temperature increases around the electrode and the heat is distributed by diffusion.

The primary purpose of this study is to describe our experience of PRFTA treatment in bone GCT recurrences, where further surgery would have been too aggressive.

Materials and Methods

We reported the cases of four patients from our institution with GCTs recurrences, who where successfully treated with PRFTA (from 2009 to 2014). The study was approved by the Institutional Medical Ethical Review Board. All patients were provided with the relevant information and signed the relevant consent forms before the procedure took place.

The recurrent GCTs were located in:

Case 1: The lateral cuneiform bone of the right tarsus

Case 2: The distal epiphysis of the left tibia involving the subchondral cortical bone

Case 3: The greater tuberosity of the right femur

Case 4: The iliac bone which included a fracture with of the subchondral cortical of acetabulum and tumor growth into the hip joint.

All four patients had been diagnosed with bone giant cell tumor diagnosed by percutaneous CT guided biopsy and subsequent surgery.

Prior surgical treatment had been performed in all patients with intra-lesion extended resection and curettage, in addition to high speed burr, pulsatile lavage, phenol, and reconstruction with bone allograft or cementplasty. Case 1 was treated surgically twice before PRFTA and case 2 was treated three times. Case 3 and 4 underwent surgery once. Recurrence of bone GCT was confirmed by percutaneous biopsy in all cases.

The Percutaneous CT guided by radiofrequency thermal ablation (RFTA) was performed in all four patients. Before undergoing RF ablation, signed consent forms were obtained from each patient. All candidates were informed with regards to alternative treatments. The procedures were carried out under general anesthesia or deep sedation in the CT room.

The technique used was the same as has been described in the literature for osteoid osteoma [4,5]. We reached the bone lesion under CT guidance with an 11–13 gauge (G) introducer bone biopsy needle. The stylet of the needle was removed and exchanged for a 17 G monopolar RF electrode (Cool-tip Covidien RAF System). The CT image ensured the right placement of the electrode active tip (7–10 mm) inside the lesion. Radiofrequency-activation time was three to five minutes providing that the core temperature reached 90°C (Figure 1). Cooling activation was not necessary due to the small size of the recurrence.

The monitoring and follow up with CT and MRI was performed for 18 months to five years after treatment.

Figure 1: (A) The electric resistance and electric power are checking on the screen (datos sensor) of the radiofrequency generator (Covidien RAF System). The time and temperature can also be checked, (B) The RF electrode is introduced throw the introducer needle. (C) Procedures were carried out in the CT room,

Results

Case 1

A 15 years old female at the time of diagnosis, had a left ankle sprain three years ago. Since then she had edema and swelling in the lateral aspect of the midfoot, and pain with exercise which was lately increasing. X-ray and CT images showed expansive and trabecular lesion in the lateral cuneiform of the right tarsus. Bone scans showed increased tracer activity. The tumor was isointense to muscle signal on T1 weighted images and slight hyperintense on STIR, without soft-tissue component. It showed high and homogeneous gadolinium enhancement.

Pathology following percutaneous ultrasound guided biopsy was reported as bone giant cell granuloma and not giant cell tumor. The Surgery as described in the materials and methods section was performed and the diagnosis was confirmed as bone GCT. A second surgery was performed due the recurrence of GCT after one year.

The follow-up with MRI monitoring showed a slow but clear growth of another recurrence (three years later), which was treated with PRFTA (Figure 2), which had a good outcome. The 18 month follow-up showed small Gd-enhancement foci of the tumor and a second PRFTA was performed without any complications. To date, the patient is asymptomatic with no evidence of recurrence or residual tumor after five years of follow-up (Figure 2).

Case 2

A 35 years old male, underwent surgery due to the presence of a giant cell tumor in the distal epiphysis of the left tibia. A local recurrence occurred 21 months later and a subsequent recurrence in the medial malleolus were operated on two years after the first recurrence. Adjuvant cementoplasty was also used in this occasion.

After one year, follow-up imaging showed a small lesion in the anterior margin of the tibial epiphysis, adjacent to the subchondral cortical bone. It was treated by PRFTA (Figure 3).

The Follow-up using image monitoring six months after the procedure showed a small residual inflammatory lesion without gadolinium enhancement but with a peripheral thin wall in the six months post-procedure imaging monitoring (Figure 3). The patient is asymptomatic and has completely recovered. The last follow-up with MRI, one year after the intervention, did not show any recurrence.

Case 3

A 25 years old male, who had experienced pain after exercising in the lateral part of the right hip, for the last six months after exercising. The bone scan showed a positive lesion with increased uptake of the tracer in the right femoral neck. The CT and MRI showed an osteolitic lesion with clear thinning of the cortical bone but no soft tissue component. The percutaneous CT guided biopsy was performed with the cauda-craneal approach just below

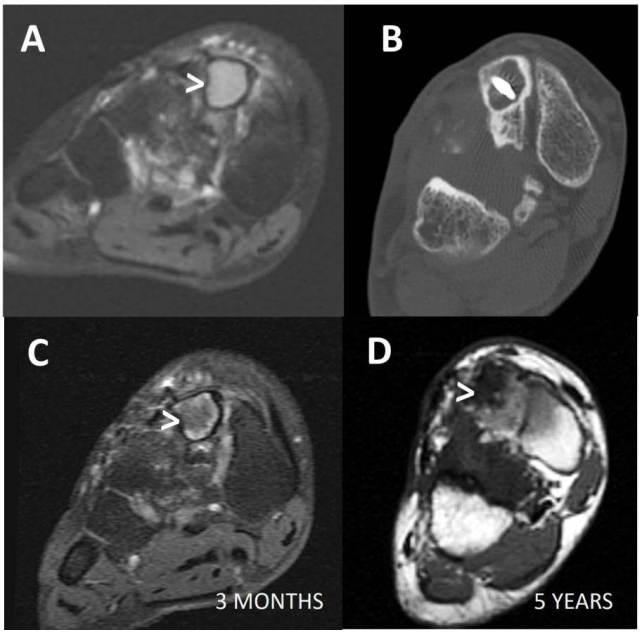

Figure 2: (A) Coronal gadolinium-enhanced fat sat T1-weighted MR image obtained after surgery shows a recurrent lesion in the lateral cuneiform of the right tarsus (arrowhead), (B) Axial CT image checking the right position of the introducer needle. Coronal gadolinium-enhanced fat sat T1-weighted image after three months, (C) Axial gadolinium-enhanced T1-weighted image after five years, (D) show no recurrence.

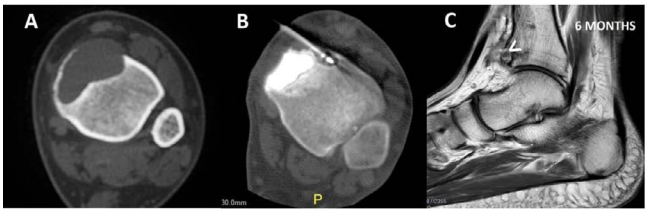

Figure 3: (A) Axial CT image obtained at diagnosis shows a GCT in distal epiphysis of the left tibia, (B) PRFA of a small recurrence in the anterior margin of the tibial epiphysis. The RF electrode tip is well seen into the lesion, (C) Sagital gadolinium-enhanced T1- weighted MR image obtained at six months after RFTA shows a small residual inflammatory lesion, without gadolinum enhancement but peripheral thin wall (arrowhead).

the greater tuberosity. The surgery treatment was performed as described previously, and a screw plate (Zimmer) with uneventful recovery outcome.

The X-ray, two years after surgery showed a small radiolucent lesion at the anatomic femoral neck, which had not been evident in previous X-rays. The SPECT-CT showed two positive lesions, with higher uptake intensity of the tracer on the proximal one (Figure 4). The percutaneous CT guided biopsy showed bone GCT recurrence in this proximal bigger lesion, and the fibrosis-reparative bone in the smaller one. The CT guided PRFTA treatment was performed. Monopolar 17 gauge needle electrode with 10 mm active tip was used for five minutes (Figure 4).

The CT and MRI follow-up did not show residual nor recurrent tumor: no gadolinium enhancement was observed until three years post-procedure. The patient is asymptomatic and has completely recovered.

Case 4

A 21 years old male who has had pain in his right hip, for the last six months, mainly at the beginning of ambulation and exercise. He has an osteolitic lesion in the right iliac bone extending to the subchondral cortical of the acetabulum, which was fractured. The percutaneous CT guided biopsy through the anterior-inferior iliac spine showed histology of bone GCT. The surgical treatment was performed without any complications.

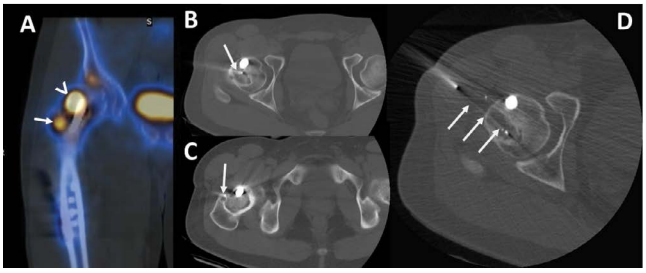

Figure 4: (A) SPECT-CT coronal image shows two positive lesions: the proximal one with higher uptake intensity of the tracer (arrowhead) and the distal one with lower uptake (white arrow), (B) Percutaneous biopsy CT-guided of the proximal bigger lesion (arrow) showed bone GCT recurrence, (C) Percutaneous biopsy CT-guided of the smaller one (arrow) showed fibrosis-reparative bone, (D) Axial CT image obtained during PRFA treatment shows the monopolar RF needle electrode introduced in the middle of the lesion (arrows).

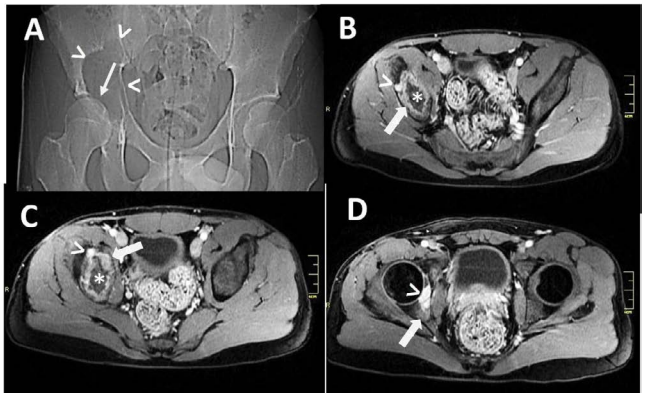

Figure 5: (A) X-ray image shows an osteolitic lesion in right iliac bone (arrowheads), extending to the subchondral cortical of acetabulum which is broken (arrow), (B–D) Axial fat sat gadolinium-enhanced T1 images show peripheral allograft gadolinium enhancement (arrows), and recurrent tumor at three locations (arrowheads).

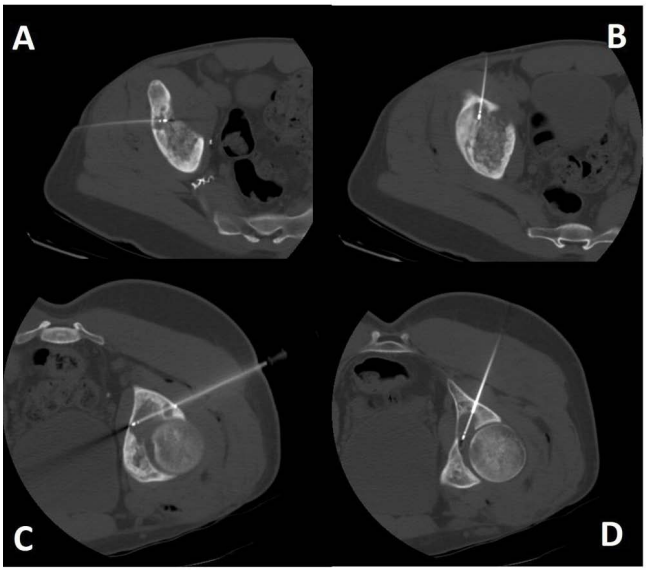

Figure 6: Axial CT images show the percutaneous CT guided PRFA at the three foci of recurrent tumor through anterior (A,B) and through posterior approach (C,D).

The MRI monitoring six months after the operation showed peripheral allograft reactive gadolinium enhancement (arrows), and suspicion of tumor recurrence at three locations (Figure 5). The recurrence was confirmed by percutaneous biopsy. We performed PRFTA treatment by means of four passes at the three foci of recurrent tumor: through the anterior approach at the two smaller lesions and two passes through the posterior approach at the third bigger intra-articular lesion (Figure 6). The radiofrequency of the intra-articular tumor caused a small superficial lesion at the adjacent femoral head which was asymptomatic. This patient was the only one using denosumab combination therapy.

The follow-up three years post-procedure showed a small stable negative SPECT-CT residual lesion at the anterior part of the acetabular allograft. The patient had a complete recovery. He is asymptomatic and at present even playing soccer although he keeps taking denosumab.

Discussion

The treatment of osteoid osteoma (OO) by thermal ablation with radiofrequency (ATRF) has been proven to be effective (within a range of 73–100% considering the different series) in the literature [4,8]. Recently, the use of this technique has become an alternative treatment method for other benign bone tumors such as osteoblastoma, chondroblastoma [5], and even of giant cells tumours (GCT) [6,7].

Bone giant cells tumors (GCTs), also known as osteoclastomas, are relatively common bone tumors, usually benign, appearing on the metaphysic and which extend into the epiphysis of the long bones up to the subchondral bone. They usually cause pain and have an aggressive local behavior [9]. The treatment of choice is surgery. It is generally treated with curettage with high speed milling, pulsatile lavage, phenolization and cementation or bone graft filling. However, depending on the locoregional extension of the tumor, it might also require prosthesis or graft replacement [10]. Recently, in some cases of special surgical morbidity (e.g when it is located in the sacrum), less aggressive methods have been used as an alternative treatment, such as percutaneous ablation techniques due to improved technological developments. The most widely used is the radiofrequency (RF) [6,7,10]. Zhang et al. [7] carried out

a study of computed thomography (CT) - guided RF ablation for the treatment of pelvis tumors, by taking a sample in 19 patients, two of which were GCTs. Santiago et al. [6] also described a single case of treatment for bone GCT, in a series of 26 cases of bone tumors of distinct entity. It involved a patient with unresectable GCT located in the sacrum, to whom PRFA was applied as well as cementation. As a result the pain was reduced and his quality of life was improved for the subsequent the two years. However, there is currently scarce literature in this field.

The bone GCT is prone to local tumor recurrence (40–60%), even after applying an adequate surgical treatment [9]. In these cases, morbidity, resulting from a second or third surgery, can be important, especially in small and load-bearing structures (such as the ankle or foot), or with articular affectation, where the placement of prosthesis may be required. In these cases, if it is proved to be effective, it would be of particular interest to use minimally invasive techniques with low morbidity and complications; with almost no skin wound (just 2–3 mm incision) and a one-day hospital stay. However, the literature does not expose any study of RF treatment regarding a recurrence GCT. Our study shows successful RFTA treatment of GCT recurrence in four patients, who had previously been treated surgically. As Santiago et al. [6] and Zhang et al. [7] did, we reached the lesion under CT guidance with an introducer needle 11–13 G and a length of 10 cm (13–15 G in Santiago et al. study). In both cases, the RF needle used had a length of 15 cm and a thickness of 17 G. The length of the active tip used was, as one would expect, smaller (7–10 mm vs 10–30 mm regarding the one used in Santiago's et al. Study) due to the smaller size of the recurrent tumour tissue. For this reason, in our study, the RF time applied was also less (3–5 minutes vs 5–15 minutes regarding in the Zhang et al. study, and six minutes in the James et al. study). Furthermore, an experimental study in vivo, carried out by our group [4], showed enough bone marrow necrosis volumes with short RF times.

Another thermal ablation technique is cryotherapy, although, in this case, cold is applied. In the RF an alternating current of 400–500 KHz produces ionic agitation and an increase in temperature above 60°C, producing denaturation and irreversible damage of the tumor tissue. In cryotherapy, a rapid argon gas decompression at the end of the needle takes place, reaching -180°C in a few seconds, which is responsible for the irreversible damage of the tumor tissue. In a retrospective study based on a sample of 122 patients with bone metastasis treated with thermal ablation Deschamps et al. [11] argue that cryotherapy is more appropriate than RF to treat a bone tumor located near neurological structures. The reason was that the freezing area is more predictable and occasionally it can be seen with CT during the procedure (monitoring the possible undesirable involvement of the healthy tissue). They also argue that it is less painful, meaning it can be done with sedation, therefore the patient being conscious.

Althausen Pl et al. [12] describe a case of adjunctive cryotherapy in a GCT located in the sacrum in a 29-year-old patient. It was treated surgically and the margins of the cavity were treated with controlled cryotherapy. The results were good at 20 months follow-up, without pain or evidence of local recurrence.

Other ablative techniques regarding bone GCT treatment have also been described, such as High Intensity Ultrasound Ablation (HIFU). Chen et al. [13], in a study of 69 patients treated with HIFU, described one case of bone GCT. This was a 40-year old man with a GCT located at the distal femur. Good results were obtained at the six years follow-up point. The procedure is carried out under ultrasound guidance which may be less accurate for the treatment of a lesion within the bone. The ablation volume is larger because it includes the lesion, 1–2 cm of soft tissue and 3–5 cm of normal bone adjacent to the lesion.

The most important limitation of this study is the small number of patients, as well as the short follow-up time period in case 2 (18 months). Moreover, in case 4 the interference with denosumab treatment may also be an issue.

Several treatment options are available to treat recurrent bone GCT. Surgery remains the gold standard, but for those cases with high morbidity, PRFTA should be an option, due to the preliminary good results obtained. It offers multiple advantages: it is minimally invasive, it allows targeted tumor destruction, it has a low rate of complications and it implies a shorter recovery in comparison to surgery.

Although larger studies must be carried out, PRFTA for recurrent bone GCT has proven to be an effective treatment without any complications in all of our four patients.

Conclusion

Percutaneous radiofrequency thermal ablation treatment of recurrent bone giant cell tumor is a reliable alternative treatment to a new surgery resection and it might be the best treatment in certain cases.

Compliance with Ethical Standards

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of Interest

The authors declared that they have no conflict of interest.

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***Corresponding author:** Ignacio Lopez-Vidaur Franco, Department of Radiology, Hospital Universitario Fundacion de Alcorcon, Madrid, Spain, E-mail: ilopezvidaur@gmail.com

Received Date: July 25, 2016, **Accepted Date:** October 28, 2016, **Published Date:** November 07, 2016.

Citation: Franco IL, Horcajadas AB, Martel J, Ortiz E (2016) Percutaneous Radiofrequency Thermal Ablation Treatment of Recurrent Bone Giant Cell Tumor. J Orth Rhe Sp Med 2(1): 114.