Treatment of Osteoid Osteomas of the Foot: A Review of 100 Cases

Andrea Angelini, Giulia Trovarelli, Todd Bertrand, Marco Maraldi, Bassem Issam Haddad, Ilaria Piraino and Pietro Ruggieri

Department of Orthopedics, University of Bologna, Istituto Ortopedico Rizzoli, Bologna, Italy

*Corresponding author: Prof. Pietro Ruggieri, Department of Orthopaedics, University of Bologna, Orthopaedic Oncology, Rizzoli Orthopaedic Institute, Via Pupilli, 1, 40136, Bologna, Italy, Tel: 00390516366222, 00393333266234; Fax: 00390516366540; E-mail: pietro.ruggieri@ior.it

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Abstract

Objectives: Osteoid osteoma (OO) is a small, benign, osteogenic bone tumor, with less than 11% of cases located in the feet. We review our experience in OO of the foot bones in order to characterize its prevalence, treatment, and recurrence rate at long term follow up.

Methods: The medical records of 100 cases of osteoid osteoma of the foot treated between 1975 and 2009 were reviewed retrospectively. There were 73 male and 27 female patients, with a mean age of 23.4 years (7-61 years). The lesions were located in the talus (n=59), calcaneus (n=14), metatarsals (n=9), cuneiform bones (n=5), phalanges (n=4), cuboid (n=4), navicular (n=2) and tarsal bones, not otherwise specified (n=3). None of the patients had received prior percutaneous or surgical treatment for the tumor. Twelve tumors were intra-articular and 88 extra-articular. All patients were taking routine analgesics including anti-inflammatory medications.

Results: Treatment consisted of radiofrequency ablation (RFA) in 43 patients, excisional CT-guided trocar biopsy, or percutaneous drill resection (PDR) in 21 patients, intra-lesional curettage in 43 patients, and wide resection alone as well as wide resection with total ankle arthroplasty in one patient each. Adequate follow-up was available for all patients. One patient treated with RFA reported recurrent pain after 2 months and was successfully treated with a second RFA. The overall recurrence rate was 1%; however, it was 2.3% in those patients treated with RFA. No adverse events related to treatment or to the anatomical location were recorded.

Conclusion: RFA is a safe and effective alternative to surgical resection of osteoid osteomas of the foot. Caution should be taken when performing this procedure on lesions less than 1 cm from neurovascular structures or in superficial locations, due to risk for soft tissue injury from thermal necrosis.

Keywords: Osteoid osteoma; Bone tumor; Talus; Radiofrequency ablation; Curettage; Recurrence; Foot

Introduction

Osteoid osteoma (OO) is a highly vascular, osteogenic tumor composed of osteoid and woven bone. It has a maximum size of 1.5 cm and is capable of inducing marked reactive changes within local bone and/or soft tissue. Although the foot is a relatively infrequent site for osteoid osteoma, comprising 2% to 11% of all locations, it is the most prevalent benign bone tumor affecting the foot. OO accounts for about 20% of all benign bone tumors in the foot and ankle, with a particular predilection for the talus and the calcaneus [1-3]. Since it can be difficult to diagnose with radiographs, cross-sectional imaging with CT remains the method of choice. The well-defined nidus is radiolucent and present in 85% of the osteoid osteomas [4], with or without a sclerotic center [5] (Figure 1). MRI may demonstrate extensive reactive periosteal marrow and soft-tissue edema [6]. Intense focal tracer accumulation on bone scintigraphy reflects the increased nidal vascularity and osteoblastic activity but is non-specific. Initial treatment for osteoid osteoma consists of prolonged non-steroidal anti-inflammatory treatment for 30-40 months [7-8] and may resolve spontaneously within 10 years [9]. En bloc excision of the nidus is usually indicated if 1) histology is in doubt, 2) symptoms remain unresponsive to medical treatment, 3) neurovascular structures are within 15 mm, or 4) percutaneous techniques have failed [7-12]. Several percutaneous techniques have been used for treatment of osteoid osteomas, including trephination, ethanol injection, laser photocoagulation, and radiofrequency ablation (RFA) [7-22]. Treatment response using these modern percutaneous techniques ranges from 83% to 92% and is comparable to reported open techniques [11,23-24]. RFA is a form of electrosurgery in which an alternating current of high-frequency radiofrequencies (10 kHz) flows from a radiofrequency (RF) generator through an electrode tip and dissipates its energy as heat [25]. Ethanol, laser, and thermoablation ablation have also been employed [5,12]. Because of the relatively small size of OOs and the predictable zone of thermal necrosis, loss and weakening of bone is minimal [16-17].

Aims of this study were to 1) evaluate the prevalence and site of OO in the foot in a tertiary orthopedic oncologic referral center 2) analyze the incidence of local recurrence considering the type of treatment (surgical excision, excisional CT-guided biopsy, or radiofrequency ablation).
Material and methods

Our institutional archive contains the original records including clinical documentation and imaging studies for patients who received treatment or consultation at the Istituto Ortopedico Rizzoli (University of Bologna, Italy) since 1900. Our database includes histologically verified diagnoses along with the available slides and tissue specimens. For the present investigation, we reviewed the database to identify all patients with a histologically-verified diagnosis of OO of the foot who had been treated from 1975 to September 2009. We identified and retrospectively studied the files of 100 patients with OOs of the foot who underwent primary treatment at our institution. There were 73 male and 27 female patients, with a mean age of 23.4 years (7-61 years). A review of all imaging studies, including plain radiographs (which were available for all patients), computed tomography, and magnetic resonance imaging studies (when available), was performed. The lesions were located in the talus (n=59), calcaneus (n=14), metatarsal bones (n=9), cuneiform bones (n=5), phalanges (n=4), cuboid (n=4), navicular (n=2) and tarsal bones, not otherwise specified (n=3). None of the patients had received previous percutaneous or surgical treatment for their tumor. We excluded from the analysis patients with osteoid osteomas of the distal fibula or distal tibia, including juxtaarticular lesions (Figures 2A and 2B).

All the procedures were performed for initial tumor treatment. Twelve tumors were intra-articular and 88 extra-articular. All patients were taking routine analgesics, including anti-inflammatory medications. Of these, 58 patients (58%) had pain for <6 months and 42 (42%) for >6 months. Patients with extra-articular tumors experienced typical symptoms, and those with intra-articular experienced atypical pain and painful motion of the involved joint. All patients or guardians provided informed consent at the time of admission to be included in scientific studies. The ethical committee at our institution granted institutional review board approval for this retrospective study.
Figure 2: A) Lateral radiograph shows a well-defined juxta-articular osteoblastic tumor in the anterior part of the ankle (arrow) B) Cherry-red elevated osteoid osteoma nidus in anteromedial portion of tibia during surgery.

Figure 3: A) 45 years-old male. CT scan, axial section, bone window: 4 mm nidus (arrow) in the anterior cortex of the talus B) computed tomography scan showing the biopsy needle's position through a dorsal approach.

The most common appearance were oval lesions surrounded by periosteal and endosteal sclerosis. The indications for RFA or surgical treatment were the typical clinical and imaging findings of osteoid osteomas. Percutaneous drill resection (PDR) is an effective technique with a reported 85%-95% success rate [24]. PDR was used as the first-line treatment for OO at our facility until 2002. At that point, we
purchased an RFA device which had become the gold standard for OO treatment. Through an RF generator, an alternative current creates heat, resulting in tissue obliteration. All patients were treated by the same operators with similar experience levels after being informed about the benefits and possible complications of the procedure. Local anesthesia (2-5 ml mepivacaine chloride 2%) in patients with subperiosteal tumors was performed prior to treatment in order to control post-procedural pain. Next, CT without contrast media was performed to localize the lesion and plan the approach to avoid vital structures. CT-guidance was performed using 3 mm slice CT at 2 mm intervals. We preferred a perpendicular approach with the patient supine and avoided a transarticular approach. After choosing the insertion point on multiplanar reconstructions, the position was ascertained by CT using a radiopaque landmark. A stab incision was made and a biopsy trochar (Bone Biopsy System, Bonopty, Radi Medical Device, Sweden) was advanced to the cortex (Figures 3A and 3B). In cases with dense cortical bone, drilling through the cortex (Bonopty drill set, standard length 122 mm, extended length 160 mm, caliber 15 G12/1.7 mm) was performed (Figures 4A and 4C). After reaching the nidus, a tissue sample was obtained for histology using a biopsy needle (Bonopty biopsy needle, Radi Medical Device, Sweden).

Next, the electrode was inserted through the trochar aiming at the center of the nidus under CT-guidance (Figures 4D and 4E). We first connected the grounding pads and then the electrode to the RF-generator (RFG-3 C Radionics, Tyco Healthcare Group LP, Burlington, Mass, USA). In the first study period, we used the RA-TC electrode (calibre 19 G/1 mm, active tip 5 mm) and thereafter until currently we used the SMK-TC electrode (calibre 20 G/0.9 mm, active tip 5-15 mm). Before supplying the RF waves, care was taken so that the active tip was not in contact with the trochar to avoid soft tissue burn, and the distance of the active tip was >15 mm from neurovascular structures and >10 mm from skin. Low energy was delivered for all lesions in the bones of the foot. Ablation time varied according to the caliber and length of the electrode’s active tip, the location, morphology, and size of the lesions [10]. After ablation, the electrode and trochar were removed, and the wound was closed with a steri-strip. Biopsy and intralesional curettage were performed in the same way in both study periods.

After the procedure, all patients were examined for bleeding, swelling, and burns, and asked about their pain. The patients were admitted the day of the procedure and discharged the next day with instructions for unrestricted weight-bearing and avoidance of sports for 3 months. Clinical follow-up examination was performed at 1, 3, 6 and 12 months after treatment. CT and/or magnetic resonance imaging was performed in patients with persistent or recurrent symptoms.

The observation period was 12 months, followed by another 12 months for patients with recurrences. Successes (pain relief) and failures (recurrences and complications) were analyzed.

Results

Treatment consisted of RFA in 43 patients, excisional CT-guided trocar biopsy, or percutaneous drill resection (PDR) in 21 patients, intra-lesional curettage in 43 patients, and wide resection alone as well as wide resection with total ankle arthroplasty in one patient each. Indications for different strategies of treatment changed during the time period studied (Table 1) in favor of RFA. All patients experienced post-procedural pain reduction.

Thirty-four (80%) out of 43 patients treated with RFA experienced pain relief the next day, 6 (14%) within the next 2-3 days, and 2 (5%) within the first week after treatment. Most of the patients (86%) experienced mild discomfort at the RFA site lasting for a few days. Although we did not measure the pain that patients experienced during or after RFA, we observed that periosteum infiltration was beneficial or at least not harmful for post-procedural pain. Imaging follow-up showed variable ossification and bone regeneration at the site of the lesion in all patients with primary tumors.

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Table 1: Type of treatment in 100 osteoid osteomas of the foot in correlation with time period.
Figure 5: A) AP and lateral radiographs demonstrating an osteoid osteoma nidus in the diaphysis of the third metatarsal (arrows). B) Lateral radiograph after intralesional curettage shows the complete excision of the nidus.

Figure 6: A-E. MRI patterns before and after RFA in a 16 years-old male A) Pretherapeutic coronal T1-weighted shows a well-demarcated bone lesion in the cuneiform, surrounded by extensive bone marrow edema pattern of the affected bone and soft tissue. B) New MR images performed two months later due to persistent pain show. T2-weighted fat-satured and C) T2-weighted hyperintense patterns, with a strongly contrast-enhanced pattern of the nidus compared with the surrounding tissue. Note also the reactive enhancement/edema of the bone marrow. D) Sagittal MRI T2-weighted hyperintense and E) T1-weighted isointense pattern of the recurrent lesion is shown.

Table 2: Type of treatment in 100 osteoid osteomas of the foot in correlation with site of the lesion. Pts: patients; CT: computed tomography; PDR: percutaneous drill resection; RFA: radiofrequency* not otherwise specified.

All patients were able to return to their jobs or school activities immediately after the procedure. Patients who engaged in sports or who had reduced or given up exercise were allowed unrestricted activity after 1.5 months postoperatively.

At the last follow-up, 99 patients (99%) remained asymptomatic, whereas only one patient experienced pain recurrence two months after RFA. This recurrence was in a 16 year-old patient with osteoid osteoma of the first cuneiform (Figure 6A) treated with RFA in May of 2008. He described site-specific pain for 5 weeks following the procedure. A new MRI was performed revealing a lesion suspicious for local recurrence (Figure 6B-6E). He was successfully treated with a second RFA. The incidence of recurrent pain was 1% of overall patients and 2.3% of patients treated with RFA. None of the patients had intraoperative or postoperative complications.

Discussion

In this study, we presented the largest long-term series for treatment of OO of the foot. Our results showed that RFA has emerged as a successful and safe minimally invasive technique if performed properly [7,15-17,26,27]. Rimondi previously reported several factors resulting in the increased rate of treatment success, including: using contiguous 1 mm slice CT-guidance, multiplanar reconstructions, 20 G/0.9 mm active tip electrodes, maintaining 60°C for 2 min and then increasing to 90-93°C for 14-15 minutes, and performing multiple ablations at the same RFA session for OO with nidus >15 mm. [12] (Table 2)

The retrospective design of the study and observational analysis are important limitations. However, this study is justified based upon the rarity of this tumor, the relatively large cohort, and the longterm followup. Moreover, wellcontrolled studies like the present one performed with data available from a single institutionare useful in establishing outcome measures in patients with OOs of the foot. One may argue that our study groups are heterogeneous with respect to treatment and other variables, but considering the rarity of the disease and the long recruitment period, we opted to include all patients with confirmed disease located in the bones of the foot. Although we did not control for the learning curve since it has not been previously found [28], we acknowledge that the initial learning curve may be steep.

In the past years, open surgery was considered the gold standard treatment for OO of the foot and ankle because complete excision of the nidus is curative and provides symptom relief. More recently several studies reported high success rate with percutaneous
techniques comparable to open surgery but with fewer complications and faster recovery time [9-10]. In fact the nidus can be difficult to identify intraoperatively, requiring an excessive amount of bone resection [19,29] and a second procedure may be required when resection is incomplete.

Successful arthroscopic excision of osteoid osteoma in accessible intra-articular locations such as the talar neck, the medial malleolus, and the tibial plafond has been reported [30-33]. Arthroscopy provides good visualization of lesions and allows for shorter postoperative rehabilitation times with excellent functional results [30,32].

On the other hand, results of CT-guided percutaneous procedures improved over time. Sans et al. [21] reported the results of percutaneous resection in 38 patients, including a patient with involvement of the talus who was treated successfully. They reported the risk of blood vessel and nerve injury was increased in the hands and feet and recommended conventional surgery at those sites [21]. In another case series of 30 patients managed by percutaneous resection, the size of the needle (8 mm) was too great to allow for resections in the hand or foot.

RFA, which induces tumor necrosis, is minimally invasive, safe, effective, and reproducible [7,11,16]. Clinical successes in most series reporting on primary RFA for OOs varied between 73-95% [7,10,15-16,26]. Most patients experienced pain relief within the first week and the remaining within 2 weeks after RFA. Patients may bear weight immediately and return to normal daily activities, even sports [16-18]. Persistent postprocedural pain for two weeks is an indication for a second RFA to be performed [17].

There are few studies focused on OOs of the foot in literature. Danilidis et al. [34] reported their experience with RFA in 29 patients with OOs as of the foot (including 17 cases located in distal tibia and 6 in distal fibula). They used a cool-tip electrode without the cooling system, heating the lesion up to 90°C for 4-5 min. In 3 patients (10%) a recurrence of the symptoms similar to that experienced on initial presentation developed after 36 months. These were successfully treated with open surgery without further recurrence. Bourgault et al. [35] reported on RFA of 87 patients, 10 of which were located in the foot. In this study they did not find any recurrence. Rehnitz et al. [36] reported on 3 out of 72 cases located in calcaneus and talus that were successfully treated with RFA. Zouari et al. [19] described 7 out of 133 patients with OO located in the foot (3 talus, 2 cuboid, 1 calcaneus, 1 cuneiform bone) treated with laser photocauterization. One patient with OO of the cuboid experienced postoperative infection 21 days after the procedure, treated with drainage of the abscess and curettage of bone. A 13 year-old female reported a recurrence 24 months after treatment of OO of the talus. The patient had a successful second laser photocauterization. Other authors have studied the role of percutaneous laser photocauterization and reported similar results to RFA in terms of pain relief and complication rate [37]. We have not used this technique since the laser device is located at another facility and used to treat other types of diseases.

Recurrences can occur in up to 11% of patients, usually within the first 7 months after RFA [18]. Repeat RFA for persistent or recurrent symptoms has been successful in 60-100% of patients [10,16,18,25]. Advanced age and multiple ablations at the same RFA session were associated with decreased risk for recurrence [28]. In our study, all patients had complete pain relief within the first week after RFA, CT-guided excisional biopsy, or surgery and 99% remained asymptomatic at the latest follow-up. Only one patient experienced recurrence two months after RFA, successfully treated with a second RFA. Due to the low incidence of local recurrence, we could not evaluate any prognostic factors. However, we agree with the theory that persistent or recurrent pain may come from incomplete ablation of the lesion [16-17,28]. In these cases, multiple ablations at the same RFA session are necessary to reduce the risk of recurrence [10,28]. The 97.7% success rate after one RFA session in our series was higher than the 76% success rate reported by Vanderschueren et al. in 97 patients [18] and the 89.5% success rate reported by Rosenthal et al. [10] in 126 cases. Our 2.3% recurrence rate was also lower than that reported in the aforementioned series. One possible explanation for the different success rates could be represented by selection bias. Moreover, as previously reported in a large series from our institution [12] it is possible that the use of a standardized treatment protocol (maintaining 60°C for 2 min and gradually increasing to 90-93°C for 14-15 minute ablation) could be one possible causative factor. Vanderschueren et al. [28] found that treatment duration affected the recurrence rate and the treatment time in our study was longer than previously reported in other studies. Another important concept is that accurate needle positioning and multiple ablations at the same RFA session for large and multiform osteoid osteomas, as reported in previous series [10,12], may also contribute to the higher success rate.

Some authors have suggested that percutaneous treatments of osteoid osteoma (OO) of the foot may carry a greater risk of injury to nerves or that the small size of the bones at these sites may pre-dispose to osteonecrosis [26]. Potential complications of RFA include cellulitis, bleeding, infection, pathological fracture, injury to adjacent neural structures, abscess formation, and skin and muscles burns [10,19,23,25,35]. Finstein et al. [23] reported a case of skin burn with 1 cm diameter necrosis after thermocoagulation of a tibial OO and Zouari et al [19] reported a postoperative infection. As in the present series, previous studies reported no major complications in patients treated with RFA for OO of the foot compared with operative excision [16,18-19,34,38-39]. Based on these and on literature analysis, RFA should be considered a safe procedure.

In order to improve accuracy and reduce complications, we revised our protocol in 2002 using contiguous 1 mm slice CT for better guidance, new types of electrode with smaller caliber active tips (20 G/0.9 mm), and increased ablation time (14-15 min) after maintaining 60°C for 2 minutes. For round 5-10 mm osteomas a single ablation is sufficient if the probe is centered in the nidus, while for larger round or oval and multiform osteomas at least two ablations at the same RFA session are necessary. Safety measures were also obtained including low energy delivery for superficial lesions and lesions in the bones of the hands and feet.

Conclusion

The current findings compare favorably with those of previous studies. Radiofrequency ablation can be performed with a short hospitalization and it is associated with a short period of convalescence and high success rate. We recommend RFA for all patients with OOs of the foot, if performed properly. Due to the low incidence of local recurrence, it has not been possible to evaluate potential prognostic factors. Caution should be taken when performing this procedure on lesions less than 1 cm from neurovascular structures or in superficial locations, due to risk for soft tissue injury from thermal necrosis.
References
