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Case Report

Osteoid osteoma of third metatarsal bone treated with radiofrequency ablation: Case report, imaging findings and review of the literature☆,☆☆

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ABSTRACT

Osteoid Osteoma (OO) is a frequent benign bone tumor that commonly affects males between 5 and 25. It usually arises from appendicular skeleton involving typically femur and tibia. OOs arising from small bones of hands and feet are very uncommon and metatarsal lesions account for only 1.7%.

We report a case of a 20 year-old boy with a long history of nocturnal left foot pain with a good clinical response to assumption of salicylates or nonsteroidal anti-inflammatory drugs (NSAIDs). Plain radiograph of his left showed unconclusive results. Therefore, he underwent a contrast enhanced CT (CECT) scan with multiplanar reconstruction (MPR) that showed a bony lesion in the left third metatarsal bone that was compatible with a nidus even in absence of clear peri-nidal sclerosis. Therefore, other ancillary techniques such as MRI and bone scintigraphy were performed. Conclusive diagnosis was OO of third left metatarsal bone. Our patient underwent a mini-invasive treatment with radiofrequency (RF) ablation. After recovery, our patient had no post-operative complications and showed optimal clinical conditions with complete remission of left foot pain and no change or impairment in walking.

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In this essay, we discuss key imaging findings of OO of small bones and its treatment with radiofrequency ablation. We describe method of execution and illustrate advantages of this mini-invasive technique. We also perform a review of the literature.

Introduction

Osteoid osteoma (OO) is a benign bone tumor accounting for about 11% of all primary benign bone tumors and 5% of bone tumors overall [1]. It usually affects children and young adults between 5 and 25 with a clear predilection for males (M:F=3:1) [2]. It typically affects appendicular skeleton frequently involving long bones of lower limbs (femur and tibia) [1,3]. OO arising from small bones of the feet is uncommon and affects mostly the talus (2%-10% of cases) followed by calcaneus (2.7%), phalanges (2%) and metatarsals (1.7%) [3,4].

OO is an osteoblastic tumor with a central radiolucent nidus surrounded by a reactive osteosclerotic area. Main clinical presentation is mild/severe nocturnal pain that typically eases with salicylates or non-steroidal anti-inflammatory drugs (NSAIDs). Diaphyseal OOs are often accompanied by local swelling [3]. In most cases, symptoms combined with imaging techniques allow a reliable diagnosis without necessity of biopsy. Plain radiograph is a first-level technique and usually shows presence of a radiolucent nidus with a surrounding area of reactive sclerosis. Contrast-enhanced computed tomography (CT) has proven superior to plain radiograph for detection of these tumors and is therefore the diagnostic procedure of choice [3]. Although magnetic resonance imaging (MRI) has shown lower sensitivity, it plays a role in the diagnosis of OOs of cancellous bone and joints when lack of perinidal sclerosis makes these tumors hard to recognize with CT alone [5,6]. Also, bone scintigraphy usually shows increased activity at tumoral site with a sensitivity of almost 100% [3,7]. Initially, conservative treatment with salicylates or NSAIDS is chosen since it alleviates pain and induces spontaneous regression in some cases [8]. When medical therapy fails or is not tolerated, surgical treatment is considered. Although efficacy of open surgery is very high [3], mini-invasive techniques such as irreversible electroporation, radiofrequency ablation or microwave ablation are making their way owing to their low complication rate and short recovery time [9–11].

Case presentation

In March 2021 we admitted to our hospital a 20-year-old boy complaining left foot pain for several months. History of the patient was negative for orthopedic or rheumatologic diseases. He was not currently taking any relevant drug and he had never undergone any type of surgery. He reported his foot ache was predominantly nocturnal and always eased after consumption of salicylates. During physical examination his left foot didn't show neither swelling nor other cutaneous lesions while palpation evoked middle dorsal pain. He had blood tests that showed only a slight increase of albumin, α-globulin and uric acid. He underwent a plain left foot radiograph (Fig. 1) that showed diffuse radio opacity of the diaphyseal portion of third metatarsal bone. Therefore, other imaging techniques were performed. Contrast enhanced CT (CECT) scan (Fig. 2) with multiplanar reconstruction (MPR) displayed a 6×6×9 mm subperiosteal osteolytic area (nidus) with an eccentric hyperdense area and associated cortical thickening. Imaging findings were suggestive for osteoid osteoma of the left third metatarsal bone. Subsequent MRI (Fig. 3-7) with T1 and T2-weighted short tau inversion recovery (STIR) sequences showed presence of perilesional edema of the cancellous bone that was an indicative element even in absence of perinidal sclerosis. Furthermore, our patient underwent a 99m-Tc bone scintigraphy (Fig. 8) that demonstrated increased activity at tumoral site. Instead of open surgery, we proposed a mini-invasive technique of radiofrequency (RF) ablation due to small dimensions and accessible tumor site. Before procedure, we performed a cardiovascular examination to check eligibility for treatment. After selective spinal anesthesia and local anesthesia (chloridate lydocaine, 20mg/ml, Lidocaina, Fisiopharma s.r.l., Sperlonga, Lazio, Italy) a CT-guided radiofrequency (RF) ablation of the tumor site was performed. Main RF approach requires a perpendicular angle between probe and cortical surface of the bone. Probe should always travel through an as short as possible distance to avoid neurovascular or other anatomic structures. The landmark on the skin was carefully placed and a 1.5 cm wide skin incision and blunt dissection was done. Trocar and cannula were positioned and then stepped nearby the bone, with the trocar tapped until reaching the nidus. A single-image CT acquisition (Fig. 9) was performed to confirm correct positioning. After trocar removal a RF ablation tool with exposed cool-tip electrode (1 cm) in absence of cooling system was placed through the cannula. The electrode was connected to the RF generator (Cool-tip RF Ablation System E Series-Medtronic). Thermal ablation is applied when RF electrode reaches a surface temperature of 90°C. Procedure time from beginning to complete ablation was 4-6 minutes. Immediately after the ablation, electrode was removed. Immediate postoperative CT scan (Fig. 10) was performed. Another injection of lydocaine was made for pain relief and a compressive sterile dressing was applied. The very same day the patient was discharged with mild pain as only referred symptom. A CT follow-up was performed 30 days and 6 months after the procedure. Both CT controls showed correctly ablated lesion, no postoperative complications were reported. As long-term outcome, our patient showed optimal clinical conditions with complete remission of left foot pain and no changes or impairment in walking.

Fig. 1 – Comparative X-ray of the feet showing diffuse radiopacity of the diaphyseal portion of third left metatarsal bone (arrow).

Fig. 2 – Preoperative CT scan of the feet with multiplanar reconstruction (MPR) displays osteoid osteoma (OO) as a hypodense nidus (arrow) with a central hyperdense spot (ovum) in the diaphyseal portion of third left metatarsal bone.

Fig. 3 – Sagittal T1-weighed sequence of MRI scan of the left foot.
Edema of cancellous bone (arrow) in the third left metatarsal is shown as inhomogeneous/hypointense area.

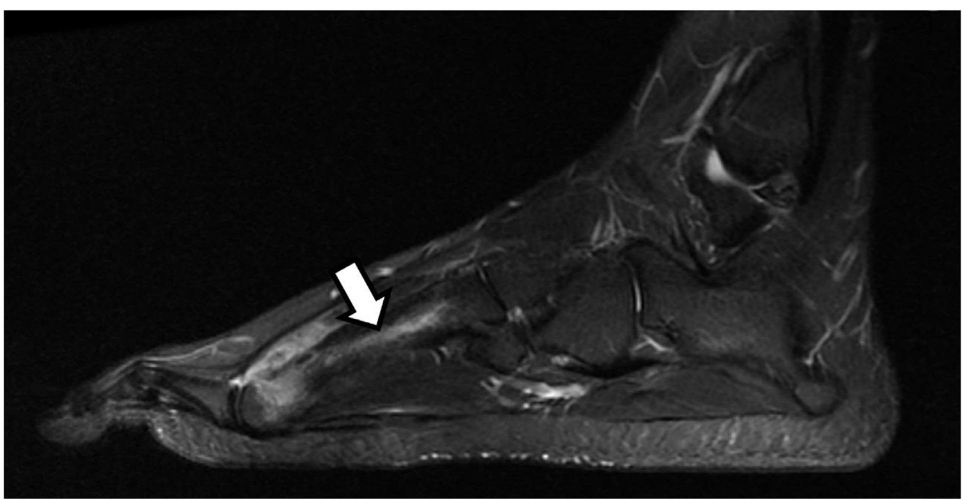

Fig. 4 – Sagittal T1 short tau inversion recovery (STIR) sequence of MRI scan of the left foot. Edema of cancellous bone (arrow) is clearly visible as a diffuse hyperintensity along the diaphyseal portion of third metatarsal.

Discussion

Osteoid Osteoma is a benign bone tumor commonly arising from appendicular skeleton. Axial localization of the OO, except for the spine (6%-20% of cases), is very uncommon [3]. Therefore, observation of OO arising from small bones of feet and hands is rare. Metatarsal lesions like that one found in our patient account for less than 2% of all cases. There are 4 main types of OO: intracortical, subperiosteal, medullary and endosteal [3]. Intracortical lesions are the most common, accounting for about 75% overall. Intracortical OO, known as "classic type", is frequently observed in long tubular bones, while subperiosteal lesions are often found in small bones of hands and feet [12]. Therefore, subperiosteal tumor observed in our case followed this trend. In presence of suggestive clinical picture, our patient underwent imaging procedures to confirm diagnosis. Presence of the "nidus" is the main condition for a conclusive imaging diagnosis. Plain radiograph we performed only showed a diffuse radiopacity of the affected metatarsal bone without evidence of radiolucent lesions. This finding was not in agreement with current literature that shows for plain x-ray a mean 66,4% detection rate for OOs of the foot and a specific rate of 80% for metatarsal lesions [4]. However, it is considered that histology and imaging features of OO depend on its localization into bone tissue. As for our patient, tumors of cancellous bone can show less typical features such as minimal or absent osteoblastic reaction

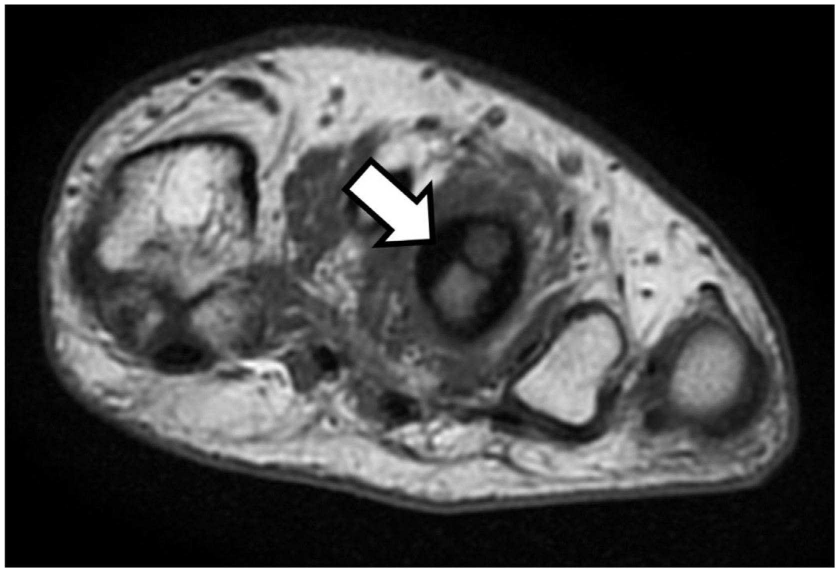

Fig. 5 – Coronal T1-weighed sequence of MRI scan of the left foot. OO is depicted as a target-like lesion (arrow) with a central hyperintense nidus surrounded by hypointense reactive sclerosis. Circumferential perilesional edema is also evident.

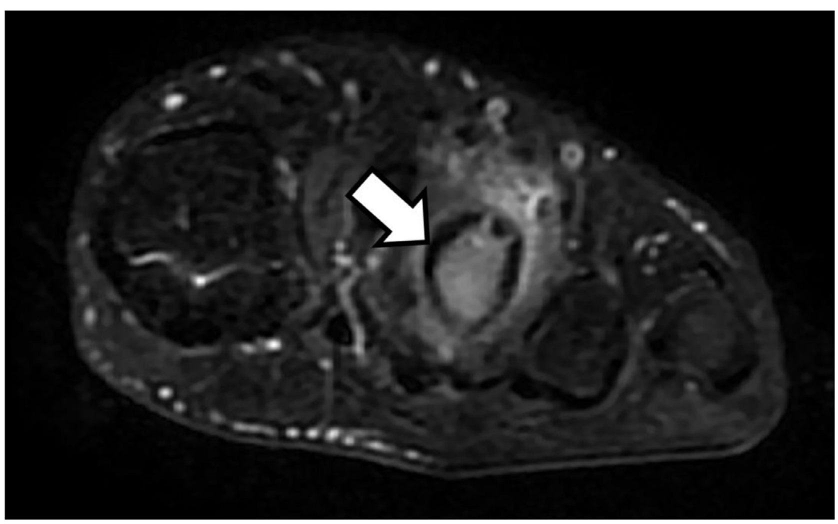

Fig. 6 – Coronal fat-saturated proton density (PD) sequence of MRI scan of the left foot. Perilesional edema is better displayed as diffuse hyperintensity surrounding tumor site (arrow).

[5,13]. Between imaging techniques, CT showed highest sensitivity with a mean detection rate of 96,4% and a specific rate of 100% for metatarsal, cuneiform, and cuboid bones [4]. CT is the best procedure to demonstrate presence of the nidus which appears as a rounded nodular hypodense area. In up to 50% of cases, it is possible to find small hyperdense areas of mineralization inside the nidus, sometimes with a peculiar "bulls-eye" appearance [3,14]. MRI has shown itself inferior to CT in detecting nidus, with a potential risk of misdiagnosis of 35% if chosen as primary imaging technique [3]. However, MRI is useful to display other suggestive findings such as bone marrow and soft tissue edema [5]. Therefore, MRI is particularly worth for fluid-rich intra-articular OOs. We performed a MRI scan with use of T2-weighted STIR sequences that showed a conspicuous edema of bone trabeculae in the third left metatarsal bone. Bone scintigraphy with m99-Tc is also a useful procedure when showing the "double density sign". This finding consists of a central focus of high bone turnover (nidus) surrounded by a larger less up taking area of host bone tumor response [15,16]. In the past, open surgery was considered the gold standard for conclusive treatment of OO. Although en-bloc resection showed a success rate of 88%-100%, it is weighed by a series of disadvantages such as prolonged time of recovery and rehabilitation, residual bone weakness

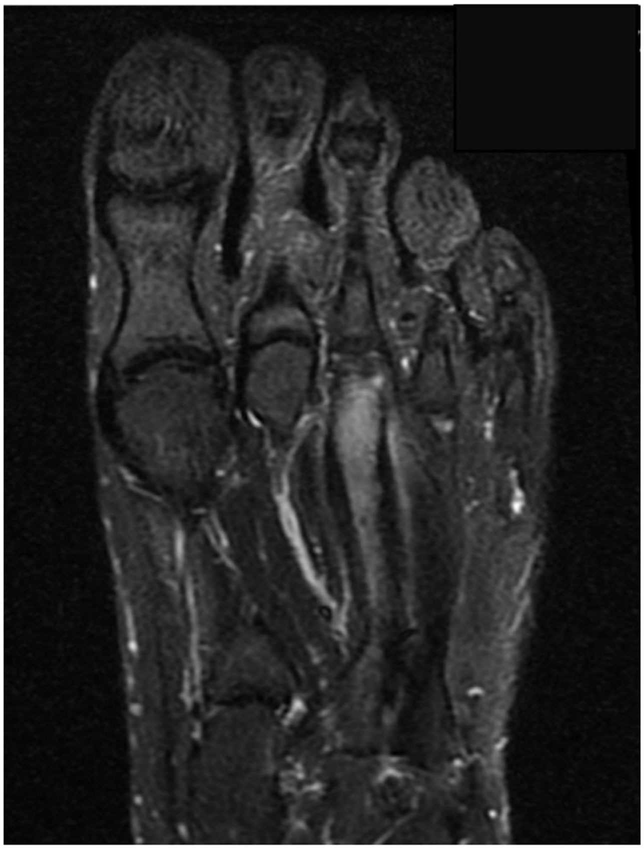

Fig. 7 – Axial view of MRI scan of the left foot. T1-weighed short tau inversion recovery (STIR) sequence showing diffuse edema of the cancellous bone in the diaphyseal portion of the left metatarsal.

with risk of fracture and, most of all, incomplete excision of tumor with a high recurrence rate (from 4.5% to 25%) [3,16]. Nowadays, mini-invasive techniques overcome limits of open surgery with optimal endpoints as well. RF ablation for treatment of OO was introduced in early '90s and resulted immediately safe and efficient [17]. First step of this technique is localization of the lesion with appropriate CT sections. Then, skin is marked and a local subcutaneous injection of lydocaine is applied. At this point, a cannula is placed in the site of interest for correct positioning of the electrode. Before the procedure

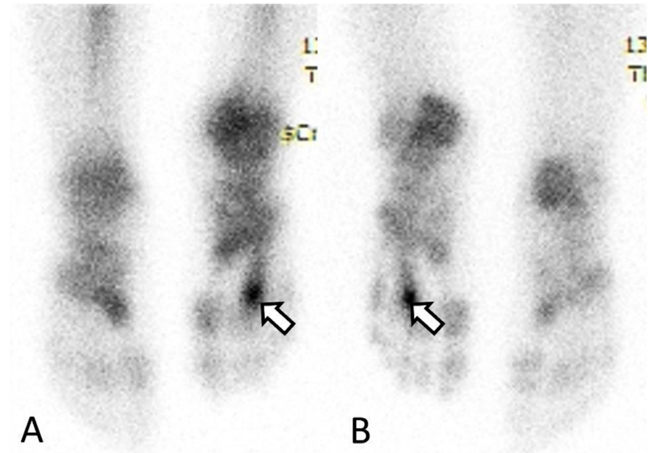

Fig. 8 – A/P view of bilateral bone scintigraphy of the feet clearly shows a focus of increased captation in the tumor site.

starts, grounding pads are applied to obtain a hairless surface at a safe distance from entry site [18]. Then, the RF probe is put through a coaxial sheath inside the osteoid osteoma. The sheath is retracted as far as possible from the probe tip [19]. When correctly positioned, electrode is turned on. An initial power of 2 W is usually applied with a 1 W increase every sixty seconds to achieve a steady rise in impedance or resistance [20]. In fact, a sudden raise of impedance could produce necrosis or desiccation of surrounding tissue with a consequent failure of ablative procedure [21]. Heat is typically released for a mean time of 4-6 minutes at a temperature of 90°C [16]. Precautions must be taken when performing thermal ablation of the foot [4]. Patients should be prone or supine depending on tumor position with the involved extremity extended to facilitate probe access and positioning. Furthermore, a proper sedation should be provided [22]. Electrode should be adapted to the size of the nidus and its placement should be accurately evaluated with CT images [18]. Since insertion of the electrode is minimally invasive, bone loss is extremely reduced and foot stability is usually preserved [23,24]. Machines used during procedure are commonly 64 slices multi-slice CT scanners [25,26]. According to our review, only a small percentage of patients (5%) don't respond or

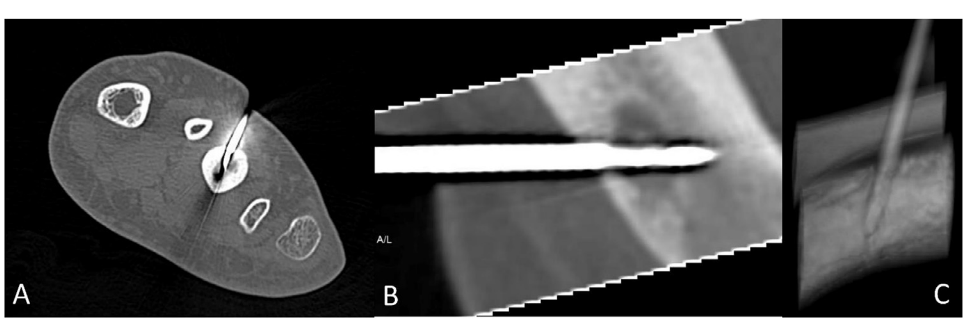

Fig. 9 – Intraoperative CT scan showing correct positioning of needle during procedure of thermal ablation (coronal view [A], sagittal view [B] and 3D shaded surface display (SSD) [C]).

Fig. 10 – Postoperative CT scan showing OO clearly imprinted by surgical needle after thermal ablation.

partially respond to radiofrequency treatment [27]. Post-procedural complications such as skin burns, muscular hematomas, infections, and nerve injury are reported in very few cases [15]. Therefore, in patients affected by OO of the foot RF ablation could be considered as a first-choice treatment since it is weighed by less complications and allows to restart walking immediately.

Conclusion

OO of the foot is a very uncommon entity and pain during walking can be a struggling condition for patients. Even though OOs of the foot can show atypical features, imaging techniques such as CT scan and MRI lead to a conclusive diagnosis in most cases. In our patient, RF ablation technique achieved a complete functional recovery avoiding more invasive procedures such as open surgeries that can harm foot structure causing deformity and impairment in walking.

Patient consent

Authors of this manuscript declare that informed consent was obtained for publication of this essay.

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