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UP-TO DATE REVIEW AND CASE REPORT

Percutaneous computed tomography-guided radiofrequency ablation of a spinal osteoid osteoma abutting the dura: a case report and review of the literature

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Abstract

Purpose Osteoid osteomas in the spine constitute a challenging group for both surgical and percutaneous approaches. Purpose of the present study is to report a case report of a spinal osteoid osteoma in a challenging spinal location and review literature for safety and efficacy of the technique.

Methods We report a case of spinal osteoid osteoma extending in the epidural space and abutting the dura in a pediatric patient treated by percutaneous computed tomography-guided radiofrequency ablation. This is not a systematic review of the literature. A number of separate literature searches were performed. Non-English studies and case reports were excluded from the study. All references of the obtained articles were also evaluated for any additional information.

Results Although all prophylactic measures were taken (hydrodissection, thermocouples and neurophysiologic monitoring) and the procedure was uneventful, patient within three hours, was unable to raise or bend the unilateral lower extremity below the knee. Pain reduction was significant from the first morning post-ablation and during the follow-up period of 18 months. MR scan was within normal limits. Dexamethasone was iv injected for 24 h and prescribed per os for 7 days. At follow-up 1 week later mobility of the lower extremity had returned to normal.

Conclusion As far as spine ablation is concerned, all prophylactic measures should be taken; neurophysiologic monitoring seems to be more sensitive than temperature measurement. Intravenous and per os corticosteroids are extremely useful in case of nerve damage.

Keywords Spine · Osteoid osteoma · Radiofrequency ablation · Case report

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Introduction

Spinal osteoid osteomas account for 7–20% of all cases and are more commonly located on the posterior elements of the lumbar spine [1]. Percutaneous thermal ablation techniques (Radiofrequency and laser ablation) are considered standard therapies for osteoid osteoma with surgery being reserved for exceptions, more commonly associated to proximity of the lesion to neural structures. Magnetic Resonance-guided High Intensity Focused Ultrasound (MR-guided HIFU) is a totally non-invasive ablative technique that can generate heat at the targeted tissue; MR-guidance provides high-resolution anatomical imaging allowing accurate targeting and treatment planning, as well as real-time 3D temperature monitoring [2]. Osteoid osteomas in the spine constitute a challenging group for both surgical and percutaneous approaches, both of which seem to be associated to higher peri- and postoperative morbidity, longer hospitalization and rehabilitation periods, lower efficacy and higher complication rates [1–5].

Here we present a case of spinal osteoid osteoma extending in the epidural space and abutting the dura in a pediatric patient treated by percutaneous computed tomography-guided radiofrequency ablation. This case presentation shows the necessity for prophylactic measures during spine ablation and the effectiveness of intravenous dexamethasone administration as first-line therapy in the early stage of post-ablation neural deficit. Additionally a literature review was performed. This is not a systematic review of the literature. A number of separate literature searches were performed. Non-English studies and case reports were excluded from the study. All references of the obtained articles were also evaluated for any additional information.

Case report

We report a case of a pediatric patient with a spinal osteoid osteoma located in the right lamina of S1 vertebral body, extending inside the epidural space. The lesion was treated with percutaneous radiofrequency ablation under computed tomography guidance. Institutional review board approval was obtained for preparation of this report.

A 12-year-old girl presented with low back pain and right S1 neuralgia due to an exophytic cortical osteoid osteoma, located in the right lamina of S1 vertebral body and extending in the epidural space. In agreement with the orthopedics and neurosurgeons, percutaneous ablation was proposed. The ablation session was performed with the patient under general anesthesia and neurophysiologic monitoring of the sensitive-evoked and motor-evoked potentials due to lesion's close proximity to the dural sac. Computed tomography guidance with sequential scanning (120 kV peak, 240 mAs wavelength and 0.9 mm slice thickness) was used for planning, targeting and intraprocedural modification during the ablation session. Post the initial CT scan, skin entry point was selected (Fig. 1a). Under extended local sterility a 22 Gauge spinal needle was inserted intradurally and myelography was performed in order to be able to distinguish the dural sac throughout the ablation session. The needle was withdrawn, repositioned epidurally and hydrodissection right next to the osteoid osteoma nidus was performed by means of Dextrose 5% mixed with contrast medium (60 ml of Dextrose solution mixed with 3 ml iodinated contrast medium). A thermosensor was placed for temperature monitoring right next to the nerve root (Fig. 1b). Following, a bone trocar (OBM, Arrow OnControl, Teleflex, Shavano Park, TX, USA) was inserted in the lesion of interest and its

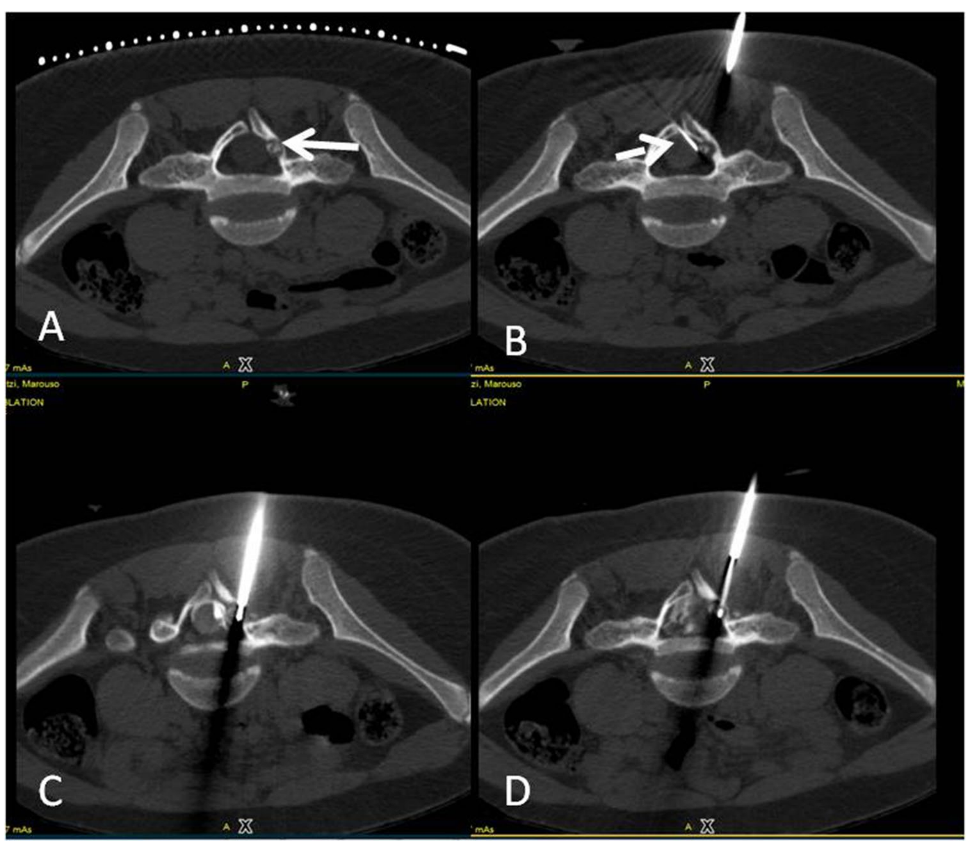

Fig. 1 **a** Computed tomography axial scan illustrating the nidus of the osteoid osteoma (white arrow) in the posterior medial wall of S1 vertebral body extending inside the epidural space right next to the dural sac. **b** Computed tomography axial scan illustrating the 22 Gauge thermosensor (white arrow) right next to the sac and nidus. **c** Computed tomography axial scan illustrating the bone biopsy needle coaxially inserted through the trocar in the nidus. **d** Computed tomography axial scan illustrating the radiofrequency electrode coaxially inserted through the trocar in the nidus; trocar is withdrawn outside the expected ablation zone (minimum 1 cm away)

approach was evaluated with sequential CT scans. Once in the correct location, coaxially the bone biopsy needle was inserted for sampling (Fig. 1c). A 15-cm long, 17-gauge Radiofrequency electrode with 1 cm single active tip (RF AMICA probe, Hospital Service S.P.A. Rome/Italy) was then introduced into the osteoid osteomas nidus through the coaxial system; the trocar was withdrawn till being outside the expected ablation zone and monopolar radiofrequency ablation was performed at 85–90 °C for 6 min (Fig. 1d). The position of the thermocouple and RF electrode was monitored by intermittent imaging during the procedure. Continuous thermal monitoring, during the ablation, via the thermocouple, showed no temperature increase above 39 °C. Intermittent neurophysiologic control of the sensitive-evoked and motor-evoked potentials was performed during the ablation with no pathologic registration. Although there was a small interference to the registration from the RF generator, no passive wave deformity was observed in comparison with the contralateral side. Active monitoring with stimulation was performed every two minutes, during which the RF energy deposition was paused. Systematic examination of both sides (afflicted and normal) showed no pathologic registration. Computed tomography assessed any potential immediate complications at the end of the ablation treatment. The procedure and recovery from general anesthesia was uneventful. On the ward, within three hours, patient was unable to raise or bend the unilateral lower extremity below the knee. Immediately the patient was clinically evaluated by a neurosurgeon who diagnosed L4 paresis and ordered a new MR examination (Fig. 2). The scan was without pathologic findings. Patient remained in the hospital overnight and dexamethasone (4 mg of dexamethasone phosphate/ml) was injected intravenously. Approximately four hours later extremity's mobility gradually started to return. Patient was discharged the next day pain free with minor mobility loss of the lower extremity which had returned to normal on the follow-up visit 1 week later. During this period patient was advised to avoid excessive stressful weight bearing and prolonged strenuous activity while oral dexamethasone phosphate per os was prescribed for 7 days (0.3 mg/kg/day in three or four divided doses). Pain reduction was significant from the first morning post-ablation; patient reported no pain from the 1st week clinical visit during the follow-up period of 18 months. Osteoid osteoma diagnosis was verified by the histologic findings, the report of which mentioned presence of nidus in the biopsy sample.

Authors were unable to identify the cause of the paresis, which seemed to respond very well to the corticosteroid treatment, but it could have equally been just spontaneous regression. One of the theories one can evoke is that the incidence is unrelated to the ablation technique, but rather related to the ancillary manoeuvres such as the epidural injection of Dextrose 5%, as a protective medium, which could have created an osmotic/volume effect on the L4 root, which was above the treated level.

Discussion

Since the first ever case report of osteoid osteoma treated with percutaneous radiofrequency ablation, things have fallen into place and nowadays the technique is considered gold-standard therapy [6]. Apart from radiofrequency alternative ablative techniques include laser interstitial therapy (LITT), microwave (MWA), cryoablation and high intensity focused ultrasound under MR guidance (MR-guided HIFU) [7–12]. Although MR-guided HIFU cannot systematically treat non-invasively all osteoid osteomas, the number of eligible cases may increase when HIFU is combined to minimally-invasive thermo-protective techniques [2]. At the moment cumulative literature data support the evidence for long-term efficacy and safety of percutaneous radiofrequency ablation [7, 13–20]. When working in pediatric cases, instrumentation suitable for the patient's smaller size, general anesthesia with intubation and exposure to ionizing radiation are areas of additional concern [21].

Spine due to the proximity with sensitive neural structures is considered a challenging location for percutaneous treatment of osteoid osteoma (Table 1). Beyer et al. [22] in a European multi-centered study enrolled 77 spinal osteoid osteomas treated with CT-guided RFA reporting significant and persistent pain reduction effect and concluding that the technique a safe and efficient method to treat spinal OO and should be regarded as first-line therapy after interdisciplinary case discussion. Apart from the standard RF electrodes, bipolar systems specifically designed for the spine have been described for the treatment of spinal osteoid osteoma [23].

Application of neuroprotective air injection during spine osteoid osteoma RFA has been described adding to increased safety [24, 25]. Real-time monitoring of the temperature close to a sensitive neural structure (must be kept below 42 °C), neurophysiologic monitoring and dissection for displacement of the sac constitute protective techniques for ablation in challenging locations; neurophysiologic monitoring seems to be more sensitive that temperature monitoring [5, 26, 27]. In case of nerve injury advantages of local and/or systematic corticosteroid administration include membrane stabilizing and analgesic effect that changes pain behaviors, silence of neural firing, reduction of inflammatory mediator synthesis as well as inhibition of neurogenic extravasation and edema formation [28]. Since the reported case as a standard protocol in the department, authors perform an epidural injection of steroids after each spine ablation session.

Fig. 2 **a** Immediate post-ablation Magnetic Resonance Imaging—sagittal T1 weighted sequence with fat signal suppression prior to iv gadolinium injection depicting the osteoid osteoma nidus (white arrow). **b** Immediate post-ablation Magnetic Resonance Imaging—sagittal T1 weighted sequence with fat signal suppression post iv gadolinium injection depicting the osteoid osteoma nidus (white arrow). There is absence of enhancement inside the nidus accompanied by peripheral post-ablative inflammatory enhancement. **c** Immediate post-ablation Magnetic Resonance Imaging—axial STIR sequence prior iv gadolinium injection depicting minor edema (white arrow) in proximity to the osteoid osteoma nidus and at the surrounding soft tissues (white dashed arrow).**d** Immediate post-ablation Magnetic Resonance Imaging—sagittal STIR sequence prior to iv gadolinium injection depicting the osteoid osteoma nidus as well as lack of any pathologic signal intensity in the visible part of spinal cord and cauda equina

When compared to open surgery, percutaneous CT-guided ablation is less invasive, easily repeatable, governed by lower morbidity and lower cost with high rates of technical and clinical success rates; on the other hand, open surgical resection is more complicated and associated to increased tissue injury, blood loss and hospitalization [29, 30]. Overall post-surgical complications range from 5.5 to 30% including among others pneumothorax, hematoma, infection, hook dislodgement, incidental durotomy, wound dehiscence and post-operative neuropathic pain [3, 31–33]. Yu et al. [29] in a retrospective cohort study comparing open surgical resection and radiofrequency ablation for spinal osteoid osteomas evaluated 28 consecutive patients; authors concluded that the presence of cerebrospinal fluid (at least 1 mm) between the spinal OO lesion and spinal cord/nerve root adds to the efficacy of radiofrequency ablation while in cases with spinal cord/nerve root compression open surgical resection should be the treatment of choice. Similarly in a retrospective study by Wang et al. [34] authors consider cerebrospinal fluid around the lesion is an appropriate indication for percutaneous RFA. Pipola et al. [35] performed a retrospective comparison analysis of data prospectively collected from 2 cohorts of consecutive patients diagnosed with OO of the spine reporting no statistically significant difference in local recurrence rate stratified for level and site of lesion. However, authors reported a statistically significant difference in the disease-free survival at longest follow-up favoring surgery concluding that spinal osteoid osteoma treatment should be tailored according to the relationship of lesions with neural structures and to advantages and disadvantages of each technique [35]. In conclusion, percutaneous radiofrequency ablation in the spine combined with the necessary protective techniques (hydro- or gas dissection, temperature monitoring and most importantly neurophysiologic monitoring) can be considered a safe and efficacious treatment for spinal osteoid osteoma. Cortisone therapy both

Table 1 Studies included for review of percutaneous radiofrequency ablation for spinal osteoid osteoma with key study parameters

Name of study	Type of study	Number of lesions	Follow-up (months)	Pain reduction (VAS units)	Success	Major complications	Comments
Beyer et al. [22]	Retrospective	77	28.49 ± 35.75	8.04 ± 0.99 before to 1.42 ± 2.03 after	94.8%	None	Multi-centered trial—CT RFA
Vidoni et al. [24]	Retrospective	17	n/a	n/a	15/17	None	Used RF electrode for pain
Estebam Cuesta et al. [25]	Retrospective	28	n/a	n/a	25/28	None	Single centered trial—CT RFA
Noel et al. [27]	Retrospective	7	35	8.8 before and 2.0 one day after	85.7%	None	Single centered trial—CT RFA
Wang et al. [34]	Retrospective	7	46.6	6/7 were free of pain—1/7 suffered occasional minor pain	6/7	None	Single centered trial—CT RFA
Albisinni et al. [18]	Retrospective	61	41.5 ± 7.1	8.0 before and 0.0 after in 57/61 patients	93.4%	None	Single centered trial—CT RFA
Vanderschueren et al. [19]	Retrospective	24	72	n/a	79%	None	Single centered trial—CT RFA
Faddoul et al. [20]	Prospective	8	48	7.55 before and 0.0 at final follow-up	100%	None	Single centered trial—CT RFA

locally and systematically administered can provide effective management as an add-on in the treatment of nerve damage.

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Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest to declare that are relevant to the content of this article.

Ethical approval 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.

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent for publication Consent for publication was obtained for every individual person's data included in the study.

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