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ORIGINAL ARTICLE

Percutaneous core excision and radiofrequency thermo-coagulation for the ablation of osteoid osteoma of the spine

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Abstract Percutaneous radiofrequency ablation is the treatment of choice for osteoid osteoma of the appendicular skeleton. However, difficulties in localizing the lesion in the spine and its proximity to neural elements have yet to make it the prevalent treatment for spine. This study assesses the safety and effectiveness of two percutaneous techniques for ablating osteoid osteoma of the spine. Seven patients were treated between 1998 and 2005. Four patients underwent percutaneous radiofrequency coagulation. The lesions were located at the articular processes of L3 and L4, the lamina of L3 and in the head of the 11th rib. Three patients with lesions in close proximity to neural structures (pedicle of T9, the posterolateral inferior aspect of L3 vertebral body and the inferior articular process of C5) were subjected to percutaneous core excision. Mean follow-up was 4.2 ± 1.6 years. Three out of four patients who underwent radiofrequency ablation had an immediate and sustained response. One patient with a lesion in the head of the rib failed to respond. The three patients in the group of pecutaneous core excisional biopsy demonstrated immediate relief of pain. However, one patient experienced relapse of symptoms 6 months after transpedicular core excision. CT scan suggested partial targeting of the lesion that corroborated with histologic examination revealing only reactive tissue. Subsequent percutaneous core excision was successful. Therefore, the overall success rate was 85.7%. Mean VAS improved dramatically from 9 ± 1 to 2 ± 1 after surgery ($P < 0.05$). No neurological or other complications were encountered. This study indicates that radiofrequency ablation of spinal osteoid osteomas is safe and reasonably effective when an intact cortical shell separates the nidus from the neural elements. Percutaneous core excision can obviate the risk of thermal damage for lesions located in close proximity to the neural elements. Effectiveness of treatment can also be evaluated by CT scan and histological examination. Difficulties in targeting the nidus can lead to treatment failure. The minimal morbidity and the effectiveness of these minimally invasive procedures make them a valid alternative in the treatment of spinal osteoid osteoma.

Keywords Osteoid osteoma · Minimally invasive surgery · Radiofrequency ablation · Percutaneous excision

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Introduction

Osteoid osteoma is a benign reactive bone lesion [1] that most frequently occurs in adolescent male patients between 10 and 20 years of age [30]. Approximately 10–25% of osteoid osteomas occur in the spine [3, 4, 6, 18, 25], with a tendency to involve the posterior elements ranging from 70 to 100% [8, 14, 28]. Osteoid osteoma typically begins with an insidious onset of pain over the affected region [35, 42], that may radiate distally [9, 14]. Characteristically, the pain is initially dull, throbbing, and intermittent and becomes more intense and knifelike over time. Physical activity may exacerbate the pain, which often occurs spontaneously and is usually worse at night. Typically salicylates or other NSAIDs relieve pain [21]. Marked spinal stiffness is common and has been reported in 89% of patients [20]. Painful scoliosis is also a frequent complication of osteoid osteoma with rates varying from 63 to 70% in adolescents [19, 26, 30, 45]. It is believed that scoliosis is provoked by the asymmetric muscle spasm due to pain on the side of the lesion [20]. It is postulated that the concave-side muscle spasms will eventually cause asymmetric growth inhibition of the vertebral epiphysis, leading to a rotational deformity and the curve to become structural [38].

The natural course of osteoid osteoma is one of potential spontaneous remission over a period of 2–8 years. In adult patients, surgery is recommended if conservative treatment with anti-inflammatory agents fails [21]. In younger patients, the lesion is usually treated with surgical excision because of the risk that the compensatory scoliosis may become structural [26]. Since the lesion is commonly localized in the posterior elements and may have a close anatomic relationship to the dura and neural structures, treatment has usually been surgical "en bloc" excision or intralesional curettage under general anesthesia [3, 24, 27, 28, 30, 33, 35, 39]. However, more recently two minimally invasive techniques: percutaneous core excisional biopsy [22, 37, 46] and radiofrequency thermocoagulation [7, 12, 25, 32] have been introduced to prevent the disadvantages associated with open surgery.

Previously, we reported the successful management of two cases of osteoid osteoma of the spine by means of minimally invasive surgery [17]. The first was treated with radiofrequency thermocoagulation and the second was managed with percutaneous core excision. We added five more cases in order to assess the safety, efficacy, and long-term results of these two minimally invasive surgical procedures.

Material and methods

Between 1999 and 2005, seven consecutive patients (six males, one female), mean age 20.1 years (16–32 years old) were treated for symptomatic osteoid osteoma of the spine. All patients were investigated by the following imaging resources: CT scan, plain X-rays and bone scan. MRI was performed in six patients. All patients had a complete clinical and routine laboratory assessment (hematological, biochemical). Pain intensity and location was evaluated on a VAS scale and pain diagrams. Four lesions were located in the lumbar spine, two in the thoracic and one in the cervical region. More specifically, two lesions were located in the superior articular process (L4 and L5), one in the lamina of L3, one in the head of the left 11th rib adjacent to the vertebral body articulation (Fig. 1), one in right pedicle of T9, one at the posterolateral inferior aspect of L3 vertebral body (Fig. 2a), and one at the inferior articular process of C5 (Fig. 3a).

Two minimally invasive surgical methods were used: percutaneous thermal coagulation and percutaneous core excision. Selection of the appropriate treatment method was made according to the proximity of the lesion to neural tissue. When a rim of intact cortical bone separating the nidus from the neural structures was evident on the preoperative CT scan, the lesion was treated with radiofrequency coagulation. Four patients with lesion located at the superior articular processes of L4 and L5, the lamina of L3 and the head of the 11th rib were considered suitable for this treatment (Table 1). A radiofrequency generator (Radionics) was used to coagulate the lesions at 90°C for 240 s. For this technique, a Craig bone biopsy needle was needed to gain access to the nidus. During the ablation, cold saline solution perfused the electrode at 80 mL/min. One patient was treated under local anesthesia in the radiology suite, where a portable fluoroscopy unit was installed at the table–gantry interface of the CT scanner. Three patients were treated in the operating room, two under local and one under general anesthesia using fluoroscopic guidance.

Lesions in the cervical spine and in close proximity to neural tissue, with no intact cortical bone separating it from the nerve roots or dura, were percutaneously cored out under fluoroscopic guidance (Table 1). The procedure was

Fig. 1 Axial 1 mm CT scan depicting the typical nidus of an osteoid osteoma at the head of the left 11th rib

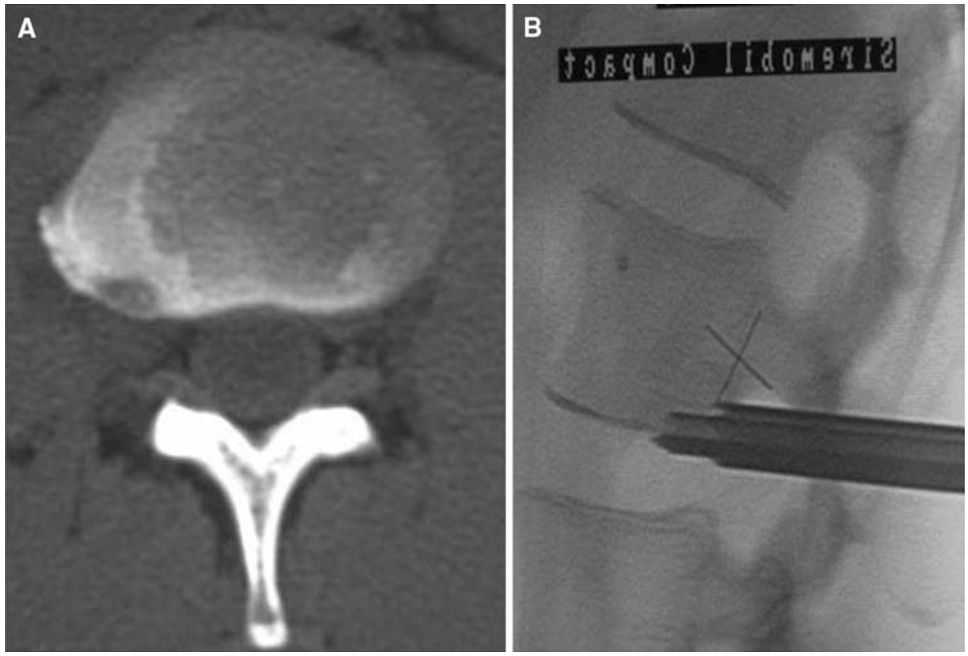

Fig. 2 **a** Axial CT scan depicting the nidus of an osteoid osteoma at the posterolateral inferior portion of L3 vertebral body, close to the adjacent disc. The lesion is in close proximity to the exiting nerve root and inaccessible by transpedicular approach. **b** Fluoroscopic image depicting percutaneous posterolateral core excisional biopsy under local anesthesia

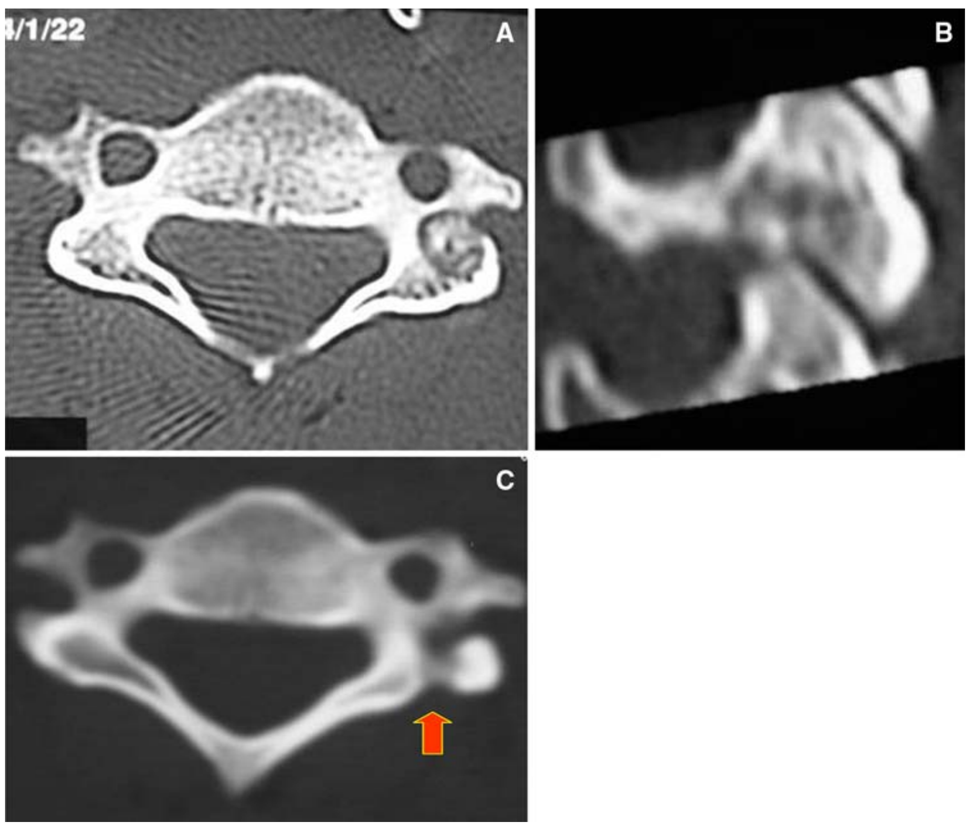

Fig. 3 **a** Axial CT depicting a nidus at the inferior articular process of C5. **b** lateral reformatted image showing the proximity of the lesion to the neural foramen. **c** Postoperative axial CT scan image demonstrating the tract made by the biopsy tool used to core out the lesion. At 6 months follow-up there is evidence of sclerosis and partial filling in of excised lesion

performed in the operating room in two patients under local anesthesia and one under general anesthesia.

The technique consists of first introducing percutaneously a 2 mm Steinmann pin into the intended area. Then, a modified 5.35 mm cannulated Kambin dilator (Smith and Nephew) and a modified 6.4 mm Kambin sleeve (Smith and Nephew) is passed over the guide pin until it abutted the cortical margin. The dilator is removed and a 5.15 mm toothed modified Kambin–Craig biopsy instrument (Smith and Nephew) is inserted for the removal of a core biopsy from the lesion area. For the lesion located at the L3 vertebral body, a 7 mm gage biopsy instrument was utilized

Table 1 Patient demographics, symptoms, location of the lesion, and method of treatment

Age/gender	Site	Location	Symptoms	Pain duration (months)	Scoliosis	Tx	Outcome	Follow-up (years)
24/M	L4	Articular process	Back pain	4	Absent	R/F	Success	8[a]
16/M	L3	Articular process	Back pain	6	Present	R/F	Success	6.4
20/M	T11	Head of the rib	Back pain	8	Present	R/F	Failure	3.4
19/M	L3	Lamina	Back pain	7	Present	R/F	Success	5.6
27/M	T9	Pedicle	Back pain Intercostal pain	16	Present	PCE	Success after 2nd PCE	5.5[a]
24/M	L3	Vertebral body	Back pain	10	Absent	PCE	Success	4.5
32/F	C5	Inferior articular process	Neck pain Left arm pain	9	Absent	PCE	Success	3.5

Tx treatment, *R/F* radiofrequency thermal coagulation, *PCB* percutaneous core excision

[a] Published previously [17]

through a posterolateral approach (Fig. 2b). Effectiveness of local ablation was evaluated by a postoperative CT scan (Fig. 3b) and a histological examination all three patients that were subjected to core excision. All patients were assessed within the first 2 days after the procedure and followed up at 1, 3, 6 months and 1 year. Last follow-up ranged from 3.5 to 8 years (mean 5.3 ± 1.6 years).

Results

All patients reported severe pain at the site of the lesion 9 ± 1° on a ten grade visual analogue scale (VAS) and four patients had pain radiating to one of the extremities (VAS 8 ± 1). Mean duration of pain before surgical intervention was 6 ± 3 months. Plain X-rays were not contributory. The most remarkable finding was scoliosis in five patients. All patients had positive T^{99} bone scan and typical findings of osteoid osteoma on computed tomography (CT) with a clear depiction of a nidus. However, 3 mm thickness CT scans fail to reveal the lesion in two patients, which then became apparent when 1 mm thickness cuts were performed. Magnetic resonance imaging demonstrated a nonspecific hypointense signal on Tl-weighted image and hyperintense signal on T2-weighted images with soft tissue mass. The routine hematologic and biochemical laboratory tests were within normal limits.

One patient failed to respond to radiofrequency ablation of the lesion located in the head of the 11th rib. The patient refused to have second procedure, he was responding to anti-inflammatory drugs and was lost to follow-up. One patient underwent an unsuccessful attempt of percutaneous core excision of a lesion located at T9 pedicle. The biopsy revealed only reactive tissue and failed to demonstrate the nidus. The patient had done well for about 6 months, after which he developed recurrence of his symptoms with the same intensity (VAS 10) of pain. Postoperative CT scan revealed partial removal of the nidus from the pedicle of T9 and the head of 11th rib, respectively. The same minimally invasive procedure was repeated, but this time, a larger (7 mm) core biopsy tool (Fig. 4) was used. The symptoms disappeared immediately (VAS 0) and histological examination confirmed the presence of the nidus in the biopsy specimen. The patient returned to work after a couple of days and to his athletic activities within 6 weeks. There were no signs of tumor recurrence in the 6-year follow-up period.

The other five patients reported excellent improvement of pain immediately after the procedure. Postoperative VAS was reduced to 1 ± 2 from the mean preoperative value of 9 ± 1. No neurological or other complications were encountered. Patients were discharged from the hospital within the first postoperative day and were able to resume their regular work within 2 weeks (2–15 days). A professional hockey player treated with percutaneous radiofrequency electrocoagulation resumed his regular competitive activities within 4 weeks. Histological examination confirmed the presence of the nidus in the biopsy specimen in the other two patients who underwent excisional core biopsy.

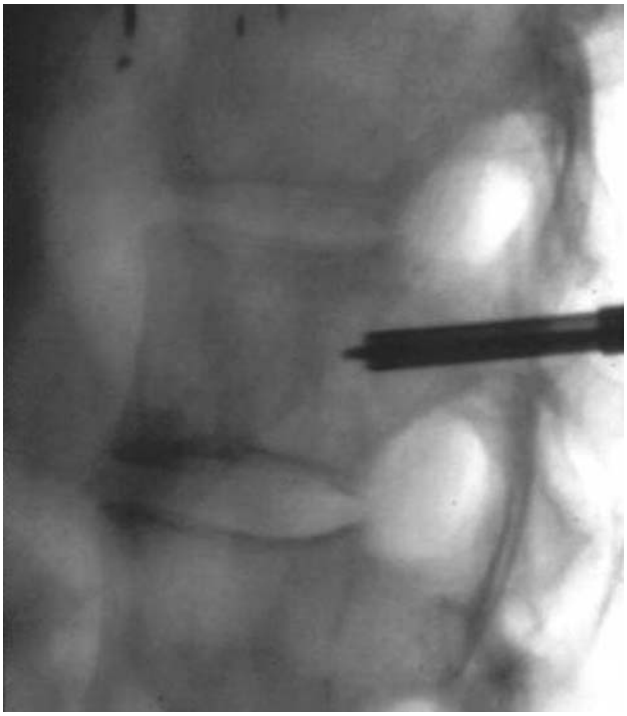

Fig. 4 Lateral fluoroscopic image depicting the biopsy instrument at the pedicle of T9

During the introduction of the needle into the lesion under local anesthesia, the procedure stimulated an exacerbation of pain, which subsided immediately following the injection of a local anesthetic.

Discussion

Osteoid osteoma should be sought as the cause of neck or back pain, painful scoliosis, radicular or referred pain in younger patients [30]. It is a likely cause of painful scoliosis in children or adolescents; the scoliosis is greater when they are in a supine position rather than standing erect [26]. The scoliosis is usually rigid, leading to limited spinal motion in all planes [20]. When the scoliosis is diagnosed, surgical excision is recommended for the curve that typically progresses rapidly with a high risk of becoming structural [20, 30, 33, 45].

Percutaneous CT guided resection of osteoid osteoma was first reported for management of lesions in the appendicular skeleton [2, 46] and subsequently applied to the spine [37]. Because of the potential risk of accidental penetration of the spinal canal [2, 31, 33] and the frequent failures of percutaneous CT guided resection of spinal lesions [2, 46], as opposed to the successful management of osteoid osteomas of the extremities [2, 5, 11, 29, 34, 40, 46, 49], its popularity has not gained momentum. Percutaneous radiofrequency ablation has been proposed as an alternative method to overcome limitations of percutaneous resection. The method was first reported in the appendicular skeleton by Rosenthal et al. [41] and soon gained popularity for the treatment of osteoid osteomas of the extremities and pelvis [10, 41, 42, 44]. Subsequently, the use of this technique has been successfully reported for management of osteoid osteoma in the lamina and the transverse process of L3 in two patients [7], in the body of lumbar vertebrae in two patients [25, 32, 50], in the pedicle of T11 in one patient [12], in the spinous process of C2 in two patients and the joint pillar of C3 in one patient [23]. Vanderschueren et al. reported six additional cases (three lumbar, one thoracic, and two cervical) with a relapse of symptoms in two patients [36, 48]. However, it has not been widely used for the management of spinal lesions, presumably because of their location adjacent to the neural structures.

Heating the tip of a needle up to 90°C for 6 min in a nidus located in the posterior structures of the spine inevitably risks thermal damage to the neural structures. However, previous ex vivo studies have shown that there was no temperature increase within the spinal canal with radiofrequency thermocoagulation in a bone with an intact cortex, suggesting the insulating effect of the cortical bone [12]. Based on these findings we selected this method for four patients. A drawback of this technique is the lack of histologic verification.

Rosenthal et al [43]. reported that the placement of a needle into the tumor might trigger intense pain. This reaction occurred in all patients treated under local anesthesia. We confirmed this in all cases treated under local anesthesia. The pain immediately disappeared after intralesional injection of local anesthetic. Even during general anesthesia, this phenomenon may cause abrupt physiologic reaction consisting of variable increases in heart rate, respiratory rate and arterial blood pressure in about 50% of patents [36]. When the lesion is completely destroyed the reaction is normalized. This phenomenon may be considered a confirmatory guide that the nidus was penetrated [36]. This was not observed in our series.

A potential complication of thermal ablation may occur when there is a breach in the shelf of protective bone separating the lesion from the neural or vascular structures. However, Dupuy et al. [12] reported successful use of thermo-coagulation of an osteoid osteoma located at the junction of pedicle and lamina, which abutted the thecal sac. We elected to avoid this method in similar cases. Furthermore, the impressively good results of transpedicular biopsy of the spine for other lesions [15, 16, 47] led us to apply this technique in a patient with osteoid osteoma located in the pedicle [17].

Inadequate removal of nidus either as a result of unsuccessful targeting or as a result of using small bone biopsy gauge (<5.0 mm) will result in failure. The size of the core biopsy should be adequate for the lesions of the vertebral body, as the diameter of these lesions may occasionally exceed 10 mm. The use of a 7 mm gauge biopsy tool led to the successful removal of the nidus from the posterolateral inferior part of the vertebral body in one patient. The close proximity of the lesion to the exiting root and its inaccessibility by the transpedicular route was a deterrent for the use of thermo-ablation in this location. Posterolateral insertion of the radiofrequency probe could have allowed heat dissemination through the surgical cortical defect into the foramen with a potential nerve root lesion. Apparently this procedure will fail if the nidus of the lesion is not included in the excised specimen.

The major advantages of percutaneous minimally invasive techniques in the surgical treatment of osteoid osteoma of the spine are the quick recovery, minimal morbidity, and the maintenance of spinal stability. Conventional open surgery with wide surgical resection of the surrounding bone (often performed), to ensure complete removal of the nidus, when intraoperative localization of a small nidus is difficult [33], may result in loss of segmental stability of the spine necessitating additional instrumented fusion [13, 31, 33, 35].

The overall success of the minimally invasive techniques reported in the current study was 85.7% per patient. Radiofrequency thermal coagulation was successful in three out of four patients. In three patients, where the lesion was located in the posterior elements of lumbar vertebrae the procedure was successful. In one patient where the lesion was located in the head of the 11th rib the procedure failed. Similar failure with this technique has been reported in the current literature [36, 48].

A limitation of this study is the small number of patients reported. However, since there are only scarce reports using these techniques for the ablation of osteoid osteoma of the spine, it gives an interesting insight into their safety, effectiveness and sustained excellent outcomes. Furthermore, it demonstrates that fluoroscopy can be a valid alternative to CT for guiding the probe to target the lesion.

In conclusion, radiofrequency thermal ablation and percutaneous core excision are two safe and effective methods for the management of osteoid osteoma of the spine. Their minimal invasiveness and limited morbidity renders them preferable to open surgery. Radiofrequency ablation does not cause thermal damage to the spinal neural elements when an intact cortex is present around the nidus. Percutaneous core biopsy can be used in cases where thermal damage to neural or vascular structures is anticipated. Incomplete removal of the nidus by excisional biopsy or imperfect targeting of the radiofrequency probe can lead to a relapse of symptoms.

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