

Clinical Study

# Percutaneous radiofrequency ablation versus open surgical resection for spinal osteoid osteoma

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## Abstract

**BACKGROUND CONTEXT:** Both open surgical resection (OSR) and radiofrequency ablation (RFA) have been reported for spinal osteoid osteoma (OO).

**PURPOSE:** To verify the clinical safety and efficiency of RFA with OSR in treating spinal OO.

**STUDY DESIGN:** Retrospective cohort study.

**PATIENT SAMPLE:** Twenty-eight consecutive patients with spinal OO who underwent either RFA or OSR in our institute between September 2006 and December 2016.

**OUTCOME MEASURES:** The age, gender, lesion distribution, surgical time, estimated blood loss, complications, local recurrence, visual analogue scale (VAS), and the modified Frankel grade were documented.

**METHODS:** We retrospectively reviewed 28 patients with spinal OO who had been treated in our hospital from September 2006 to December 2016. Patients were followed at 3, 6, 12, and 24 months after the index surgery. The minimum follow-up period was 12 months. This study was funded by Peking University Third Hospital (Y71508-01) (¥ 400,000).

**RESULTS:** Twelve and 16 patients were treated with CT-guided percutaneous RFA and OSR, respectively. Spinal OO locations were cervical in 4, thoracic in 4, lumbar in 3, and sacral vertebra in 1 in the RFA group and cervical in 12, thoracic in 1, and lumbar in 3 in the OSR group. RFA showed shorter operating time, less blood loss, and less in-hospital stay than open surgery [105.0 ± 33.8 minutes vs. 186.4 ± 53.5 minutes ( $p < .001$ ), 1 (0 to 5) ml vs. 125 (30–1200) ml ( $p < .001$ ) and 1 (1–3) days vs. 6 (3–10) days ( $p < .001$ ), respectively]. At last follow-up, one patient underwent a secondary RFA for recurrence. VAS improvement was 7.5 (3–10) and 6.5 (4–9) ( $p = .945$ ) in the RFA and OSR groups, respectively. The overall complication rate was 8.3% (1/12) and 18.8% (3/16) in the RFA and OSR groups, respectively.

**CONCLUSIONS:** If there is sufficient cerebrospinal fluid between the spinal OO lesion and spinal cord/nerve root (more than 1 mm), RFA is effective and safe for treatment of well-selected spinal OO, showing

FDA device/drug status: Not applicable.

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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.

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reduced operating time, blood loss, in-hospital stay, and complications compared to OSR. However, OSR is still recommended in cases with spinal cord/nerve root compression. © 2018 Elsevier Inc. All rights reserved.

**Keywords:** Comparative study; Complications; Open surgical resection; Radiofrequency ablation; Spinal cord compression; Spinal osteoid osteoma.

## Introduction

Osteoid osteomas (OOs) are the most common benign bone-forming lesion, accounting for 3% of all primary bone tumors [1]. Ten percent of OOs are located in the spine, mainly in the posterior elements of the lumbar and thoracic vertebral column. When conservative treatment with anti-inflammatory agents fails, surgery is recommended. Intralesional curettage and en bloc excision are effective and reliable treatments for spinal OO. However, surgical complications include incomplete removal, postoperative hematoma, and neurological injury, among others [2,3].

Radiofrequency ablation (RFA) is a safe and effective treatment for OO in the limbs and pelvis. In recent years, as a result of technical developments, a number of reports have shown satisfactory results with RFA in treatment of spinal OO [4–7]. However, it is not widely accepted because of potential heat injury to spinal cord or nerve root. In this retrospective cohort study, we compared the safety and efficacy of RFA and traditional open surgical resection (OSR) in treating spinal OO. The hypothesis we hold is that RFA is an effective and safe treatment for spinal OO, with less injury, shorter in-hospital stay, and fewer complications, compared to OSR.

## Materials and methods

This study was approved by the Ethical Committee of our university hospital.

## Patients

Twenty-eight consecutive patients with spinal OO who underwent either RFA or OSR in our institute between September 2006 and December 2016 were included in this study. Exclusion criteria included other pathologic diagnosis, nidus size over 2.0 cm on computed tomography (CT) scan, and/or insufficient cerebrospinal fluid between the lesion and nerve root or spinal cord (less than 1 mm, which was only indicated for OSR) (Fig. 1).

## Treatment protocol

RFA indications included no neurological deficits, presence of intact cortical bone around CT lesions, and presence of cerebrospinal fluid between the lesion and nerve root (or spinal cord) on magnetic resonance imaging. If the cerebrospinal fluid between the lesion and nerve root or spinal cord is sufficient (>1 mm), RFA may be performed without damage to them. Otherwise, surgery is recommended [8]. Before 2011, OSR was our standard treatment for all patients with spinal OO. Since January 2011, RFA was indicated for selected OO patients. Patients are informed of the advantages and disadvantages of both RFA and OSR before deciding on the treatment. Clearly surgical lesions, which are dangerous for RFA, were excluded from this study (Fig. 1).

## RFA procedural technique

The patients in this study underwent percutaneous CT-guided biopsy or RFA under local anesthesia (lidocaine)

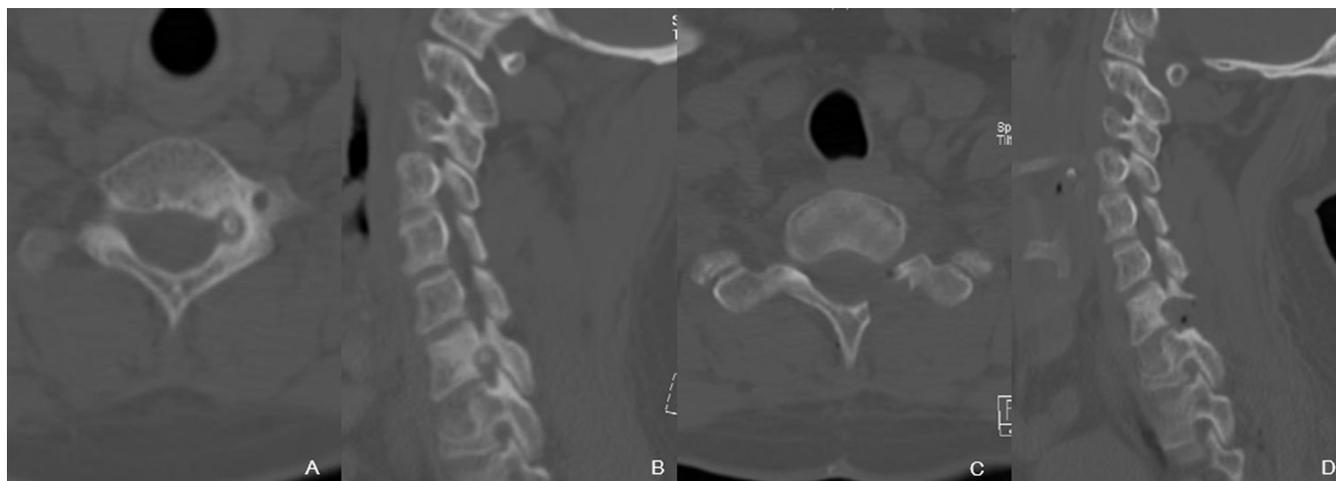


Fig. 1. Excluded case of spinal osteoid osteoma. (a, b) Axial and sagittal CT revealed insufficient cerebrospinal fluid between the lesion and nerve root, which was only indicated for open surgical resection and excluded from this study. (c, d) Postoperative axial and sagittal CT showed complete removal of the lesion.

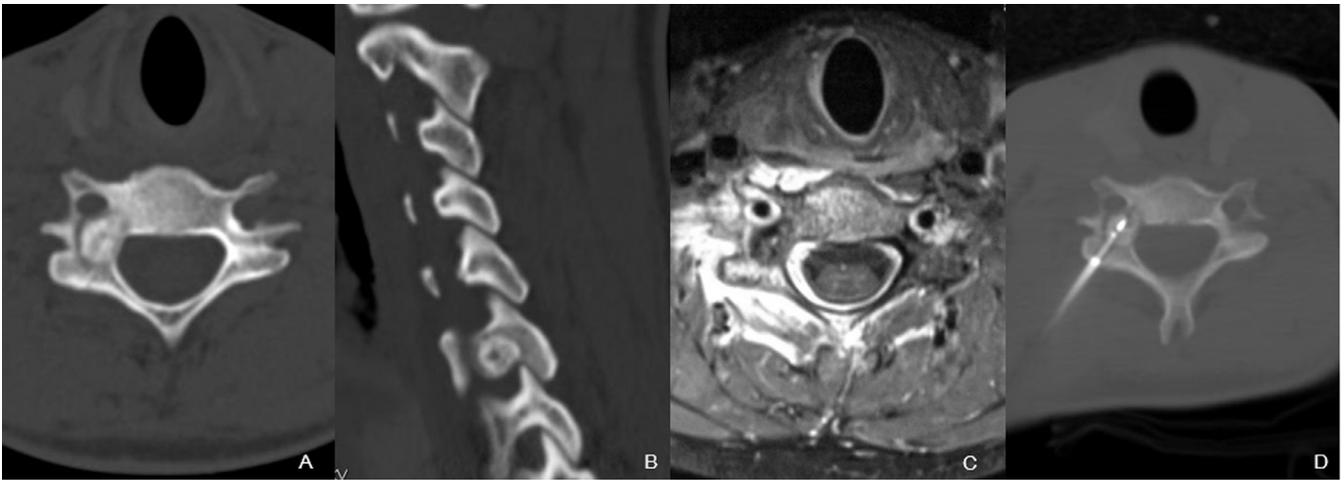


Fig. 2. Case 20 in radiofrequency ablation (RFA) group. A 16-year-old man with local pain for 24 months, and VAS of 8/10. (a and b) Axial and sagittal CT showed a expansive lesion with central nidus and surrounding sclerosis in right C6 pedicle. The maximum diameter is 10 mm. (c) MRI showed sufficient distance between the lesion and nerve root or spinal cord. (d) Percutaneous radiofrequency ablation was carried out under local anesthesia in prone position along the longitudinal axis of the lesion.

and intravenous conscious sedation (remifentanyl and propofol). General anesthesia was indicated for children and those unable to tolerate local pain during RFA. Local anesthesia and moderate sedation were preferred, especially for lesions close to the nerve root or dural sac, which might be injured during RFA. Patients were placed in the prone or lateral recumbent position, according to the tumor location. The entry point and trocar trajectory were planned on the CT scan with skin markers. CT was repeated during trocar insertion (T-Lok, Angiotech, Vancouver, BC) to confirm the appropriate position and trajectory. RFA was performed with a Cool-tip RFA system (Valleylab, Covidien, Mansfield, MA, USA). The RFA active tip was heated to 90°C for 4 to 12 minutes in impedance mode. Patients were closely monitored during the procedure (Fig. 2). Patients

were usually discharged within 48 hours after RFA. Non-steroidal anti-inflammatory drugs were administered for a few days after the procedure [8].

#### *Open surgical resection*

One patient underwent transoral curettage for an odontoid process lesion. The other patients in this group had conventional posterior intralesional curettage under general anesthesia. Internal fixation was used when there was instability, for example, after facet joint resection (Figs. 3 and 4).

#### *Data and imaging*

All clinical data including patients' demographic data, symptoms, neurological function, radiological features,

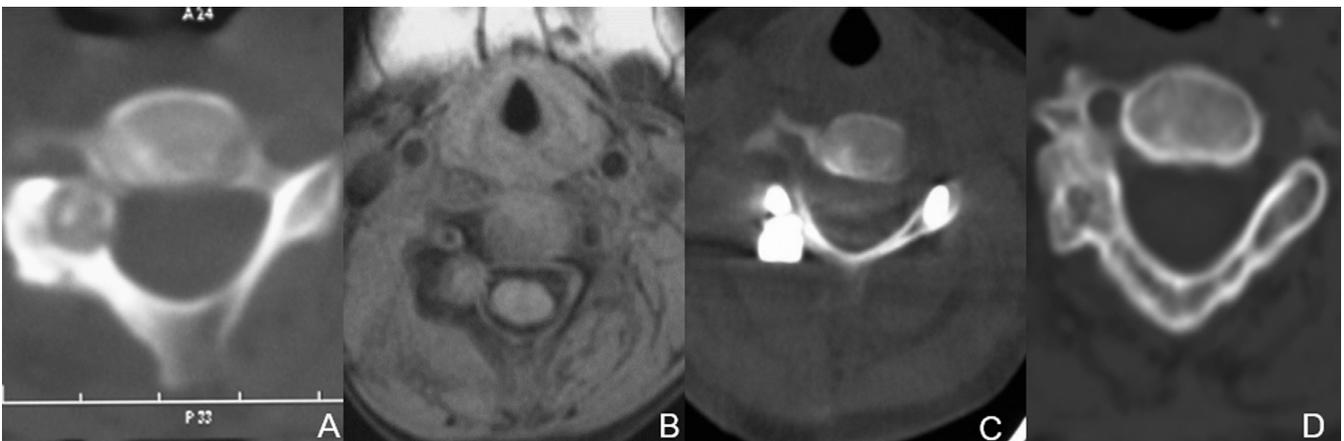


Fig. 3. Case 3 in OSR group. A 10-year-old woman with local pain for 5 months, and VAS of 6/10. (a, b) Axial CT and MRI showed a lytic and expansive lesion with central nidus and surrounding sclerosis in right C5 pedicle and facet joint. The maximum diameter is 15 mm. (c) Open posterior curettage and C4/C6 pedicle screw instrumentation were performed and postoperative axial CT showed removal of the tumor. At the 24-month follow-up, the patient was pain-free and no recurrence was found. The pedicle screw was subsequently removed. (d) At 7-year follow-up, axial CT showed sclerosis of the internal cortex in lamina.

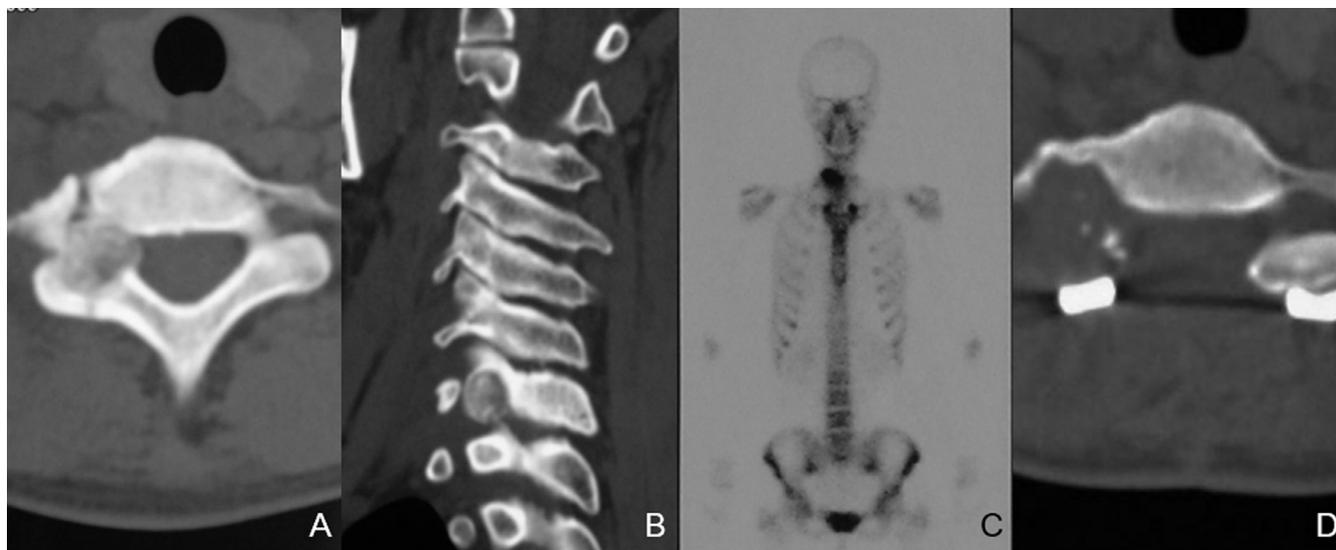


Fig. 4. Case 8 in OSR group. A 26-year-old woman with local pain for 24 months, and VAS of 5/10. (a, b) Axial and sagittal CT showed a lytic and expansive lesion with central nidus and surrounding sclerosis in right C7 pedicle. The maximum diameter is 20 mm. (c) Bone scan. An open posterior tumor curettage and a plate fixation were performed. (d) At 24-month follow-up, CT shows no tumor recurrence and patient was pain-free.

pathology, details of RFA, outcome, and treatment complications were collected from hospital charts, operating room reports, office charts, pathology reports, and radiographs. Visual analogue scale (VAS) and the modified Frankel grade were used to assess the pain and neurological status, respectively. All patients routinely underwent X-ray, CT, and magnetic resonance imaging to assess tumors. Bone scans were performed, if necessary. Percutaneous CT-guided trocar biopsy was conducted before percutaneous RFA or surgery in single stage (typical tumor) or two stages (atypical tumor) to confirm the pathological diagnosis.

Patients were followed-up with CT at 3, 6, and 12 and 24 months after the index intervention, and every 2 years thereafter. If recurrence was suspected, a bone scan was also obtained. Repeat RFA or surgery was indicated for recurrence. The minimum follow-up period was 12 months.

### Statistics

Data were statistically analyzed using SPSS (version 22.0, IBM, USA). Categorical variables are presented as counts with percentages and continuous variables with a normal distribution and non-normal distribution are presented as means  $\pm$  standard deviations or medians (ranges), respectively. The chi-square test, *t*-test, or non-parametric analyses were used to assess differences among approaches, as appropriate. Unless stated otherwise, a two-tailed *p*-value of less than .05 was considered statistically significant.

### Results

The study included 28 patients with spinal OO treated in our department between September 2006 and December

2016, both indicated to RFA or OSR, consisting of 16 cases in the OSR group and 12 cases in the RFA group.

In the OSR group, there were 6 females and 10 males from September 2006 to December 2016. In the RFA group, there were 3 females and 9 males treated between January 2011 and December 2016 (Table 1). There was no significant statistical difference between groups in age ( $26.4 \pm 13.8$ ,  $27.2 \pm 13.4$ ,  $p = .890$  in the OSR and RFA groups, respectively) and gender distribution ( $p = .429$ ).

In the OSR group, 12 lesions were located in the cervical spine (including 4 atlantoaxial lesions), 1 in the thoracic spine, and 3 in the lumbar spine (Table 2). The lesions were located in the vertebral body and/or odontoid process in 2 patients, facet joint or C1 lateral mass in 4 patients, pedicle in 5 patients, and lamina in 5 patients.

In the RFA group, the lesions were located in the cervical spine in 4 patients, thoracic spine in 4 patients, lumbar spine in 3 patients, and sacrum in 1 patient. The lesions were located in the odontoid process and vertebral body in 4 patients, in the facet joint in 4 patients, in the pedicle in 1 patient, and in the lamina in 3. Most lesions were located in the neural arch (14/16 in surgical group and 8/12 in RFA group) ( $p = .387$ ). There was no significant statistical difference between groups in segmental location (cervical, thoracic, lumbar, and sacral spine) ( $p = .095$ ), facet joint involvement (12/16 in the surgical group and 6/12 in the RFA group,  $p = .333$ ), tumor size ( $1.3 \pm 0.4$  cm in the surgical group and  $1.1 \pm 0.3$  cm in the RFA group,  $p = .256$ ), and distance to neural element ( $0.6 \pm 0.5$  cm in the surgical group and  $0.6 \pm 0.2$  cm in the RFA group,  $p = .749$ ).

The duration of symptoms prior to diagnosis was 14.5 (2–120) months in the OSR group, and 24 (8–30) months in the RFA group ( $p = .324$ ). No patients had had a previous

Table 1  
Case information for open surgical resection and radiofrequency ablation groups

No.	Gender	Age (y)	Location	Size (max. diameter, cm)	WBB sector	Facet joint involvement	Treatment protocol (OSR or RFA)	Pre-op VAS	Follow-up time (mo)	Follow-up VAS
1	M	7	C2	1.3	2-4 B-D	N	OSR	8	31	0
2	M	7	C1	1.1	2-4 B-C	N	OSR	7	117	0
3	F	10	C5	1.5	8-9 B-C	Y	OSR	6	109	0
4	F	13	C6	1.8	2-4 B-C	Y	OSR	6	86	0
5	F	16	C3	0.9	3-4 B-C	Y	OSR	8	95	0
6	F	18	C7	0.7	5-6 C	N	OSR	9	36	0
7	M	19	C2	1.4	5-6 A-B	N	OSR	7	79	0
8	F	26	C7	2.0	8-10 B-C	Y	OSR	5	122	0
9	M	31	T11	1.6	3-4 B-C	Y	OSR	8	20	0
10	M	31	L3	0.8	2-3 B-C	Y	OSR	6	90	0
11	M	35	C23	0.9	3-4 B-C	Y	OSR	4	110	0
12	F	37	C5	1.0	4-5 B-C	Y	OSR	6	39	0
13	M	37	L5	1.2	3-5 C-D	Y	OSR	6	72	0
14	M	42	C7	1.4	1-3 B-C	Y	OSR	9	12	0
15	M	45	C3	2.0	3-5 B-C	Y	OSR	6	98	0
16	M	49	L34	1.2	10-11 B-C	Y	OSR	9	12	0
17	M	32	T9	1.0	10 B-C	N	RFA	8	20	2
18	F	32	C2	1.5	6-7 B-C	N	RFA	6	24	2
19	M	23	T7	1.2	2-3 B-C	Y	RFA	8	24	0
20	M	16	C6	1.0	9-10 B-C	Y	RFA	8	73	0
21	M	27	L2	1.0	2 B-C	N	RFA	7	74	0
22	M	55	C2	1.1	8-9 B-C	Y	RFA	10	78	0
23	M	26	S2	1.0	2-3 B-C	N	RFA	6	79	3
24	F	26	C4	1.8	5-7 B-C	N	RFA	8	13	2
25	F	32	T12	0.6	2-3 B-C	Y	RFA	8	15	0
26	M	42	T9	1.2	10-11 B-C	Y	RFA	8	12	0
27	M	9	L3	1.3	12-2 B-C	N	RFA	6	13	0
28	M	6	L3	0.9	10-11 B-C	Y	RFA	8	12	0

RFA, radiofrequency ablation; OSR, open surgical resection; VAS, visual analogue scale; Y, yes; N, no.

surgical intervention. The preoperative pain VAS was 6.5 (4–9) and 8 (6–10) ( $p = .260$ ) in the OSR and RFA groups, respectively. These baseline data did not show statistically significant differences between the two groups. All patients in the RFA group and 14/16 patients in the OSR group had night pain, which was partially relieved with nonsteroidal anti-inflammatory drugs management.

Five patients had obvious scoliosis (Cobb angle  $> 10^\circ$ ) on the standing film, including two patients in the OSR

group (Cobb angles of  $14^\circ$  and  $15^\circ$ ) and three patients in the RFA group (Cobb angles of  $11^\circ$ ,  $14^\circ$ , and  $25^\circ$ ).

In the OSR group, 13 patients (81.3%) who underwent vertebral corpectomy or facet joint resection required internal fixation, and 3 patients had instrument removal after solid bony fusion.

RFA patients show shorter operating time and less blood loss than OSR patients,  $105.0 \pm 33.8$  minutes versus  $186.4 \pm 53.5$  minutes,  $p < .001$ , and 1 (0–5) ml versus 125 (30–1200) ml,  $p < .001$ , respectively. The median RFA time was 11 (4–12) minutes.

All patients had a minimum follow-up period of 12 months, with a median follow-up period of 55.5 (12–122) months.

During follow-up, four patients reported occasional pain, and no patients complained of persistent pain in the RFA group (VAS 2–3). VAS improvement was 6.5 (4–9) and 7.5 (3–10),  $p = .945$ , in the OSR and RFA groups, respectively. The RFA group showed significantly better immediate post-operative pain control than the OSR group (VAS score 1 [0–3] and 2 [1–4],  $p = .008$ ), as well as shorter in-hospital stay (1 [1–3] days and 6 [3–10] days,  $p < .001$ ). No patients had neurological symptoms at the final follow-up.

In the OSR group, one patient suffered delayed wound healing, which was successfully treated conservatively.

Table 2  
Comparison of the various lesion features for open surgical resection and radiofrequency ablation groups

Group	RFA	OSR	p
Location (cervical/thoracic/lumbar/sacral spine)	4/4/3/1	12/1/3/0	.095
Distance to neural element (cm)	$0.6 \pm 0.5$	$0.6 \pm 0.2$	.749
Size (max. diameter, cm)	$1.1 \pm 0.3$	$1.3 \pm 0.4$	.263
Sector (lamina/not)	8/4	14/2	.387
Facet joint involvement (yes/no)	6/6	12/4	.333
Pre-op VAS	8 (6–10)	6.5 (4–9)	.187
Duration of symptoms prior to diagnosis (mo)	24 (8–30)	14.5 (2–120)	.735

RFA, radiofrequency ablation; OSR, open surgical resection; VAS, visual analogue scale.

Two patients with cervical lesions suffered with postoperative axial pain (Cases 7 and 12). One of them complained of stiffness and the other reported soreness with Neck Disability Index scores of 4 and 7, respectively. The overall complication rate in this group was 18.8%. One patient underwent a second RFA 2 years after the index procedure for local recurrence (residual lesion was confirmed by CT). The recurrence rate was 8.3%.

## Discussion

RFA and surgery are two main therapies to treat osteoid osteoma. There are several studies on treatment of spinal OO case series with surgery only or RFA only [2,5,11,12], all of which showed clinical success. In this study, we compared these two techniques for spinal OO, focusing on their clinical efficacy and complication rates.

OSR is usually more complicated, with more tissue injury, more blood loss, and more in-hospital days. In the present study, the median intraoperative blood loss was 125 ml, significantly more than 1 ml in RFA group. Intraoperative blood loss has been previously reported to be between 25 and 500 ml with operating times ranging from 70 to 300 minutes for surgical resection [13]. The duration of hospital stay after treatment has been reported to be 1 to 2 days [14] for RFA and approximately 9 days for surgery [4]. RFA, unlike OSR, can simultaneously eliminate the tumor and minimize the possible iatrogenic injury of nerves, blood vessels, and muscles, reducing intraoperative bleeding and preserving spinal range of motion [8,10,15–17].

Excision of spinal OO, which might lead to spinal instability, has been the standard treatment [2]. Etemadifar et al. [18] reported 19 patients who underwent open surgery with intralaminar curettage, with complete recovery of pain and deformity and no recurrence after a mean follow-up of 44.5 months. However, 21.1% of those patients received internal fixation to reduce instability. Internal fixation rates have been reported ranging from 6.7% to 50% in other studies [3,13,18,19]. High rates of instrumentation are associated with high cost, risk of infection, and other related complications. In our OSR group, the rate of internal fixation was 81.3% (13/16) for complex lesions located in the facet joint and pedicle. Damage to the posterior vertebral structure led to instability, so internal fixation was required in these cases (Figs. 3 and 4).

In previous studies, complications such as pneumothorax, postoperative hematoma [3], hook dislodgement [18], incidental durotomy, wound infection, wound dehiscence, and postoperative neuropathic pain [2] have been reported after open surgical procedures. Overall complication rates ranged from 5.3% to 30% in previous studies [2,3,13,18]. In the present study, the overall complication rate in the OSR group was 18.8% (infection and axial neck pain), inferior to the RFA group complication rate of 8.3% (recurrence).

Heating injury is a major limitation of applying RFA for spinal OO [20]. The insulation effect of cortical bone [21]

and the “sink effect” of spinal fluid and venous plexus [5] could ensure that RFA can be safely carried out in appropriately selected spinal OO cases (ie, intact cortex and sufficient cerebrospinal fluid). When the lesion is close to, or compresses, the nerve root and/or spinal cord, RFA may be dangerous, and open surgical treatment is recommended.

The recurrence rate is of great importance in the evaluation of spinal OO treatment. We reviewed 102 patients in nine case series [4,5,7,9,10,14,16,22,23] on RFA for spinal OO published in the past 10 years. The recurrence rate ranged from 0% to 21%, and all recurrences occurred between 1 and 6 months after the initial procedure. We found one recurrence in 12 RFA cases, consistent with previous studies. Lanza et al. [17] suggested that the reason for recurrence is incomplete treatment, and some authors suggest multiple ablations for a large OO and/or prolonged ablation time to ensure an RFA temperature of 90°C. Secondary RFA for recurrence can usually ablate residual disease.

There are several limitations in the present study. First, the traditional technique, open surgery, is evolving. To minimize selection bias, patients with spinal cord/nerve root compression, which are contraindications for RFA, were excluded from this study (Fig. 1). Second, a larger sample size, longer follow-up, and prospective research are necessary to validate our findings. Third, as a spinal center experienced in cervical surgery, many cervical OO patients were referred to our department, which may have led to patient selection bias, especially in the OSR group.

In conclusion, if there is sufficient cerebrospinal fluid between the spinal OO lesion and spinal cord/nerve root (more than 1 mm), RFA is an effective and safe treatment, with shorter operating time, less blood loss, shorter in-hospital stays, and fewer complications as compared to OSR. However, OSR is still recommended in cases with spinal cord/nerve root compression.

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