Management of Complications Following Radiofrequency Ablation of a Pedicle Osteoid Osteoma

Joseph W. Owen, MD, Keith H. Bridwell, MD, and Louis A. Gilula, MD

Abstract

Radiofrequency ablation (RFA) has become an accepted first-line treatment for osteoid osteomas. Ablation of spinal osteoid osteomas has presented a particular challenge because of their proximity to delicate neural structures. Although many case series have reported multiple successfully treated spinal osteoid osteomas, there are no reports of thermal injury or insufficiency fracture associated with RFA of spinal osteoid osteomas. We report the management of complications that result from treating a spinal osteoid osteoma within a pedicle.

Spinal osteoid osteomas account for approximately 10% of all osteoid osteomas.[1] Over the past 20 years, their treatment has progressed from invasive surgical excision to minimally invasive radiofrequency ablation (RFA).[2-5] The initial investigators who described RFA of osteoid osteomas were concerned about the use of RFA within 1 cm of neural structures because of the potential for thermal injury.[2,5-7] For this reason, they excluded patients with an osteoid osteoma of the posterior elements[3,4] or within 1.5 cm of a neurovascular bundle[8] from RFA treatment, and spinal lesions in challenging locations were treated surgically.[9] Concerns about thermal injury were supported by in vivo RFA in porcine models, which showed the development of radiculopathy and paraplegia when RFA was performed in the pedicles and posterior cortex, respectively.[10]

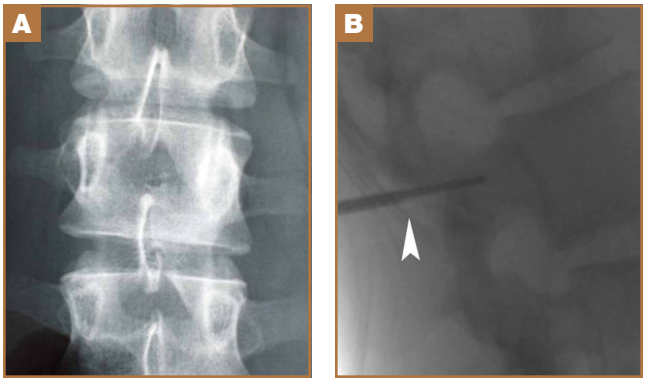
A single case of spinal osteoid osteoma RFA without complication was reported in a lumbar pedicle, despite concerns for neural injury.[11] In vitro models have shown an insulating effect of intact cortex, and the authors suggested that spinal fluid and the epidural venous plexus dissipated heat and provided additional protection for neural structures.[12] Later case studies reported successful treatment of spinal osteoid osteoma,[12-18] but "treatment for lesions in close proximity to neural structures remained controversial."[19] Recent case series have described epidural irrigation and epidural injection of air for neural protection when spinal osteoid osteomas are in close proximity to neural elements.[19,20] In 24 reported cases of RFA of pedicular osteoid osteoma, the only reported complications were treatment failures.[14,21]

This is the first case to report the development of radicular pain after spinal osteoid osteoma RFA, the first case complicated by the development of pars defect after spinal osteoid osteoma RFA, and the first case to describe successful management of these complications. The authors have obtained the patient's informed written consent for print and electronic publication of this case report.

Case Report

An 18-year-old woman presented with a 12-month history of persistent lumbar back pain. The patient's pain was worse at night and relieved by aspirin, a classic description associated with osteoid osteoma.[5] When the pain became debilitating, the patient stopped competing in high school athletics. Conventional radiographs (**Figure 1A**), computed tomography (CT), and magnetic resonance imaging (MRI) showed an expansile sclerotic lesion within the posterior aspect of the left L2 pedicle with a central nidus, most consistent with an osteoid osteoma. She was referred for a bone biopsy and RFA of an osteoid os-

Figure 1. (A) Frontal radiograph of the lumbar spine shows enlargement and sclerosis of the left L2 pedicle. (B) The cross-table lateral fluoroscopic image shows RFA electrode passing through the Ackermann cannula (arrowhead) within the left L2 pedicle.



Authors' Disclosure Statement: The authors report no actual or potential conflict of interest in relation to this article.

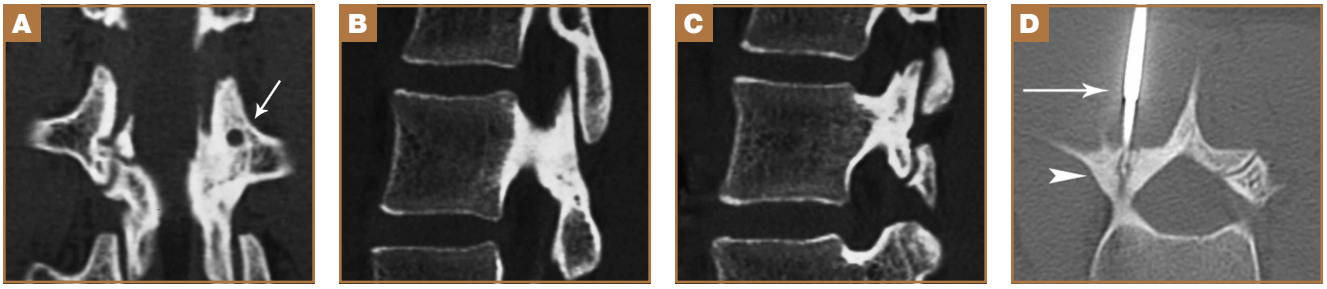


Figure 2. (A) Two-month follow-up CT scan in coronal plane shows the cannula track superior to the nidus (arrow). (B) Sagittal reconstructions show intact left pars interarticularis, and (C) sagittal reconstructions through the right pars interarticularis show the right pars interarticularis defect. (D) Second RFA under CT guidance, with the treating RF electrode (arrow) slightly out of plane to show the nidus (arrowhead).

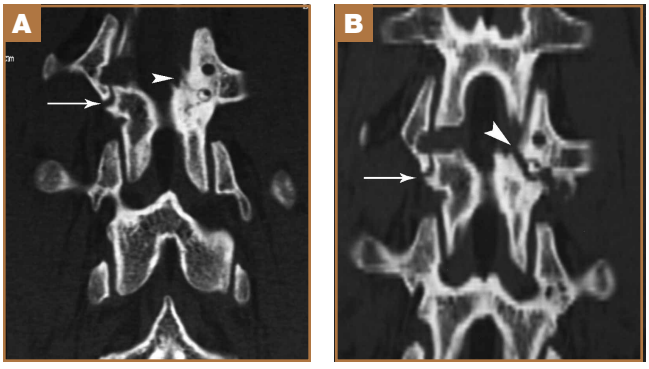


Figure 3. (A) Follow-up CT images 3 weeks after second RFA show minimally displaced left pars interarticularis defect (arrowhead) and unchanged right pars interarticularis defect (arrow). (B) Follow-up CT images 6 months after second RFA show nonunion of the left pars interarticularis defect (arrowhead) and unchanged right pars interarticularis defect (arrow).

teoma in the left pedicle of L2.

The procedure was performed under general anesthesia in the prone position under fluoroscopic guidance in sterile fashion. Local anesthesia was infiltrated prior to advancement of a Craig cutting needle (George Tiemann & Co, Hauppauge, New York) through the subcutaneous tissues to the posterior aspect of the left L2 pedicle. A bone biopsy was obtained with several cores taken out of the tract. Because of the hardness of the bone, several placements of the Craig needle were necessary to pass into the middle anterior of the left L2 pedicle. The Craig cutting needle was removed, and the Craig cannula was exchanged for the cannula in an Ackermann bone biopsy needle set (Cook Group Inc, Bloomington, Indiana). A Ray rhizotomy electrode (Integra Radionics, Burlington, Massachusetts) was placed into the midportion of the left L2 pedicle through the Ackermann cannula. The cannula was withdrawn to expose the tip of the Ray electrode (**Figure 1B**). The impedance was greater than 300 ohms, and radiofrequency was applied for 4 minutes at 90°C. There were no immediate postprocedure complications. The biopsy specimen was considered insufficient for diagnosis by pathology.

The patient reported 3 weeks' relief of her back pain (worse at night and relieved by aspirin), after which the pain returned to preprocedure levels. Repeat CT examination showed the needle tract from the initial RFA was above the nidus of the osteoid osteoma (**Figure 2A**), and showed a pars interarticularis defect on the right with an intact but sclerosed pars on the left (**Figures 2B, 2C**). Because of recurrent back pain, the patient returned for a repeat attempt to ablate the lesion in the inferior border of the left pedicle of L2, again under general anesthesia, in the prone position, but using CT guidance (**Figure 2D**). The same sequence and techniques described above were repeated with the exception of the ablation, which was performed for 6 minutes at 90°C. There were no immediate postprocedure complications.

Although the patient had relief of the osteoid osteoma back-pain symptoms, she experienced a distinctly different form of back pain, left-sided back pain with radiation to the thigh and upper calf. Physiatry evaluation suggested development of a radiculopathy secondary to thermal injury from RFA. The patient was managed conservatively for 4 months because her doctors did not want to pursue nerve-root block to treat the radiculopathy. When the radicular pain persisted and interfered with her activities of daily living, she was referred for nerve block with foraminal epidural injection 16 weeks after the second RFA treatment.

Prior to the nerve block, CT images showed a chronic right pars interarticularis defect at L2 and a subacute left pars interarticularis defect (**Figures 3A, 3B**). To maximize local treatment effect, it was decided to block the left L2 pars area at the posterior aspect of the foramen and the left L2 nerve root at the anterior aspect of the foramen. Using sterile precautions and local anesthesia, a 22-gauge needle was placed into the left L2 pars interarticularis defect (**Figures 4A, 4B**). After the needle tip position was verified with iohexol (Omnipaque-180; Amersham Health Inc, Princeton, New Jersey) under fluoroscopic guidance, 1 mL Kenalog-40 (Bristol-Myers Squibb, Princeton, New Jersey), 1 mL bupivacaine 0.25% (Hospira, Inc, Lake Forest, Illinois) and 0.5 mL Omnipaque-180 were injected. The patient was asked to turn and roll on the table; this normally elicited pain. Her pain, however, had decreased from 8/10 to 4/10. The needle was redirected to the anterior aspect of the foramen, and 2.5 mL of the same steroid anesthetic was injected anteri-

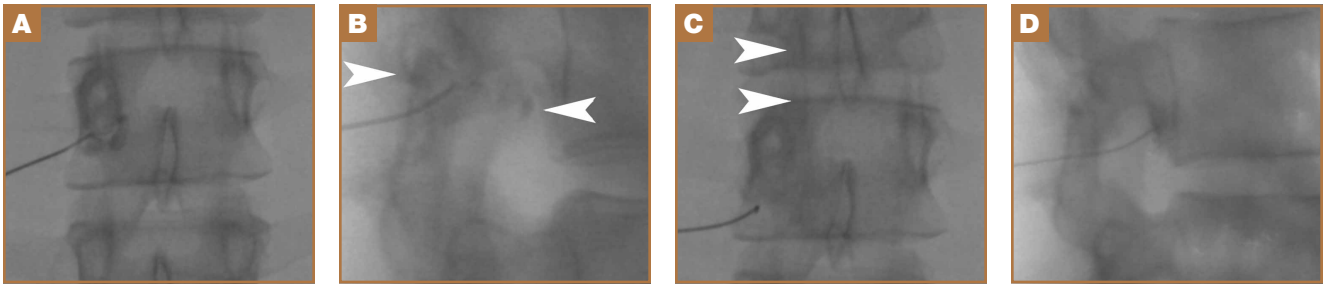


Figure 4. (A) Frontal and (B) lateral fluoroscopic needle localization at the left pars interarticularis defect. Contrast passes through the defect and lies anterior and posterior to the defect (arrowheads). (C) Frontal and (D) lateral fluoroscopic needle localization at the nerve root. Contrast mixed with the injectate passes in the epidural space anteriorly and medially (arrowheads).

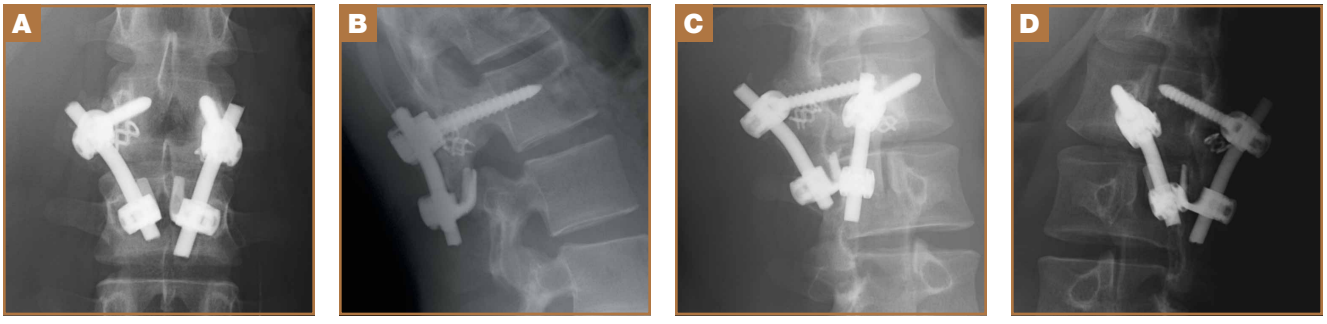


Figure 5. One-year follow-up (A) posteroanterior, (B) lateral, and (C, D) bilateral oblique radiographs of the lumbar spine show bilateral pedicle screws, bone cages, vertical rods, and laminar hooks providing fixation of the bilateral pars interarticularis defects without recurrence of osteoid osteoma. Solid bone healing of the pars defects is also evident.

orly in the L2-L3 foramen (**Figures 4C, 4D**). With the 2 injections, injectate passed into the epidural space and bathed the pars interarticularis defect and the neural foramen. The patient tolerated the procedure well with no immediate postprocedure complication; the patient stood, tested, and retested her pain. Prior to the procedure, the patient reported a pain score of 8/10 in her left lower back and 6/10 in her left thigh and proximal left calf. After the pars and foraminal blocks, her pain on the table decreased to 4/10 in her lower back. Upon standing and moving around, the pain in her left lower back decreased to 2-3/10, and the pain in her left thigh decreased to 3/10. The patient's radicular symptoms resolved completely within 6 weeks, but the focal left-sided lumbar back pain persisted.

Retrospective review of CT imaging showed the presence of the right pars defect, which had been present prior to osteoid osteoma treatment and predisposed the patient to a left pars defect. The left pars interarticularis defect developed posttreatment likely as a complication of RFA from a preexisting contralateral pars defect. With no evidence of healing at 3 months postepidural injection and persistent focal lumbar tenderness, bilateral fusion procedure of the pars defects at L2 was performed with the following operative procedure. Bilateral pedicle screws were placed in L2, and 6-mm modified bone cages with bone morphogenic protein and right iliac bone graft were placed in the bilateral pars defects. Two oblique hooks were placed under the laminae and fixed to the pedicle screws with bilateral vertical rods. The fixation created compression on the bone cages within the pars defects and allowed coordinated movement of the posterior elements with the pedicles. No instrumentation or fixation of the caudal and rostral vertebrae was required. This construct allowed normal motion at adjacent disc spaces in this young patient to diminish the possibility of later development of degenerative disc disease.

Follow-up 12 months later showed healed pars defects with intact instrumentation (**Figures 5A-5D**), and the patient reported no back pain. She returned to full sports and normal life activities. The patient continued to be free of back pain at her most recent follow-up, 6 years 11 months after the repeat RFA, and 6 years 8 months after the lumbar procedure to fuse the pars defects.

Discussion

This case describes RFA of a left pedicular osteoid osteoma complicated by development of a radiculopathy and a pars interarticularis defect. After initial treatment, the patient had temporary relief of her presenting symptoms, which returned 3 weeks posttreatment. After a second RFA, the patient again experienced relief of her symptoms but developed distinctly different pain, consisting of radicular symptoms and localized left-sided lumbar spine pain. The development of a radiculopathy was likely the result of thermal injury to the adjacent nerve root and was successfully treated with foraminal epidural injection. The lumbar spine pain was likely secondary to development of an ipsilateral pars interarticularis defect, which

was treated with instrumented bilateral single-level fusion. The patient has remained symptom-free for about 7 years. This case report illustrates a series of interconnected complications that were managed successfully.

In prior studies, the need to shorten ablation time when in close proximity to neural structures led to treatment failure.[14,21] In this case, it is unclear whether the initial treatment, which was adjacent to the nidus, failed secondary to length of treatment or because of poor positioning. Rosenthal and colleagues[3] described RFA ablation for 6 minutes at 90°C, and our initial treatment was for 4 minutes at 90°C, a commonly accepted procedure.[1,22] Vanderschueren and colleagues[21] reported 2 cases of treatment failures in pedicular osteoid osteoma related to a treatment time of 2 minutes. In our case, the initial RFA was performed under fluoroscopic guidance, and the central nidus of the osteoid osteoma was not clearly visible on spot images. The follow-up CT images showed the needle track superior to the nidus; therefore, inadequate positioning likely caused treatment failure, although the short ablation time may have been a factor.

Case series have described the development of reactive sclerosis with development of a pars defect or pedicle fracture in the setting of a preexisting contralateral pars defect.[23-26] The reactive sclerosis has been described as mimicking osteoid osteoma and has led to erroneous surgical excision of hypertrophic bone. In our case, the presence of a central nidus and the classic symptomatology of night pain relieved by aspirin reinforce the diagnosis of osteoid osteoma.[23] The pathologic specimen was nondiagnostic; however, this is often the case, with negative biopsy rates in the literature ranging from 27% to 62% of patients diagnosed and treated for osteoid osteoma.[2,27] Additionally, the patient's presenting pain, worse at night and relieved by aspirin, resolved after the nidus was properly targeted under CT guidance. With the development of the ipsilateral left pars interarticularis defect, a distinctly different focal left-sided pain was present.

The identification of the contralateral pars defect prior to treatment may have altered the management discussion, with surgical resection of the osteoid osteoma and lumbar fusion more strongly considered or greater restriction in activity instituted postprocedure. Insufficiency fractures have always been a concern after RFA ablation, with wide variation in recommended postprocedure activity restriction. Our patient restricted activities to accommodate her symptoms. She was able to resume full activity after the second treatment but developed radiculopathy and lumbar back pain associated with the nerve injury and ipsilateral pars defect. Recommendations for activity restriction in the literature range from "limiting strenuous sports with prolonged running or jumping for 3 months,"[2,28] to "no sports for 2 weeks,"[20] to "no activity restrictions."[1,22] Despite these variations, there are no reported insufficiency fractures following osteoid osteoma RFA.

This case is unique because a preexisting contralateral pars defect in combination with RFA treatment likely led to development of an ipsilateral pars defect. While this patient has been symptom-free after management of her complications for osteoid osteoma, we suggest that contralateral pars defect is a relative contraindication to RFA of pedicular osteoid osteoma, and requires special attention to potential sequelae of treatment. We also emphasize that evaluating for preexisting pars defects prior to diagnosis is critical because hypertrophic bone from a contralateral pars defect can mimic osteoid osteoma.

There are no reported cases of radiculopathy after RFA, but the theoretical risks have been extensively discussed and investigated in animal models.[3,4,8,10,12,29] In our case, the treatment time and the development of an occult pars defect may have resulted in thermal injury. Six-minute treatment time of spinal osteoid osteoma was established verbally by Dr. Gilula and Dr. Rosenthal[2,3,5,6] between the first and second RFA treatments in this patient. This treatment time, consistent with that described by Rybak and colleagues,[19] is generally accepted. When performing RFA or laser ablation, any structure with a radius of approximately 8 mm should be protected from thermal injury; an infusion of dextrose, saline or CO_2 gas will accomplish this.[19,20,30] Additionally, solid bone appears to be protective. The left pars interarticularis defect found prior to the epidural injection may have been occult at the time of the second treatment; thus, the protective insulation of the cortex may have been disrupted, allowing thermal injury to the nerve. It is our opinion that the thermal injury resulted from the 6-minute treatment time under conditions of weakened, if not disrupted, cortex. Importantly, epidural steroid and local anesthetic injection provided immediate and continued relief from the radicular symptoms even after a delayed period of time.

Conclusion

Despite theoretical concerns, this is the first report describing persistent radiculopathy as a sequela of RFA of a spinal osteoid osteoma and the first case describing spinal osteoid osteoma treatment with subsequent insufficiency fracture in the spine. While these complications resulted in prolonged pain and impairment, they were managed without long-term sequelae.

We recommend carefully evaluating potential patients with osteoid osteoma of the pedicle or posterior elements for preexisting contralateral pars defect because this may alter treatment. Radiofrequency ablation may be preferred to excision, because primary surgical treatment of such a lesion would require removal of most, if not the entire, pedicle, presenting its own challenges with a concomitant contralateral pars interarticularis defect. Single-level surgical fixation of bilateral pars defects should be considered to preserve motion at discs above and below the defects. Also, placement of catheters to infuse dextrose, saline, or CO_2 fluids adjacent to the treatment site to dissipate heat during treatment, as published years after performance of this procedure, should be considered.[19,20,30] Regardless of the presence or absence of a pars defect, epidural steroid and local anesthetic should be considered in initial management if thermal injury occurs after RFA.

Dr. Owen is Radiology Resident, Mallinckrodt Institute of Radiology, Washington University School of Medicine, Saint Louis, Missouri. Dr. Bridwell is J. Albert Key Distinguished Professor of Orthopaedic Sur-

gery and Professor of Neurological Surgery, Washington University School of Medicine, Saint Louis, Missouri. Dr. Gilula is Professor of Radiology, Orthopaedics, and Plastic and Reconstructive Surgery, Mallinckrodt Institute of Radiology, Washington University School of Medicine, Saint Louis, Missouri.

Address correspondence to: Joseph W. Owen, MD, Box 8131, Mallinckrodt Institute of Radiology, Washington University School of Medicine, 510 South Kingshighway Blvd., Saint Louis, MO 63110 (tel, 314-362-5139; fax, 314-747-4671; e-mail, owenj@mir.wustl.edu).

Am J Orthop. 2014;43(6):E124-E128.

References

1. Pinto CH, Taminiau AH, Vanderschueren GM, Hogendoorn PC, Bloem JL, Obermann WR. Technical considerations in CT-guided radiofrequency thermal ablation of osteoid osteoma: tricks of the trade. *AJR Am J Roentgenol.* 2002;179(6):1633-1642.
2. Rosenthal DI, Hornicek FJ, Torriani M, Gebhardt MC, Mankin HJ. Osteoid osteoma: percutaneous treatment with radiofrequency energy. *Radiology.* 2003;229(1):171-175.
3. Rosenthal DI, Hornicek FJ, Wolfe MW, Jennings LC, Gebhardt MC, Mankin HJ. Percutaneous radiofrequency coagulation of osteoid osteoma compared with operative treatment. *J Bone Joint Surg Am.* 1998;80(6):815-821.
4. Lindner NJ, Ozaki T, Roedl R, Gosheger G, Winkelmann W, Wörtler K. Percutaneous radiofrequency ablation in osteoid osteoma. *J Bone Joint Surg Br.* 2001;83(3):391-396.
5. Rosenthal DI, Alexander A, Rosenberg AE, Springfield D. Ablation of osteoid osteomas with a percutaneously placed electrode: a new procedure. *Radiology.* 1992;183(1):29-33.
6. Rosenthal DI, Springfield DS, Gebhardt MC, Rosenberg AE, Mankin HJ. Osteoid osteoma: percutaneous radio-frequency ablation. *Radiology.* 1995;197(2):451-454.
7. Froese G, Das RM, Dunscombe PB. The sensitivity of the thoracolumbar spinal cord of the mouse to hyperthermia. *Radiat Res.* 1991;125(2):173-180.
8. Cantwell CP, O'Byrne J, Eustace S. Radiofrequency ablation of osteoid osteoma with cooled probes and impedance-control energy delivery. *AJR Am J Roentgenol.* 2006;186(suppl 5):S244-S248.
9. Ozaki T, Liljenqvist U, Hillmann A, et al. Osteoid osteoma and osteoblastoma of the spine: experiences with 22 patients. *Clin Orthop.* 2002;(397):394-402.
10. Nour SG, Aschoff AJ, Mitchell IC, Emancipator SN, Duerk JL, Lewin JS. MR imaging-guided radio-frequency thermal ablation of the lumbar vertebrae in porcine models. *Radiology.* 2002;224(2):452-462.
11. Osti OL, Sebben R. High-frequency radio-wave ablation of osteoid osteoma in the lumbar spine. *Eur Spine J.* 1998;7(5):422-425.
12. Dupuy DE, Hong R, Oliver B, Goldberg SN. Radiofrequency ablation of spinal tumors: temperature distribution in the spinal canal. *AJR Am J Roentgenol.* 2000;175(5):1263-1266.
13. Cove JA, Taminiau AH, Obermann WR, Vanderschueren GM. Osteoid osteoma of the spine treated with percutaneous computed tomography-guided thermocoagulation. *Spine (Phila Pa 1976).* 2000;25(10):1283-1286.
14. Hoffmann RT, Jakobs TF, Kubisch CH, et al. Radiofrequency ablation in the treatment of osteoid osteoma—5-year experience. *Eur J Radiol.* 2010;73(2):374-379.
15. Mylona S, Patsoura S, Galani P, Karapostolakis G, Pomoni A, Thanos L. Osteoid osteomas in common and in technically challenging locations treated with computed tomography-guided percutaneous radiofrequency ablation. *Skeletal Radiol.* 2010;39(5):443-449.
16. Laus M, Albisinni U, Alfonso C, Zappoli FA. Osteoid osteoma of the cervical spine: surgical treatment or percutaneous radiofrequency coagulation? *Eur Spine J.* 2007;16(12):2078-2082.
17. Hadjipavlou AG, Lander PH, Marchesi D, Katonis PG, Gaitanis IN. Minimally invasive surgery for ablation of osteoid osteoma of the spine. *Spine (Phila Pa 1976).* 2003;28(22):E472-E477.
18. Samaha EI, Ghanem IB, Moussa RF, Kharrat KE, Okais NM, Dagher FM. Percutaneous radiofrequency coagulation of osteoid osteoma of the "Neural Spinal Ring." *Eur Spine J.* 2005;14(7):702-705.
19. Rybak LD, Gangi A, Buy X, La Rocca Vieira R, Wittig J. Thermal ablation of spinal osteoid osteomas close to neural elements: technical considerations. *AJR Am J Roentgenol.* 2010;195(4):W293-W298.
20. Klass D, Marshall T, Toms A. CT-guided radiofrequency ablation of spinal osteoid osteomas with concomitant perineural and epidural irrigation for neuroprotection. *Eur Radiol.* 2009;19(9):2238-2243.
21. Vanderschueren GM, Taminiau AH, Obermann WR, van den Berg-Huysmans AA, Bloem JL. Osteoid osteoma: factors for increased risk of unsuccessful thermal coagulation. *Radiology.* 2004;233(3):757-762.
22. Martel J, Bueno A, Nieto-Morales ML, Ortiz EJ. Osteoid osteoma of the spine: CT-guided monopolar radiofrequency ablation. *Eur J Radiol.* 2009;71(3):564-569.
23. Sherman FC, Wilkinson RH, Hall JE. Reactive sclerosis of a pedicle and spondylolysis in the lumbar spine. *J Bone Joint Surg Am.* 1977;59(1):49-54.
24. Aland C, Rineberg BA, Malberg M, Fried SH. Fracture of the pedicle of the fourth lumbar vertebra associated with contralateral spondylolysis. Report of a case. *J Bone Joint Surg Am.* 1986;68(9):1454-1455.
25. Araki T, Harata S, Nakano K, Satoh T. Reactive sclerosis of the pedicle associated with contralateral spondylolysis. *Spine (Phila Pa 1976).* 1992;17(11):1424-1426.
26. Guillodo Y, Botton E, Saraux A, Le Goff P. Contralateral spondylolysis and fracture of the lumbar pedicle in an elite female gymnast: a case report. *Spine (Phila Pa 1976).* 2000;25(19):2541-2543.
27. Vanderschueren GM, Taminiau AH, Obermann WR, Bloem JL. Osteoid osteoma: clinical results with thermocoagulation. *Radiology.* 2002;224(1):82-86.
28. Torriani M, Rosenthal DI. Percutaneous radiofrequency treatment of osteoid osteoma. *Pediatr Radiol.* 2002;32(8):615-618.
29. Adachi A, Kaminou T, Ogawa T, et al. Heat distribution in the spinal canal during radiofrequency ablation for vertebral lesions: study in swine. *Radiology.* 2008;247(2):374-380.
30. Buy X, Tok CH, Szwarc D, Bierry G, Gangi A. Thermal protection during percutaneous thermal ablation procedures: interest of carbon dioxide dissection and temperature monitoring. *Cardiovascular Intervent Radiol.* 2009;32(3):529-534.

This paper will be judged for the Resident Writer's Award.