Table 1. Summary of cases

Parameter	Group 1	Group 2
Total no. of study patients	44	19
Age (years), mean and range	76.9 (44–92)	76.8 (67–86)
Women (no.)	30	15
Patients with multilevel treatment	30	10
No. of treated vertebral bodies		
T6	1	0
T7	1	1
T8	3	0
T9	4	1
T10	3	0
T11	4	5
T12	14	10
L1	21	5
L2	11	5
L3	9	5
L4	9	5
L5	3	2
Total	83	39

workup prior to PVP consisted of plain radiographs and MRI. MRI was performed with a 1.5-T system (Signa Horizon; GE Medical Systems, Milwaukee, WI, USA) using a spine-array surface coil. Routine MR sequences included T1-weighted imaging, fat-suppressed T2-weighted imaging, and fat-suppressed gadolinium (Gd)-enhanced T1 weighted imaging.

The percutaneous vertebroplasty procedure was performed in a conventional manner. The patient was placed in the prone position on an angiography table with sterile conditions. A small skin incision was made, and a disposable 11- or 13-gauge bone biopsy needle (Cook, Bloomington, IN, USA) was positioned with its tip near the center of the pedicle. Lateral fluoroscopy was used to advance the needle through the pedicle into the vertebral body. Polymethylmethacrylate (PMMA) is prepared by combining sterile barium and cranioplastic cement (Codman Cranioplastic; Johnson & Johnson Medical, Bershire, UK). Injection of PMMA was performed with lateral and anteroposterior fluoroscopic guidance.

The subject evaluated on MRI was the extent of CE on the preprocedural MRI. The most extensively enhancing plane of sagittal fat-suppressed Gd-enhanced T1-weighted imaging was used for the evaluation. Based on the extent of CE on preprocedural MRI, each case was classified into group 1, which represented more than 50% of the vertebral body enhanced, or group 2, which represented less than 50% of the vertebral body enhanced. If there were clefts or Schmorl's nodes in the vertebral bodies, images were evaluated excluding them. The MRI was evaluated by two neuroradiologists by mutual agreement (A.U., N.K.) who were blinded to the results of the PVP. The most enhancing level was evaluated at multilevel PVP sessions.

Pain relief was used as an outcome assessment. Patients were questioned about their pain level prior to and following the procedure, and the patients used a visual pain intensity scale method to assess their pain level on a scale of 0–10, with 0 being no pain and 10 indicating the worst pain. The degree of pain relief was assessed based on the difference between pre- and postprocedural pain scale results. Pain scale assessment was established on the day before PVP and around 3–90 days (mean 13.3 days) after the procedure when the pain had subsided. We evaluated the difference of pre- and postprocedural pain scale scores between groups 1 and 2 using Mann-Whitney's U-test.

Results

As to the extent of CE on Gd-enhanced fat-suppressed T1-weighted imaging, 65 vertebral bodies showed CE less than 50%. CE was noted in more than 50% of 57 vertebral bodies. The most enhancing level was evaluated at multilevel PVP sessions; 44 patients were classified into group 1 and 19 patients into group 2. Illustrative cases are shown in Fig. 1. Regarding the correlation of pain relief with the extent of CE, the average preprocedural pain score in group 1 was 8.3, which was reduced to 1.1 after PVP. In contrast, in group 2 the average preprocedural pain score was 7.1, which was reduced to 3.1 after PVP.

There was a trend toward higher preprocedural pain scale in group 1, but it was not statistically significant ($P = 0.0537$). In addition, the postprocedural pain score in group 2 was significantly higher than that in group 1 ($P = 0.0007$). The difference between pre- and postprocedural pain scores was significantly higher in group 1 than in group 2 ($P = 0.0001$). In fact, there was a better pain relief in group 1.

Discussion

Although PVP is now frequently used in the management of painful vertebral compression fractures, patient selection becomes increasingly difficult. Patients with percussion or pressure pain over the spinous process at the involved level are generally good candidates for vertebroplasty.[1] However, in many patients with subacute or chronic pain in the setting of multiple fractures, the physical examination is unrevealing, and adjunctive evaluation is required. A recent study by Maynard et al. suggested that increased tracer uptake at the involved level is predictive of good pain relief after PVP;[2] however, increased tracer uptake is recognized for as long as 12

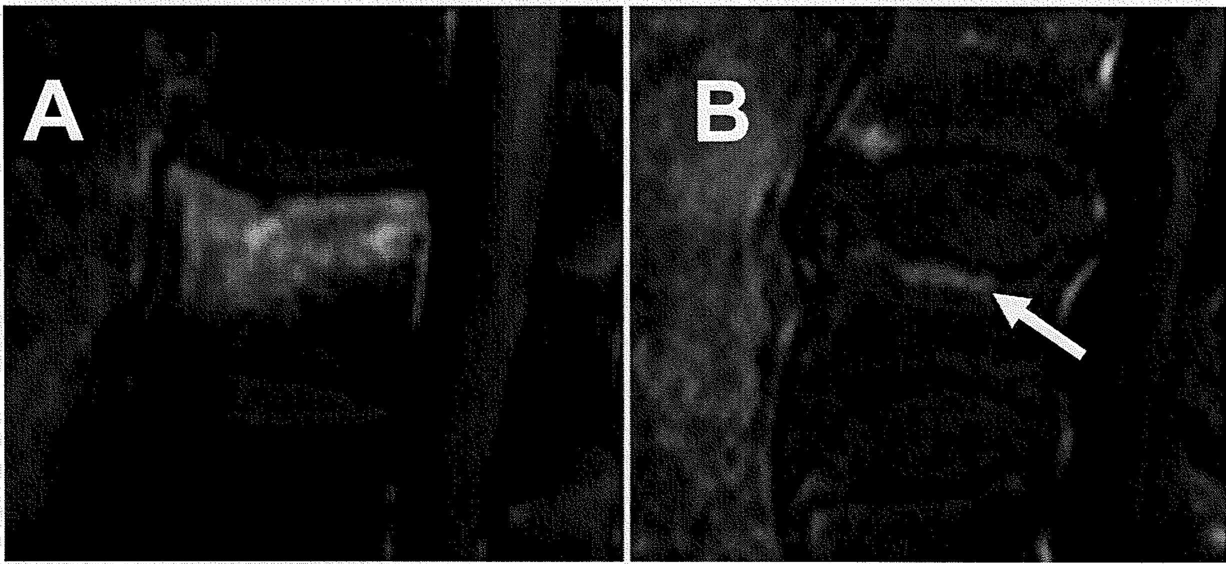

Fig. 1. Classification of the extent of contrast enhancement (CE) on sagittal fat-suppressed gadolinium-enhanced T1-weighted imaging. **A** Group 1: >50% CE of the vertebral body. **B** Group 2: <50% CE of the vertebral body

Table 2. Mean pain scores recorded in group 1 versus group 2 in preprocedural and postprocedural settings

	Mean pain score	
Group	Preprocedural	Postprocedural
1	8.3	1.1
2	7.1	3.1

months after fracture onset, and detailed information is not obtained by bone scan alone. MRI is probably the most useful preprocedural evaluation of compression fractures. However, the role of MRI in PVP is generally recognized as determining ambiguous fracture age and ruling out a malignant tumor or other etiologies such as disc herniation, spinal canal stenosis, or facet arthropathy.[1,3] Alvarez et al. reported that the presence of signal changes on MRI is a predictor of good pain relief after PVP.[4] However, the signal change alone on MRI is ambiguous, and more detailed and practical evaluation is necessary when selecting the vertebral level to be treated.

Our study showed that extensive CE predicted better pain relief after PVP. The pain score was relatively higher in group 1 (Table 2), which suggested that CE itself may indicate a painful area. Evaluation of CE extent is useful for triaging patients before performing PVP, especially when multiple fractures are present or the pain is not localized. However, appropriate pain relief was obtained in group 2 (<50% CE) as well. Therefore less CE is not necessarily a contraindication for PVP.

The area of CE probably represents granulation tissue, fibrosis, inflammation, and/or edema, indicating an unhealed fracture. Extensive CE is more common in acute cases than chronic cases.[5] In acute cases, CE may mainly represent inflammation or edema, not granulation or fibrosis. Thus, filling the vertebral body with cement may cause paralysis of the inflamed nerve, and thus may be a main means of pain relief. CE of a chronic fracture is thought mainly to represent granulation or fibrosis, which weakens the strength of the bone. With such long-standing fractures, filling the weakened bone by cement injection would increase the stability and strength of the vertebral column, resulting in pain relief.

There is a strong correlation between the findings on the images obtained with gadolinium enhancement and on those obtained with fat-suppressed T2-weighted imaging/STIR imaging of bone marrow.[6,7] Two studies have evaluated postprocedural pain relief in patients with bone marrow edema using fat-suppressed T2-weighted imaging/STIR imaging.[8,9] However, gadolinium enhancement helps differentiate granulation or fibrotic tissue from nonspecific bone marrow abnormalities. Furthermore, contrast is much greater on fat-suppressed Gd-enhanced T1-weighted images, and the potential benefit of gadolinium enhancement provides increased confidence when diagnosing bone marrow abnormalities.[10] Another important benefit of gadolinium enhancement is that it allows clear visualization of the boundary between the residual trabecular bone and necrotic area.

There are several limitations in this study. First, the follow-up periods were short. However, the incidence of new fractures may mask both the benefits and the risks of the procedure during the long-term follow-up, especially when there is cement leakage into an adjacent disc.[11] The short-term assessment may be reasonable to compare the effectiveness of PVP between groups.

Second, we assessed CE extent regardless of the existence of intravertebral clefts. Lane et al. stated that after reviewing 75 (31%) of 236 treated vertebral collapses that showed intravertebral clefts at the time of vertebroplasty, there was a trend toward greater pain relief at 6 and 12 months in the patients with clefts.[12,13] Intravertebral clefts are suggested to represent fracture nonunion, causing instability. The cleft is an important factor contributing to persistent pain in patients with a compression fracture, although CE is not seen on MRI. In patients with intravertebral clefts, another approach should be applied in the preprocedural evaluation regardless of CE.

Yamato et al. stated that the acute or subacute stage of compression fractures is characterized by a large alteration of the geographic signal, whereas the chronic stage was evidenced by a smaller area of signal alteration.[14] Less CE of a compression fracture is presumably related to the long-standing fracture. Relatively, the refractory nature to PVP in cases of less CE may be explained by the structural changes, nerve irritation, and muscle strain due to it being a long-standing fracture. However, the existence of CE in vertebral bodies represents a painful bony lesion, and it is useful to identify relatively mature or unhealed fractures among chronically developing multiple compression fractures.

Conclusion

Contrast enhancement on MRI indicates a painful lesion, and extensive CE predicts better pain relief after PVP. Vertebral bodies that show extensive CE should be treated to obtain a satisfactory clinical outcome.

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CASE REPORT

Percutaneous Pediculoplasty for Vertebral Hemangioma Involving the Neural Arch: A Case Report

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Abstract

Vertebral hemangiomas occasionally involve the neural arch and they can be symptomatic. We report a case of symptomatic vertebral hemangioma mainly involving the unilateral neural arch which was successfully treated with percutaneous pediculoplasty using a single-needle technique.

Key words: Bone cement—Percutaneous pediculoplasty—Percutaneous vertebroplasty—PMMA—Vertebral hemangioma

Vertebral hemangiomas are common and are frequently seen on imaging studies as an incidental finding. They are usually asymptomatic but can be symptomatic in rare cases [1, 2]. Most vertebral hemangiomas are located in the vertebral bodies but they sometimes extend to the pedicles or are solely seen in the pedicles [3].

We herein report a case of symptomatic hemangioma which was mainly located in the neural arch. It was successfully treated with percutaneous pediculoplasty using polymethylmethacrylate (PMMA) and a single-needle technique.

Case Report

A 42-year-old woman presented with rapid progression of back pain in the mid-thoracic region that had been resistant to conventional pain management for 2 years. Her back pain was initially 5/10 by visual analog scale (VAS) but had gradually increased and she began to feel instability of her trunk. MRI was performed at another institution and she was diagnosed as having a thoracic vertebral hemangioma which was thought to be causing her symptoms. She was referred to our hospital for the treatment.

On admission, the level of her back pain was 9/10 by VAS, she felt constant instability of her back and could not walk without a corset. Her physical examination showed tenderness and knocking pain in the back at the 10th thoracic vertebra (T10). Her plain radiographs showed vertical striations in the right pedicle (Fig. 1).

On MRI, the lesion was located mainly in the right pedicle but also noted in the posterior part of the vertebral body, lamina, and transverse process on the right. It showed prominent hyperintensity on T1- and T2-weighted images, indicating a fat component. After intravenous injection of contrast medium, there was homogeneous and intense contrast enhancement in the lesion (Fig. 2). Involvement of the tumor in the epidural space

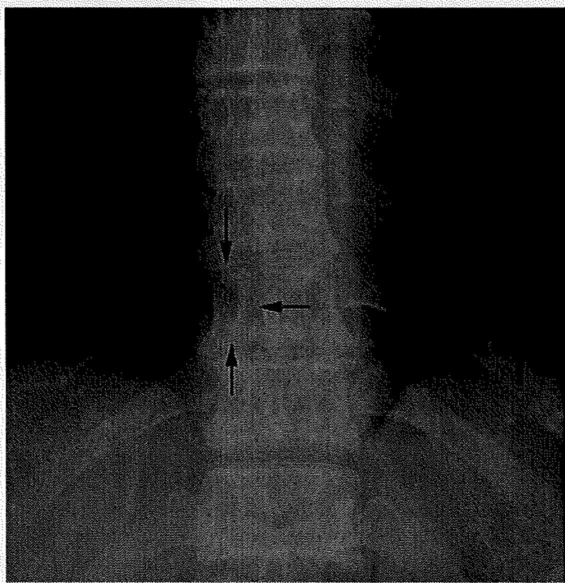

Fig. 1. Anteroposterior view of the thoracic spine shows vertical striation in the right pedicle of T10 (arrows).

was not seen. On CT, the lesion showed bulging of the right pedicle with loss of the trabecular bone and thickening of the remaining vertical osseous network. There was focal angulation of the cortex in the pedicle indicating fracture (Fig. 3). A bone scan with using technetium-99 showed subtle uptake at the right pedicle of T10. All these radiological findings were compatible with vertebral hemangioma. Percutaneous pediculoplasty using PMMA was offered to the patient as the treatment of choice. The patient provided written informed consent for the procedure.

The patient was placed on the angiography table in the prone position. The procedure was performed under local anesthesia, using an 11-gauge vertebroplasty needle (Osteo-site; Cook, Bloomington, IN, USA) that was advanced into the right pedicle of T10 under biplanar fluoroscopic guidance. After several bone samples had been taken from the pedicle with a 18-gauge biopsy needle, the needle was advanced into the posterior part of the vertebral body. PMMA powder (Cranioplastic; Johnson & Johnson, Raynham, MA, USA) was mixed with sterilized barium sulfate powder, and liquid methylmethacrylate monomer added until a toothpaste-like consistency was obtained. Under alternative frontal and lateral fluoroscopic guidance, approximately 1 ml of PMMA mixture was injected from the

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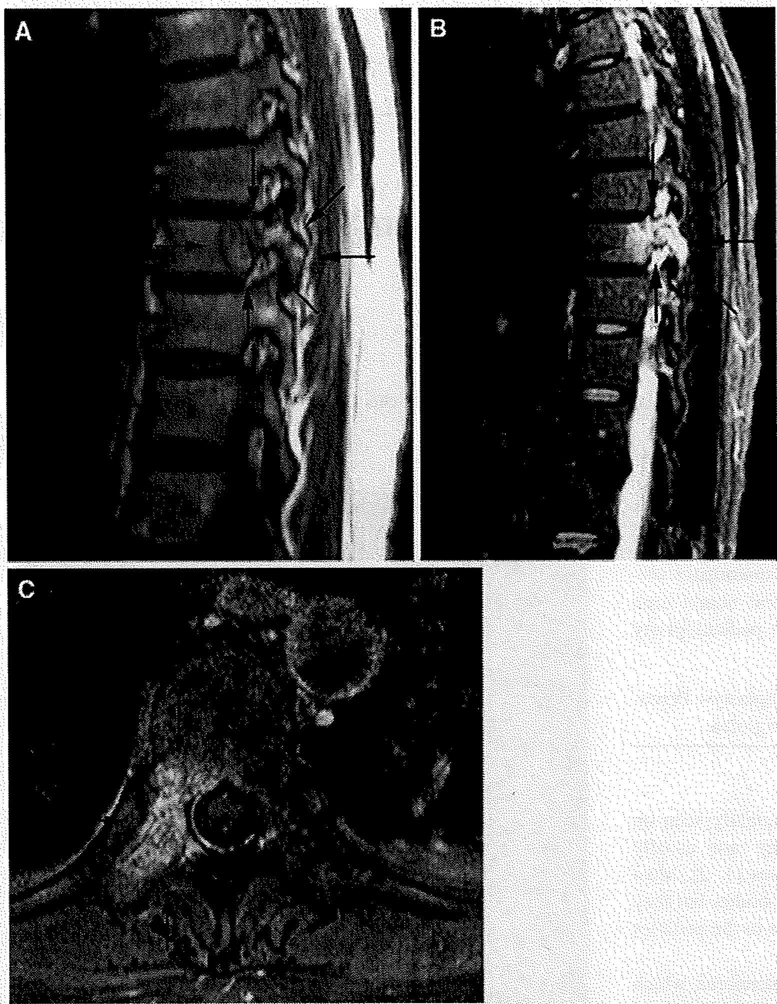

Fig. 2. **A** T1-weighted MR image shows a well-demarcated lesion in the posterior part of the vertebral body and neural arch containing heterogeneous hyperintensity (arrows). **B** STIR MR image demonstrates prominent hyperintensity in the lesion described above (arrows). **C** Contrast enhanced T1-weighted MR image shows homogeneous enhancement in the posterior part of the vertebral body, pedicle, lamina, and transverse process (arrow).

right posterior part of the vertebral body, and then the needle gradually withdrawn into the pedicle. An additional 1.5 ml of PMMA mixture was injected into the tumor of the pedicle and good cement filling was observed in the lesion of the lamina and transverse process. CT was performed after pediculoplasty and confirmed good distribution of cement in the pedicle with subtle leakage into the posterior epidural vein (Fig. 4). The bone biopsy result was nondiagnostic due to lack of sufficient bone tissue, and showed only a mixture of blood and fibrous tissue in all samples. The day after the procedure the patient's back pain was relieved to the level of the 1/10 by VAS without any complications. She was discharged without pain and instability. At 6 months follow-up, her back pain remained 1/10 by VAS and she can walk in comfort without a corset.

Discussion

Hemangioma is a benign vasoformative neoplasm or developmental condition, originating from the vascular endothelium. Autopsy studies have identified hemangioma in the vertebrae in approximately 10% of the adult population [4]. Thoracic vertebrae are most common site, followed by lumbar vertebrae and then cervical vertebrae. Hemangioma can occur at any age, but most are diagnosed during middle and late middle age, with peak incidence in the fifth decade of life. The male to female ratio is about 2:3 [4].

Symptomatic vertebral hemangiomas are rare and have a frequency of about 0.9–1.2% [1]. From the clinical point of view, symptomatic hemangioma can be classified into painful hemangioma and those with neurologic symptoms [1, 4, 5]. The most frequent symptom is severe mechanical back pain that increases with movement, even minimal movement such as shifting position in a chair, as noted in our case [1]. The neurologic symptoms may be related to nerve root/or spinal cord compression by the vertebral hemangioma invading the neural foramen or epidural space [1, 3].

From the radiological point of view, vertebral hemangiomas can be classified into nonaggressive and aggressive types. Plain radiographs typically show the nonaggressive type as localized and regular vertical striation of the vertebral bodies. CT shows replacement of the trabecular bone by a low-density area indicating fatty tissue, and thickening of the remaining vertical osseous network. On MRI there is hyperintensity on both T1- and T2-weighted images with intense enhancement after intravenous injection of contrast medium [1, 3]. Aggressive vertebral hemangiomas are characterized radiologically by involvement of the entire vertebra with an irregular honeycomb appearance of trabeculation, expanded and poorly defined cortical bone, and paravertebral soft tissue mass [1, 3, 6]. They are symptomatic in most cases [1].

In our case, the radiological findings showed expanded cortical bone, a regular honeycomb appearance of trabeculation with fracture of the cortical bone, and fatty tissue in the tumor. These

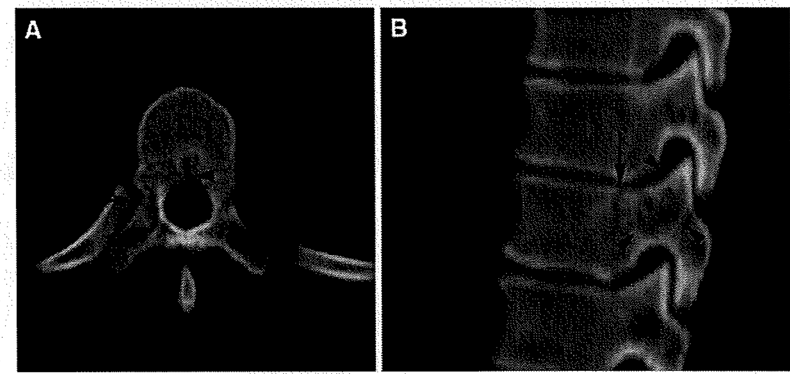

Fig. 3. A Axial and B sagittal CT images demonstrate focal bulging of the right pedicle (arrowheads) and fracture lines in the anterior part of the right pedicle (arrows).

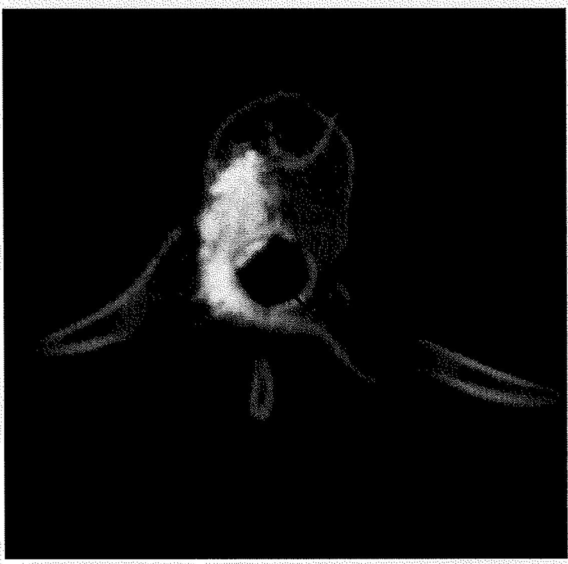

Fig. 4. Axial CT scan after PMMA injection shows good cement distribution in the vertebral body and right neural arch. Minimal extravasation of PMMA into the epidural vein is noted (arrow).

findings would classify the hemangioma radiologically as focally aggressive, although pathologic confirmation was not obtained. Aggressive hemangiomas occasionally extend to the pedicle, but those located mainly in the pedicle are uncommon and are usually symptomatic [1, 3].

Treatments for the aggressive vertebral hemangioma include surgery, radiation therapy, transarterial embolization, ethanol injection therapy, and percutaneous sclerotherapy [1, 7, 8].

Over the past 10 years, percutaneous vertebroplasty (PV) has been used extensively for pain relief and bone strengthening of weakened vertebral bodies. There is a general consensus that PV has approximately 90% efficacy in pain relief [2]. Since the first description of PV by Galibert et al. [9] in 1987 for the treatment of aggressive and symptomatic C2 angioma, many investigators have described the efficacy of PV in treating vertebral hemangiomas [2, 5, 10]. Deramond et al. [11] reported the efficacy of PV for symptomatic hemangioma with a long-term follow-up in 61 patients. Structural reinforcement was reportedly obtained in all patients with relief of back pain in more than 90% of cases. Complications were noted in less than 1% of patients.

There have been few reports referring to the treatment of the pedicles (pediculoplasty) using PV. Eyheremendy et al. [12] reported 5 cases of percutaneous pediculoplasty for osteoporotic compression fracture with pedicular fracture. They did not inject cement into the pedicle, but rather pulled back the needle and filled the needle tract with thick PMMA after injecting PMMA into the vertebral body using a single needle. Martin et al. [13] described percutaneous pediculoplasty for 51 cases of metastatic vertebral tumors with pedicular involvement using a single-needle technique. They mentioned that it was sufficient to deliver only the amount of cement contained in the lumen of the needle (0.7 ml) in most patients. Gailloud et al. [14] described a case of vertebral hemangioma of the pedicle treated by pediculoplasty. They placed two needles through the unilateral pedicle: one in the pedicle and the other in the vertebral body. PMMA was first injected into the pedicle and then into the vertebral body, so that they could see the medial cortex of the pedicle in the anteroposterior plane while injecting PMMA into the pedicle.

In our case, the lesion occupied the entire right pedicle, lamina, right transverse process, and posterior part of the vertebral body. We were able to inject a sufficient amount of PMMA into the tumor using a single-needle technique under biplanar fluoroscopic control, injecting cement first into the vertebral body and then into the pedicular lesion while withdrawing the needle. Although PMMA in the vertebral body makes the medial cortex of the pedicle invisible in the anteroposterior plane as pointed out by Gailloud et al. [14], it is possible to identify the distribution of cement in the pedicle in the lateral plane by using high-quality biplanar fluoroscopy.

We believe that symptomatic lesions in the pedicles, such as hemangioma, can successfully be treated with percutaneous pediculoplasty using a single-needle technique.

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