Objective: For the treatment of osteoporotic vertebral compression fracture, percutaneous vertebroplasty (PVP) is currently widely used as an effective and relatively safe procedure. However, some patients do not experience pain relief after PVP. We performed several additional PVP procedures in those patients who did not have any improvement of pain after their initial PVP and we obtained good results. Our purpose is to demonstrate the effective results of an additional PVP procedure at the same previously treated level.

Methods: We reviewed the medical records and the radiologic data of the PVP procedures that were performed at our hospital from November 2005 to May 2008 to determine the patients who had undergone additional PVP. We identified ten patients and we measured the clinical outcomes according to the visual analogue scale (VAS) score and the radiologic parameters, including the anterior body height and the kyphotic angulation.

Results: The mean volume of polymethylmethacrylate injected into each vertebrae was 4.3 mL (range: 2-8 mL). The mean VAS score was reduced from 8 to 2.32. The anterior body height was increased from 1.7 cm to 2.32 cm. The kyphotic angulation was restored from 10.14 degrees to 2.32 degrees. There were no complications noted.

Conclusion: The clinical and radiologic outcomes suggest that additional PVP is effective for relieving pain and restoring the vertebral body in patients who have unrelieved pain after their initial PVP. Our study demonstrates that additional PVP performed at the previously-treated vertebral levels could provide therapeutic benefit.

KEY WORDS: Percutaneous vertebroplasty · Vertebral compression fracture · Unrelieved pain.
a population of patients that underwent additional PVP for their unrelieved pain. Between November 2005 and May 2008, 1,057 cases were diagnosed with osteoporotic VCFs, and ten patients received additional PVP at the previously treated level due to unrelieved pain after the initial PVP. Almost all the recurrent pain after PVP usually represents newly developed fractures at other different vertebral levels. We excluded these subsequent VCFs at other vertebral levels. For those patients with unrelieved pain, we reevaluated them with X-rays, computed tomography (CT) and magnetic resonance image (MRI). We treated them with conservative techniques such as analgesics, medial branch blocks and applying a back brace. Despite the conservative treatments, their pain did not improve. So, we decided to perform additional PVP at the same vertebra in the patients who were refractory to conservative treatments. All the patients treated by initial PVP were prescribed with osteoporosis medication, including bisphosphonate, vitamin D and calcium. The clinical and radiologic outcomes were assessed by using the preoperative and postoperative visual analogue scale (VAS) score and such parameters as the preoperative and postoperative anterior body height and the kyphotic angulation. The kyphotic angulation was measured by the angulation of the lower end plate lines between the upper vertebra and the involved vertebra on the lateral radiographs. The technique for additional PVP was similar to that of the initial procedure. PVP was performed by the unilateral or bilateral transpedicular approach, which was determined by the symptoms and the MRI findings. We prefer the direction on the side where the more severe pain is located. Polymethylmethacrylate (PMMA) cement (DePuy International Ltd., UK) was mixed with barium sulfate powder, and this was allowed to polymerize to a toothpaste-like density. The PMMA was carefully injected by monitoring the procedure with a C-arm fluoroscope to check for cement leaks into the neural canal or the venous channel.

RESULTS

The characteristics of the patients who underwent an additional PVP procedure are shown in Table 1. They consisted of eight women and two men, and their mean age was 75 years (range: 65-82 years). All patients had severe osteoporosis, as was confirmed by their bone mineral density (mean T score: -5.3, range: -3.26 - -5.76). These patients were prescribed risendronate and calcium carbonate mixed with vitamin D in order not to aggravate the osteoporosis. The mean period between the two procedures was 114 days (range: 16-710 days). The mean amount of injected cement was 4.2 mL (range: 2.8 mL). The thoracolumbar areas were mostly involved (T6: 1 case, T12: 3 cases, L1: 2 cases, L2: 3 cases, L3: 1 case). Four patients received their initial PVP at other hospitals and six patients received their initial PVP at our hospital. Seven patients among these patients were revealed to have avascular necrosis (AVN) of the vertebral body at the previously treated level on the rechecked MRI. Their images showed high signal intensity on the T2 weighted image and low signal intensity on the T1 image of the sagittal and axial MRIs, and this was suggestive of a fluid collection. There were no other subsequent fractures. During the additional PVP, the bone cement was well injected along the cavity that was made by the fluid collection. We were able to confirm the restoration of the kyphotic angulation by the postoperative radiographs. All the patients showed improvement for their pain and mobility. The anterior vertebral body height (preoperative: 1.7 cm ± 0.56 cm and postoperative: 2.32 ± 0.43 cm) and the kyphotic angulation (preoperative: 10.14 ± 4.35 degrees and postoperative: 2.32 ± 3.21 degrees) were restored. The VAS score for back pain was improved from 8 to 2.6. No serious complications related to the procedure occurred.

Table 1. The patients' characteristics

|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Sex | F | F | F | M | F | F | M | F | F | F |
| Age | 82 | 78 | 65 | 79 | 76 | 82 | 76 | 81 | 65 | 65 |
| Level | L1 | T12 | L2 | T12 | L1 | L2 | T12 | L2 | T6 | L3 |
| Interval (days) | 710 | 71 | 111 | 72 | 20 | 16 | 36 | 30 | 41 | 36 |
| Cement 1st (mL) | 45 | * | * | * | 6 | 6 | 5 | * | 1.5 | 5 |
| Cement 2nd (mL) | 4 | 5 | 3 | 8 | 6 | 4 | 4 | 4.5 | 2 | 2.5 |
| MRI findings | Fluid | Fluid | Fluid | Fluid | Fluid | Fluid | Fluid | Fluid | Fluid | Fluid |
| Approach 1st | Lt | Both | Both | Both | Lt | Both | Lt | Both | Lt | Rt |
| Approach 2nd | Lt | Rt | Lt | Rt | Lt | Both | Both | Both | Rt | Lt |
| F/U period (months) | 21.6 | 31 | 30.6 | 25.5 | 25 | 12 | 12.5 | 12 | 12 | 34 |

*The exact amount of cement injected could not be checked, because the initial PVPs were done at other hospital. F/U : follow up, PVP : percutaneous vertebroplasty.
DISCUSSION

The back pain of osteoporotic VCFs may be related to the intraosseous or periosteal nerves being worsened by their motion around the fracture site. This has been supported by studies in which PVP increases the vertebral body strength and stiffness. Although PVP is usually effective to provide pain relief, a few patients experience no improvement of their pain after PVP. There have been only a few articles that have focused on those patients who failed to respond to the PVP and the causes of this failure to respond to PVP were not clarified. Some biomechanical tests have suggested that the strength and the stiffness of the vertebral body are weakly correlated with the volume of injected cement. Nevertheless, a sufficient amount of cement may be necessary for pain relief in at least some patients. We thought that an inadequate amount of injected cement may be one of the causes of unrelieved pain. Unrelieved pain after the initial PVP may have other causes as well. In most of the additional PVP cases reported in the literature, the preoperative MRI images showed a fluid collection, which means AVN of the vertebral body. AVN is a known disease entity and various terms have been used to name it, such as intravertebral vacuum cleft, intra-vertebral pseudoarthrosis, vertebral osteonecrosis, vertebral fluid collection associated with vertebral collapse, delayed post-traumatic vertebral collapse and Kümmell's disease. Malagut et al. first described the intravertebral vacuum cleft phenomenon as the accumulation of gas within a vertebral body, which was defined as a pathognomonic sign for AVN. AVN can also be caused by malignancy, infection, radiotherapy, steroid treatment and other systemic diseases. In our cases, there were no past or present histories of any of the conditions mentioned above, except trauma. We think that AVN of the vertebral body is closely related to the re-collapse of the vertebral body. Performing the PVP can not prevent the progression of AVN of the vertebral body. So, although we conducted the PVP, AVN of the vertebral body may have progressed and caused a re-collapse of the vertebral body. The re-collapse of the vertebral body may be a cause of unrelieved pain despite performing the cement augmentation procedure. Heo et al. reported that eleven patients out of a total of 343 had a re-collapse of the same vertebra after PVP for an approximate 3% incidence rate. They suggested that osteonecrosis is one of the important predisposing factors for the re-collapse of a vertebral body. The incidence rate of vertebral re-collapse was significantly higher for the patients with osteonecrosis than that for the patients without osteonecrosis (28.57% vs. 1.24%, respectively). He et al. reported that additional PVP achieved excellent pain relief in all fifteen patients of their study. All the patients had improved mobility and they stopped their use of analgesics within 24 hours after additional PVP. Among the fifteen patients, four patients had a vacuum cavity filled with fluid, which can be called AVN. They suggested the cause of the unrelieved pain after PVP to be the absence or inadequate filling of cement in the unstable fractured areas of the vertebral body. They emphasized that a sufficient amount of cement should be injected into the area that is responsible for the pain for the successful treatment of osteoporotic VCFs. Other authors have mentioned some strategies after the initial failure of PVP to treatment VCFs, such as additional PVP or the anterior or posterior approached fusion techniques. However, the patients enrolled in this study were elderly and they had severe osteoporosis. Instead of fusion, we performed additional PVP, which is a relatively safe and minimally invasive procedure, and we obtained good results. The trajectory route in our additional PVP proce-

![Fig. 1. Preoperative MRI (A) shows the fluid collection around the bone cement, and preoperative CT (B) shows the scattered cement with vacuum at T12 level.](image1)

![Fig. 2. Preoperative (A) and postoperative (B) radiographs show the filling of cement and improvement of kyphotic angulation at T12 level.](image2)
dures was decided upon with considering where the patients felt the most pain and where the cement was least filled, as assessed on MRI. We tried to position the needle as close to the center of the vertebral body as possible under the guidance of a fluoroscope. However, for cases where the needle positioning was in an unwanted direction, a transpedicular approach was taken on both sides. In most of our cases where fluid existed, the cement was inserted into the cavity created by the aspiration, and even if the fluid was not fully aspirated, the overall procedure was smoothly carried out. During the additional PVPs, these procedures were safely and feasibly performed without any complications.

There are some limitations in this study. The number of cases enrolled in our study was not sufficient to assess the statistical outcome. The causes of the unrelieved pain after PVP were not definitely proven and the rationales for the efficacy of additional PVP are perhaps insufficient. Yet in our study, all the patients treated with additional PVP experienced an considerable improvement of their pain. Though the mechanism of the pain relief for additional PVP remains elusive, performing the additional PVP may be an effective therapeutic option prior to performing fusion. When we do not obtain enough pain relief after PVP, then additional PVP could be one of the treatment options for the successful management of VCFs.

CONCLUSION

For the cases of unrelieved pain after PVP, a retri of additional PVP can be considered after conservative treatment has failed. The clinical outcomes of our study suggest that repeat PVP performed at the previously-treated vertebral levels for unrelieved pain provides excellent therapeutic benefit.

References
1. Alvarez L, Alcaraz M, Perez-Higuera A, Granizo JJ, de Miguel I, Rossi RE, et al.: Percutaneous vertebroplasty: functional improvement in patients with osteoporotic compression fractures. Spine (Phila Pa 1976) 31:1113-1118, 2006
2. Belkoff SM, Mathis JM, Jasper LE, Deramon H: The biomechanics of vertebroplasty. The effect of cement volume on mechanical behavior. Spine (Phila Pa 1976) 26:1537-1541, 2001
3. Chou LH, Knight RQ: Idiopathic avascular necrosis of a vertebral body. Case report and literature review. Spine (Phila Pa 1976) 22:1928-1932, 1997
4. Gaughen JR, Jensen ME, Schweickert PA, Marx WF, Kallmes DF: The therapeutic benefit of repeat percutaneous vertebroplasty at previously treated vertebral levels. AJNR Am J Neuroradiol 23:1657-1661, 2002
5. Grohs JG, Matzner M, Trieb K, Kepler P: Treatment of intravertebral pseudoarthrosis by balloon kyphoplasty. J Spinal Disord Tech 19:560-565, 2006
6. Heo DH, Chin DK, Yoon YS, Kuh SU: Recollapse of previous vertebral compression fracture after percutaneous vertebroplasty. Osteoporos Int 20:473-480, 2009
7. He SC, Teng GJ, Deung G, Fang W, Guo JH, Zhu GY, et al.: Repeat vertebroplasty for unrelieved pain at previously treated vertebral levels with osteoporotic vertebroplasty compression fractures. Spine (Phila Pa 1976) 33:640-647, 2008
8. Jang JS, Kim DY, Lee SH: Efficacy of percutaneous vertebroplasty in the treatment of intravertebral pseudoarthrosis associated with noninfectious avascular necrosis of the vertebral body. Spine (Phila Pa 1976) 28:1588-1592, 2003
9. Lafforgue P, Chagnaud C, Daumen-Legre V, Daver L, Kasbarian M, Acquaviva PC: The intravertebral vacuum phenomenon (“vertebral osteonecrosis”). Migration of intradiscal gas in a fractured vertebral body? Spine (Phila Pa 1976) 22:1885-1891, 1997
10. Leslie-Mazwi T, Deen HG: Repeated fracture of a vertebral body after treatment with balloon kyphoplasty: case illustration. J Neurosurg Spine 4:270, 2006
11. Maheshwari PR, Nagar AM, Prasad SS, Shah JR, Patkar DP: Avascular necrosis of spine: a rare appearance. Spine (Phila Pa 1976) 29:E119-E122, 2004
12. Maldague BE, Noel HM, Malghem JJ: The intravertebral vacuum cleft: a sign of ischemic vertebral collapse. Radiology 129:23-29, 1978
13. Molly S, Mathis JM, Belkoff SM: The effect of vertebral body percentage fill on mechanical behavior during percutaneous vertebroplasty. Spine (Phila Pa 1976) 28:1549-1554, 2003
14. Noh CH, Yi JS, Lee HJ, Yang JH, Lee IW, Kim MC: Effect of percutaneous vertebroplasty with polymethylmethacrylate to osteoporotic spinal compression fractures and bursting fractures. J Korean Neurosurg Soc 35:365-371, 2004
15. Oh YK, Ruy KS, Park CK, Kang JK: Epidermal leakage of polymethylmethacrylate following percutaneous vertebroplasty in the patients with osteoporotic vertebral compression fractures. J Korean Neurosurg Soc 30:319-324, 2001
16. Polkeite A, Nolte LP, Ferguson SJ: The effect of cement augmentation on the load transfer in an osteoporotic functional spinal unit: finite-element analysis. Spine (Phila Pa 1976) 28:991-996 2003
17. Steinmann J, Tingery CT, Cruz G, Dai Q: Biomechanical comparison of unipedicular versus bipedicular kyphoplasty. Spine (Phila Pa 1976) 30:201-205, 2005
18. Sugita M, Watanabe N, Mikami Y, Hase H, Kubo T: Classification of vertebral compression fractures in the osteoporotic spine. J Spinal Disord Tech 18:376-381, 2005
19. Tohneh AG, Mathis JM, Fenton DC, Levine AM, Belkoff SM: Biomechanical efficacy of unipedicular versus bipedicular vertebroplasty for the management of osteoporotic compression fractures. Spine (Phila Pa 1976) 24:1772-1776, 1999
20. Yang SC, Chen WJ, Yu SW, Tu YK, Kao YH, Chueng KC: Revision strategies for complications and failure of vertebroplasties. Eur Spine J 17:982-988, 2008