

Percutaneous Polymethylmethacrylate Vertebroplasty for the Treatment of Adjacent Vertebral Body Fracture after Long Spinal Instrumentation

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Abstract: Objectives: This study aims to assess clinical performance regarding pain relief and spinal stabilization with or without using PMMA (polymethylmethacrylate) for the treatment of adjacent vertebral body fracture after long spinal instrumentation. **Methods:** Twenty-four patients that underwent spinal instrumentation of at least 4 segments due to osteoporotic compression fracture (11 patients) or degenerative scoliosis (13 patients) developed adjacent vertebral fractures. They were 22 female and 2 male patients with an average age of 69 years old (range: 54-77 years). The mean follow-up was 25 months. Percutaneous vertebroplasty was performed in 11 patients, and another 13 received conservative treatment. **Results:** The results were assessed clinically and radiographically. Clinical follow-up involved an evaluation using the Huskisson's visual analog scale (VAS: 0 mm means no pain and 100 mm means the most pain possible) and mobility (walking ability, 4 grades). Preoperative and postoperative radiographs were compared to evaluate the maintenance of vertebral body height and sagittal alignment. There were no major complications in the vertebroplasty group. Immediate pain relief (vertebroplasty group: 73 to 29, control: 72 to 68), reduction in pain after the final follow-up (vertebroplasty group: 32, control: 65), and improvement in walking ability (vertebroplasty group: 2.3 to 0.5, control group: 2.4 to 1.5) were significantly satisfactory in the vertebroplasty group ($p < 0.05$). The maintenance of sagittal alignment [vertebroplasty group: 8° (range, -15° to 25°) to 2° (range, -20° to 22°), control: 9° (range, -5° to 25°) to 19° (range, 3° to 45°)] and vertebral body height [vertebroplasty group: 0.63 (range, 0.40 to 0.88) to 0.7 (range, 0.41 to 0.92), control: 0.68 (range, 0.51 to 0.87) to 0.56 (range, 0.30 to 0.75)] was also significantly satisfactory in the vertebroplasty group ($p < 0.05$). **Conclusions:** Percutaneous vertebroplasty provides significant pain relief and maintenance of sagittal alignment in the adjacent vertebral body fracture after long spinal instrumentation. It is a useful and safe procedure for painful adjacent vertebral body fracture after long spinal instrumentation.

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1. Introduction

In biomechanical studies, spinal instrumentation has strong rigidity at the fused level, and might cause extra stress on the adjacent vertebral segments.¹⁻³ The number of segments fused can also promote adjacent segmental disease, for the longer lever arm produced with polysegmental fusions causes more stress at the remaining free segments.⁴ The extra stress may superimpose the adjacent vertebral pathology and even cause vertebral fractures.⁵ Percutaneous vertebroplasty (PV) with polymethylmethacrylate (PMMA) is a radiologically-guided therapeutic procedure that has been used successfully to treat aggressive vertebral angiomas and painful osteolytic vertebral tumors.^{6,7} The procedure has subsequently been extended to patients with osteoporotic compression fractures. It results in good pain relief and has a low complication rate.⁸⁻¹¹ There are very few reports on the use of vertebroplasty in the management of adjacent vertebral body fracture after long spinal instrumentation. The purpose of this study was to

assess clinical performance regarding pain relief and spinal stabilization with or without the use of PMMA for the treatment of adjacent vertebral body fracture after long spinal instrumentation.

2. Materials and Methods

Twenty-four patients that underwent spinal instrumentation of at least 4 segments due to osteoporotic compression fracture (11 patients) or degenerative scoliosis (13 patients) developed adjacent vertebral fractures. They were 22 female and 2 male patients with an average age of 69 years old (range: 54-77 years). The mean follow-up was 25 months. The conditions of treatment were discussed with the patients and the benefit/risk ratio was carefully explained. Eleven patients (vertebroplasty group) underwent PV treatment and another 13 (control group) received conservative treatment, including bed rest, analgesics, and bracing. The fracture locations were from the T4 to the L4 level (Table 1).

The vertebroplasty procedures were performed after neuroleptanalgesia and under local anesthesia with the patients in the prone position. In all cases, vertebroplasty was done under fluoroscopic guidance with a guide pin through the pedicle into the fractured vertebra. Then, a cannulated obturator was placed over the guide pin to create a larger working channel advancing into the anterior of the vertebrae body. After correctly positioning the needle, the inner stylet was removed. Contrast material was then injected to assure that the needle was not positioned in the venous flow path. If this occurred, repositioning of the needle was required. The PMMA powder was mixed with liquid and contrast medium to increase its radio-opacity until a homogenous liquid form was achieved. The flow of the cement was followed on the image intensifier. The needle was repositioned if the cement preferentially flowed to the endplate fractures or into the adjacent venous flow pathway. The distribution of the cement was usually homogenous after injection (Figure 1A, B). A follow-up CT (Figure 1C) was done routinely within a few hours after the procedure to evaluate the extent of filling, the distribution of cement in the vertebral body, and the avoidance of cement flowing into the spinal canal, the neural foramina, the adjacent intervertebral discs, paravertebral tissues, or paraspinal veins. Adverse effects, pain, and radiographs were evaluated before and after treatment, and at follow-up. The patients were asked to quantify their degree of pain using a Huskisson's visual analog scale¹² (VAS: 0 mm means no pain and 100 mm means the most pain possible). Mobility was assessed using the following semiquantitative scale: 0, walking without assistance; 1, walking with assistance; 2, wheelchair-bound; 3, activity restricted to sitting in bed; 4, bedridden.¹³ The vertical height of all pretreatment, post-treatment, and follow-up fractured vertebrae were measured in series. The vertebral height was defined as the distance (endplate to endplate) at the center (A) of the vertebral body on a lateral spinal radiograph. The vertical height (B) of the vertebra above the fractured vertebra was also measured to give an estimate of the pre-fracture height.¹⁴ The ratio of vertebral height (A/B) was calculated to evaluate the maintenance of the vertebral body height in series. Sagittal alignment was measured as the angle between the lower endplate of the intact vertebrae above the lesioned vertebra and the lower end plate of the lesioned vertebra. Data for preoperative and postoperative radiographic analysis were compared using a Student's t test. Fish's exact test was used to analyze the outcome data for each group. A p value of <0.05 was considered significant.

3. Results

The vertebroplasty group tolerated the

percutaneous PMMA vertebroplasty procedure well, and the VAS scores decreased significantly between baseline and after injection, and between baseline and the final follow-up (Table 2). The scoring did not significantly change in the control group. Immediate pain relief (vertebral group: 73 to 29, control: 72 to 68) and the reduction in pain after the final follow-up (vertebral group: 32, control: 65) were significantly satisfactory in the vertebroplasty group ($p < 0.05$). In the vertebroplasty group (Table 3), the middle/posterior body height ratio was 0.63 before treatment, 0.73 after treatment, and 0.70 at the final follow-up. In the control group, the middle/posterior body height ratio was 0.68 at baseline, and showed a progressive loss to 0.56 at the final follow-up. The sagittal alignment varied from a maximum kyphotic angle of 25 degrees to a minimum lordotic angle of 15 degrees, with an final average improvement of 6 degrees (Table 4) in the vertebroplasty group. In the control group, kyphosis varied from a maximum kyphotic angle of 25 degrees to a minimum lordotic angle of 5 degrees, with an average worsening of 10 degrees in the final follow-up. The maintenance of sagittal alignment and vertebral body height was significantly satisfactory, as well, in the vertebroplasty group (Figs 1, 2). There was no major systemic complication in the vertebroplasty group. The mean bone mineral density was available in 18 of 24 cases, with a T score < -2.5 for the femoral neck.

4. Discussion

Many reports have suggested that spinal fusion creates a significant compensatory increased motion in the adjacent mobile segments through the increased stiffness of the fused segments.¹⁻³ These levels were thought to be subjected to higher loads during normal activities. There is also a common belief that the fusion of parts of the spine creates extra stress in the neighboring unfused segments, and that the longer and stiffer the fusion mass, the greater this stress.³⁻⁵ The extra stress may be superimposed on the adjacent vertebral deformity and exaggerate the clinical symptoms. The minimal approach^{15,16} of vertebroplasty can avoid that surgical intervention in this complex problem is fraught with complications and poor results, especially in patients with advanced osteoporosis.¹⁷ To prevent the disastrous situation of an adjacent pathology, attention must be paid to the treatment of this complex problem, although no beneficial effect of vertebroplasty as compared with a sham procedure in patients with painful osteoporotic vertebral fracture has been reported.^{18,19} Radiographically-evident vertebral deformities are recognized as discrete clinical events characterized by persistent pain which typically is less when the patient is at rest and worse when the patient is active.^{20,21} This

is consistent with our findings in the control group, in which there was persistent pain and no significant improvement in walking ability. The PV procedure was introduced for the treatment of osteoporosis in patients who have prolonged pain and disability following vertebral fractures.²² Studies have shown that this procedure is associated with good pain relief.^{20,22,23} As the menopausal symptoms, high prevalence of menopausal symptoms that adversely affected their quality of life, the chronic pain is associated with the poor quality of life.^{24,25} Walking ability improved an average of 1.8 grades in our vertebroplasty group compared with 1.9 grades in Tohmeh's study.²⁶ Our results are promising and match previous reports.

Complications after PV occur with extremely low frequency. The complication rate in osteoporotic fractures is 1%-3%, and as high as 10% in the treatment of metastatic lesions.^{6,7,23} The risks and complications of vertebroplasty, including bleeding, infection, pain, cement leakage, nerve root compression, paralysis and pulmonary embolization have been reported.²⁷⁻³² Most of the complications resulted from the injection of cement. The best way to inject cement safely without unexpected or undesired migration has been discussed widely. First, we believe that careful patient selection is essential to the success of PV. Second, safe needle placement under fluoroscopy must avoid not only the spinal canal and existing nerve roots, but also the center of the posterior portion of the vertebral body, where there may be a higher likelihood of entering a large channel of the basivertebral plexus. Good visualization of the clear anatomy and cement deposition are very important, especially in patients with severe scoliosis. Imaging of the thoracic and lumbar vertebra would be hampered by air in the lung and bowel gas, respectively. We stress the benefit of biplane fluoroscopic guidance, which is better than portable fluoroscopy and stationary C-arm equipment, to produce live images. The imaging quality of biplane fluoroscopy is superior to the others and it makes real time cement monitoring possible. Third, no obvious neurologic side effect has occurred during follow-up till now. We believe that early postoperative detection of undesired cement migration is as important as safe cement injection, especially with regard to most neurologic complications, and allows the operator to take action before the situation deteriorates and becomes irreversible. With proper patient selection and good technique, complications after vertebroplasty have been infrequent, and most were minor.^{9,19,33,34} There were no major systemic complications in this series.

However, there were some limitations to this study. One is that this was not a prospective

randomized clinical trial, although most variables were collected. The other is that the number of patients available was small. The research team is currently considering increasing the patient sample size and arranging a prospective randomized clinical trial. In conclusion, PV provided significant pain relief and satisfactory maintenance of sagittal alignment in the painful adjacent vertebral body fracture after long spinal instrumentation. It is a safe and useful procedure for painful adjacent vertebral body fractures after long spinal instrumentation.

Table 1. Fracture level

	Vertebroplasty Group		Control
T4			1
T6			1
T8	1		1
T10	2		
T11			1
T12	2		1
L1	4		5
L3	1		2
L4	1		1

The locations of fracture were from the T4 to L4 levels. In the vertebroplasty group, 3 patients had a fracture in the thoracic region (T8-T10), 6 in the thoracolumbar region (T11-L2), and 2 in the low lumbar region (L2-L4). In the control group, 3 patients had a fracture in the thoracic region (T4-T8), 7 in the thoracolumbar region (T11-L2) and 3 in the low lumbar region (L2-L4).

Table 2. Changes over time in the verbal scale

	Initial	Follow-up	Final
Vertebroplasty Group		73±21	29±20* 32±19*
Control		72±23	68±22 65±18**

The VAS scores decreased significantly between baseline and after injection, and between baseline and the final follow-up. The scoring did not significantly change in the control group.

* $p < 0.05$ (pair-wise comparisons from base line)

** $p < 0.05$ (pair-wise comparisons between the vertebroplasty and control groups)

Table 3

	Initial	Follow-up	Final
Vertebroplasty	0.63	0.73	0.7
Group	(Range: 0.40↔0.88)	(Range: 0.45↔0.96)	(Range: 0.41↔0.92)
Control	0.68	0.62	0.56*
	(Range: 0.51↔0.87)	(Range: 0.42↔0.80)	(Range: 0.30↔0.75)

The average restoration of the fractured vertebral body height was significantly satisfactory in the vertebroplasty group.

* p<0.05 (pair-wise comparisons between the vertebroplasty and control groups)

Table 4. Segmental Kyphosis

	Initial	Follow-up	Final
Vertebroplasty	8°	1°	2°
Group	(Range: -15°↔25°)	(Range: -22°↔20°)	(Range: -20°↔22°)
Control	9°	15°	19°*
	(Range: -5°↔25°)	(Range: 0°↔40°)	(Range: 3°↔45°)

The maintenance of sagittal alignment was significantly satisfactory in the vertebroplasty group.

* p<0.05 (pair-wise comparisons between the vertebroplasty and control groups)

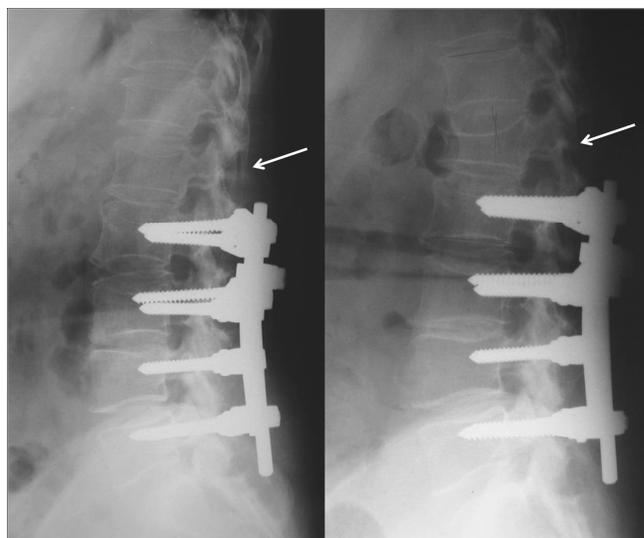


Fig. 1A. A 65-year-old female who had received spinal operation one year before suffered from intractable back pain with buttock radiation after falling. The radiography showed a L1 osteoporotic vertebral compression fracture.

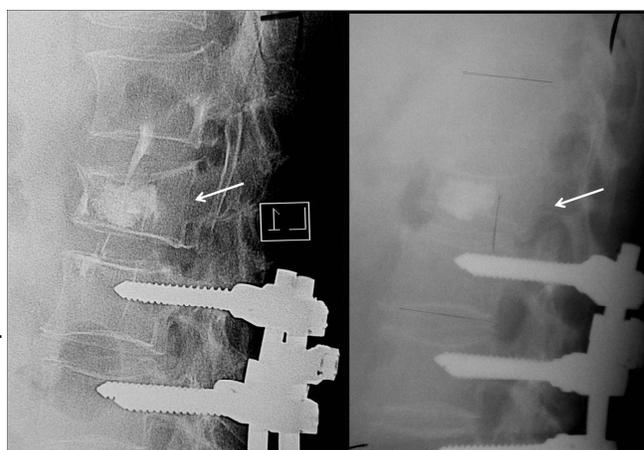


Fig. 1B. The postoperative radiography revealed good augmentation of the fractured vertebral body after cement pouring, and the maintenance of sagittal alignment and vertebral body height were good in the final follow-up.



Fig. 1C. Postvertebroplasty CT showed cement was in the vertebral body without leakage and the previous inserted needle hole (arrow) was noted.

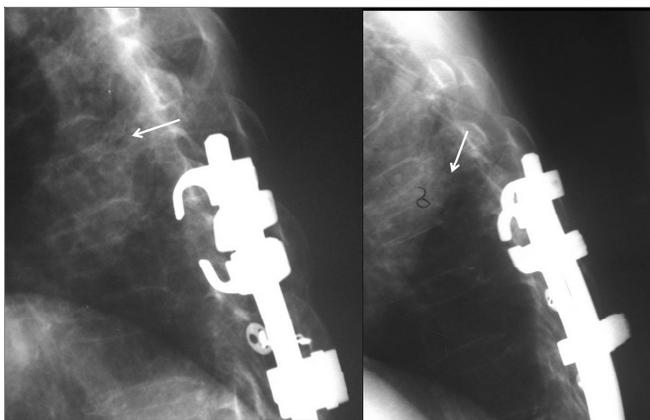


Fig. 2A. A 68-year-old female who had received spinal operation 15 months before suffered from intractable back pain after falling. The radiography showed a T6 osteoporotic vertebral compression fracture.

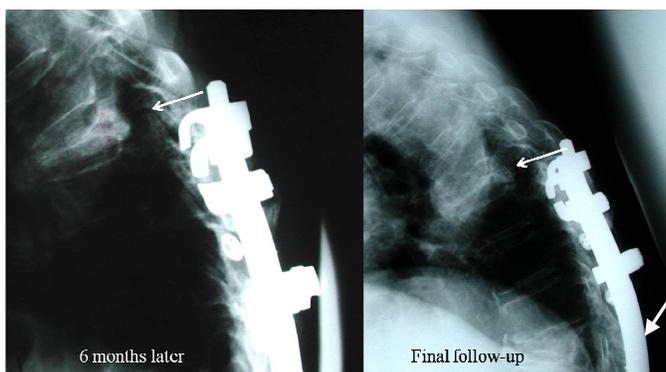


Fig. 2B. Radiographic evaluation of the vertebral compression fracture demonstrated loss of vertebral body height and significantly increased segmental kyphosis at the final follow-up.

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