

Original Article

Comparison of hyperextension reduction and balloon dilation method combined with vertebroplasty in treatment of osteoporotic vertebral compressive fractures

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Abstract: Vertebroplasty is often used to treat osteoporotic vertebral compression fractures (OVCF). The number of affected vertebrae can be reduced to a certain extent by some reduction methods including hyperextension and balloon dilation. There have been only a few studies on the effectiveness of vertebroplasty combined with hyperextension or balloon dilation. We collected data of 216 OVCF patients who underwent vertebroplasty between January 2010 and September 2014. These patients were divided into the balloon dilation group (66 patients) and hyperextension group (150 patients). Balloon dilation or hyperextension was performed under C-arm fluoroscopic guidance. Vertebroplasty was then carried out by injecting bone cement. After surgery, the degree of reduction, bone cement distribution, presence of bone cement leakage, anterior vertebral body height, Cobb angle, visual analog scale (VAS) score, and Oswestry Disability Index (ODI) score were measured. The results showed that both balloon dilation and hyperextension can relieve pain and improve the quality of life, and that there were no significant differences between the two groups in VAS score or ODI score. However, the outcomes of vertebral height restoration and improvement of kyphosis were significantly better in the balloon dilation group compared with the hyperextension group. Intervertebral or anterior extravertebral cement leakage occurred in 19 patients, 6 were in the balloon dilation group and 13 were in the hyperextension group. There were no complications such as spinal cord injury, infection, and pulmonary embolism. In conclusion, both hyperextension and balloon dilation are safe and effective when combined with vertebroplasty. Balloon dilation is more effective for restoring vertebral height and improving spinal kyphosis.

Keywords: Osteoporotic vertebral compressive fractures, hyperextension reduction, balloon, percutaneous vertebroplasty

Introduction

In an increasingly aged society the number of patients with osteoporotic vertebral compression fractures (OVCF) will increase. There are non-surgical and surgical treatments for OVCF. Non-surgical treatment requires bed rest for a long time, which is very harmful for elderly patients and may increase the risk of residual back pain and spinal kyphosis. Traditional pedicle screw fixation is often used for young patients with good bone quality. However, OVCF usually involves elderly patients and the bone-internal fixation interface may not meet the requirement for stable fixation. Therefore, pedicle screw fixation is not suitable for OVCF patients. Percutaneous vertebroplasty (PVP) is

a minimally invasive spinal surgery procedure that can be used to treat OVCF effectively. PVP can be combined with hyperextension or balloon dilation to restore anterior vertebral body height (AVBH) and improve spinopelvic balance. However, there have been few studies on the outcomes of hyperextension and balloon dilation with regard to the restoration of vertebral height and improvement of spinal kyphosis.

Materials and methods

General information

A total of 216 OVCF patients who underwent vertebroplasty between January 2010 and September 2014 were included in the present

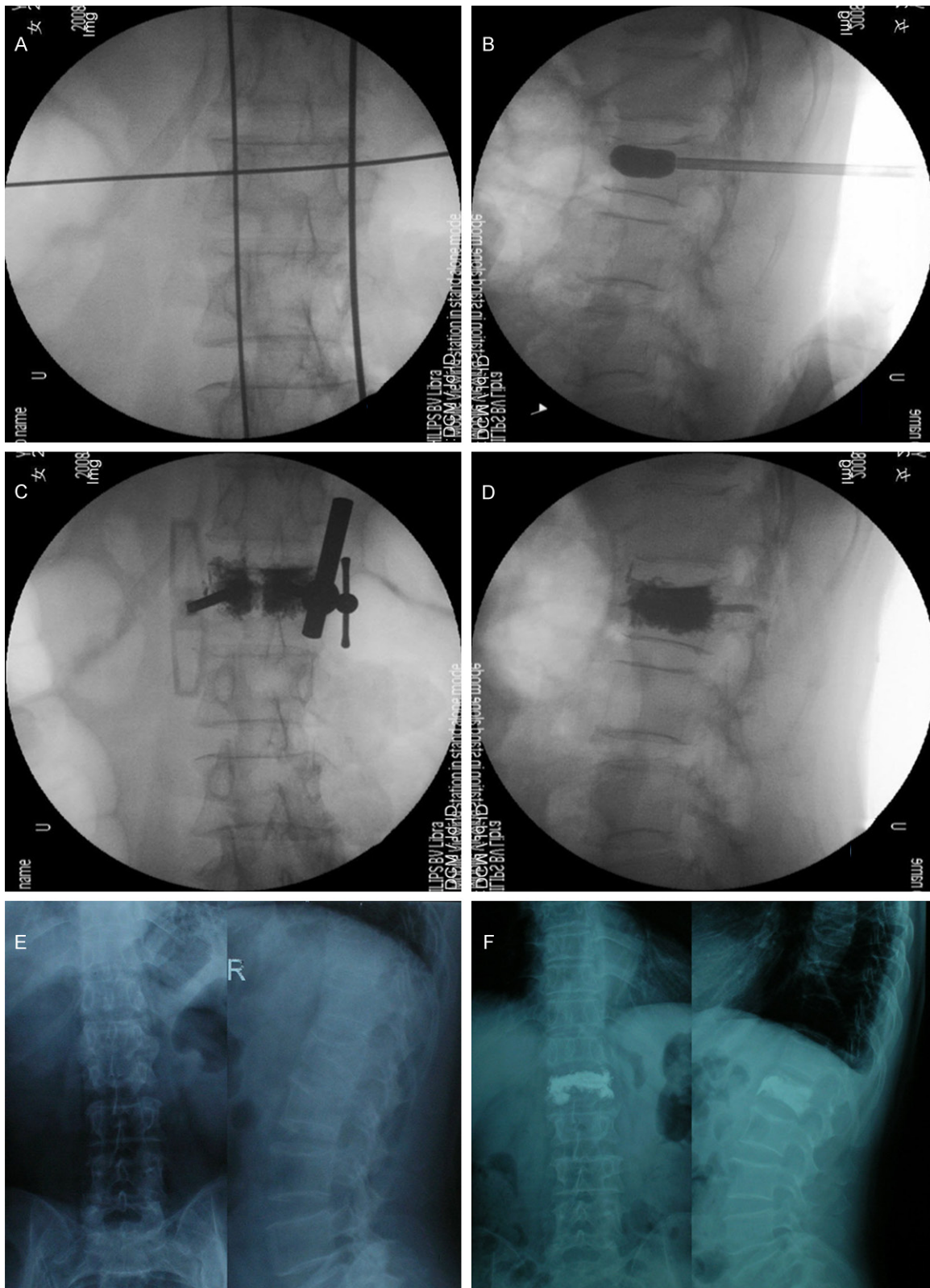


Figure 1. Data of a percutaneous balloon kyphoplasty case. A: The projection points of bilateral pedicles on the posterior aspect were located under C-arm fluoroscopic guidance; B: The balloon was dilated after successful puncture; C: Anteroposterior and lateral radiographs of the thoracolumbar spine after injecting bone cement; D: Postoperative lateral view of fluoroscopy; E: An OVCF case involving L1 (PKP was performed); F: Anteroposterior and lateral radiographs of the thoracolumbar spine obtained one year after surgery showed that the reduction of the affected vertebra was excellent and there was no loss of correction in vertebral height.

study. Their mean age was 66.8 years (range, 54 to 91 years) and the mean time interval between injury and surgery was 2.8 days (range, 1 to 20 days). All patients had fresh fractures following mild injuries. X-ray together with CT or MRI was used for diagnosis. There were no symptoms or signs of nerve injury. The level of injury was at T8 in 3 patients, T9 in 6, T10 in 13, T11 in 33, T12 in 57, L1 in 62, L2 in 24, L3 in 13, and L4 in 5. Preoperative examinations such as routine blood tests, liver and kidney function tests, chest X-ray, and ECG did not show significant contraindications to surgery. The 216 patients were divided into a balloon dilation group and hyperextension group. The balloon dilation group included 66 patients and the hyperextension group included 150 patients. Bone cement was injected after reduction.

Therapeutic method

Patients were placed in the prone position. In the hyperextension group, the fractured vertebra was reduced by hyperextension using the function of the operating table. The outcome of reduction was observed under the C-arm fluoroscope. After satisfactory reduction, the projection of a pedicle of the affected vertebra was marked. Local anesthesia was applied and a puncture needle was inserted via the pedicle to the middle of the vertebral body. Then bone cement (2-5 mL) was injected.

In the patients in the balloon dilation group, a puncture needle was inserted under C-arm fluoroscopic guidance and a balloon was placed into the vertebral body. The balloon was dilated by injecting contrast agent into it to reduce the fractured vertebra. The balloon was removed after satisfactory dilation and bone cement (2-5 mL) was injected via the working sleeve. The status of bone cement injection was observed closely under the C-arm fluoroscope to prevent epidural cement leakage (**Figure 1**).

Ten minutes after surgery, the bone cement became hard and patients in both groups were discharged to their own wards. Crutch-assisted partial weight bearing was started one day after surgery. Following surgery, all patients were asked to comply with long-term anti-osteoporosis treatment to prevent the occurrence of a new OVCF caused by fall injury.

Observation and statistical treatment

Thoracolumbar spine radiographs were obtained after surgery to observe the degree of reduction of the fractured vertebra, distribution of the bone cement, and presence of cement leakage. The AVBH and Cobb angle were measured on the lateral radiograph to identify the degree of reduction of the fractured vertebra. Visual analog scale (VAS) scores and Oswestry Disability Index (ODI) scores were recorded. SPSS 16.0 was used for data analysis. Paired t-test was used for all preoperative and postoperative data and data of last follow-up.

Results

In the balloon dilation group the mean operative time was 41 minutes (range, 32 to 77 minutes) and in the hyperextension group the mean operative time was 33 minutes (range, 18 to 49 minutes). In both groups, 2-5 ml of bone cement were injected into each vertebral body. The mean amount of injected bone cement was 3.5 mL in the balloon dilation group and 2.8 mL in the hyperextension group. Postoperative anteroposterior and lateral radiographs showed that the bone cement filling was excellent. intervertebral or anterior extravertebral cement leakage occurred in 19 patients, 6 were in the balloon dilation group and 13 were in the hyperextension group. Cement leakage into the spinal canal was not observed. There were no complications such as massive bleeding, spinal cord injury, infection, and pulmonary embolism.

Fifty-one patients in the balloon dilation group and 121 in the hyperextension group were followed up. Forty-four patients were lost to follow-up. The mean follow-up period was 19.6 months (range, 12 to 37 months). The results showed that pain relief occurred immediately after surgery in both groups and there were no significant differences between the two groups in the VAS score (**Table 1**) or ODI score (**Table 2**). The outcomes of vertebral height restoration and improvement of kyphosis were significantly better in the balloon dilation group compared with the hyperextension group (**Tables 3 and 4**).

Discussion

The number of patients with OVCF will rise in an increasingly aged society, resulting in high

Balloon vertebroplasty in osteoporotic vertebral compressive fractures

Table 1. Evaluation of pain (VAS score)

	Pre-operation VAS	Short-time VAS	Long time VAS
Balloon dilation group	7.47±0.85	3.25±1.06*	1.74±1.13*
Hyperextension group	7.11±1.02	3.69±0.89*	1.89±0.98*

Tips: *compared with Pre-operation, P < 0.05.

Table 2. Evaluation of quality of life (ODI score)

	Pre-operation	Short-time ODI	Long time ODI
Balloon dilation group	52.3±3.15	35.05±7.01*	22.55±4.91*
Hyperextension group	48.9±3.36	36.64±9.82*	27.25±10.71*

Tips: *compared with Pre-operation, P < 0.05.

Table 3. Evaluation of anterior vertebral body height (AVBH)

	Pre-operation	Postoperative vertebral height
Balloon dilation group	13.7±6.01	21.71±5.11*, ^Δ
Hyperextension group	12.3±4.12	16.34±4.16*

Tips: *compared with Pre-operation, P < 0.05, ^Δcompared with hyperextension group, P < 0.05.

Table 4. Evaluation of Cobb angle

	Pre-operation	Cobb angle-short	Cobb angle-long
Balloon dilation group	25.7±7.05	7.69±4.01*, ^Δ	8.59±4.98*, ^Δ
Hyperextension group	24.1±6.32	10.84±3.85*	12.67±4.31*

Tips: *compared with Pre-operation, P < 0.05, ^Δcompared with hyperextension group, P < 0.05.

medical expenses. Non-surgical treatments for OVCF include bed rest, analgesic administration, anti-osteoporosis medical treatment, and brace application. However, the non-surgical treatments have disadvantages such as decline in quality of life, potential risk of disability, poor patient tolerance, long recovery period, requirement of medical care, high cost, etc. Because of osteoporosis in elderly patients, open surgery using pedicle screw fixation cannot achieve strong and stable fixation, and may cause massive surgical trauma. Therefore, it is not the preferred treatment for OVCF in elderly patients.

The minimally invasive spinal surgery procedure vertebroplasty has been commonly used for the last two decades. Vertebroplasty can be used to treat OVCF, spinal metastases [1], and multiple myeloma [2]. In the treatment of OVCF, this procedure has many advantages such as approving analgesic effect, early ambulation, satisfactory quality of life, excellent functional recovery, etc. Though there is still controversy over the effect of vertebroplasty on OVCF [3],

more and more studies including a meta-analysis have provided evidence that percutaneous vertebroplasty and percutaneous balloon kyphoplasty (PKP) can significantly relieve pain, improve quality of life, and correct kyphotic deformity [4-8]. Traditional vertebroplasty cannot reduce the vertebral fracture. In order to improve vertebral body height, restore the spinopelvic balance, and correct spinal kyphosis, hyperextension or balloon dilation can be used during vertebroplasty.

There have been many studies comparing PVP and PKP. However, only a few studies have compared the effect of hyperextension with that of balloon dilation on the reduction of vertebral fracture. In the present study, we found that both hyperextension and balloon dilation can restore AVBH, improve spinal kyphosis, and achieve satisfactory outcomes by bone cement injection.

However, there were certain differences in outcome between these two reduction methods. We found that balloon dilation can obtain a better reduction and more bone cement can be injected while the risk of bone cement leakage was relatively low. Therefore, we believe that the balloon dilation is a more effective and safe method for the treatment of vertebral fracture. Previous studies have obtained similar results [9] and proved that the PKP procedure has a higher cost-effectiveness [10]. However, there were no significant differences in the VAS score and ODI score between the two groups in the present study, which showed that both methods had a similar effect on pain relief and functional recovery. This result is also similar to what others have found [11]. Hence, the hyperextension procedure is also a reliable method for use with vertebroplasty.

Both the hyperextension and balloon dilation methods are associated with a certain risk for complications. The main complications include bone cement leakage [12], spinal cord injury,

pulmonary fat embolism [13], bone cement displacement [14], and adjacent vertebral fracture. There are some key points for preventing cement leakage: application of balloon dilation for reduction [6], application of high-viscosity cement [15], accurate pedicle puncture, and continuous C-arm fluoroscopic monitoring during cement injection. During PKP, the space formed after balloon dilation can reduce the pressure produced by cement injection. Compared with PVP, though more bone cement can be injected during PKP, the distribution of bone cement in the vertebral body is more ideal and the risk of bone cement leakage is relatively low. During surgery, continuous C-arm fluoroscopic monitoring is required to prevent cement leakage into the spinal canal, which could induce spinal cord or nerve root compression. However, intervertebral cement leakage does not affect the outcome [16]. In addition, the incidence of pulmonary embolism is 2.1% to 26% [17]. Fortunately, most patients with pulmonary embolism are asymptomatic. However, emergency treatment should be carried out for patients with related symptoms. Careful preoperative evaluation and intraoperative close monitoring is necessary to prevent this complication.

Adjacent vertebral fractures and new VCFs are common complications of vertebroplasty. The main predictive factors include degree of osteoporosis, altered biomechanics due to spinopelvic imbalance [18], initial multiple-level fractures [19], etc. Movrin [20] found that the risk of adjacent vertebral fracture is very low after PKP or PVP, which is similar to that of conservative treatment. Even if the adjacent vertebral OVCF occurs, it can be treated by PKP or PVP again. Therefore, we had the patients in the present study receive routine anti-osteoporosis treatment after surgery and recommended measures to prevent a fall.

In conclusion, both hyperextension and balloon dilation are safe and effective when combined with vertebroplasty. Balloon dilation is more effective for restoring vertebral height and improving spinal kyphosis.

Disclosure of conflict of interest

None.

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References

- [1] Liu W, Zhou S, Wang S. Application of percutaneous vertebroplasty in the treatment of multiple thoracic metastases. *Oncol Lett* 2015; 9: 2775-2780.
- [2] Tosi P, Sintini M, Molinari AL, Imola M, Ciotta G, Tomassetti S, Mianulli AM, Ratta M, Mangianti S, Merli A, Polli V. Early application of percutaneous vertebroplasty reduces pain without affecting peripheral blood stem cell (PBSC) collection and transplant in newly diagnosed multiple myeloma (MM) patients. *Eur J Cancer Care (Engl)* 2014; 23: 773-778.
- [3] Macías-Hernández SI, Chávez-Arias DD, Miranda-Duarte A, Coronado-Zarco R, Díez-García MP. Percutaneous Vertebroplasty Versus Conservative Treatment and Rehabilitation in Women with Vertebral Fractures due to Osteoporosis: A Prospective Comparative Study. *Rev Invest Clin* 2015; 67: 98-103.
- [4] Saxena BP, Shah BV, Joshi SP. Outcome of percutaneous balloon kyphoplasty in vertebral compression fractures. *Indian J Orthop* 2015; 49: 458-464.
- [5] Shi-Ming G, Wen-Juan L, Yun-Mei H, Yin-Sheng W, Mei-Ya H, Yan-Ping L. Percutaneous vertebroplasty and percutaneous balloon kyphoplasty for osteoporotic vertebral compression fracture: A metaanalysis. *Indian J Orthop* 2015; 49: 377-387.
- [6] Wang H, Sribastav SS, Ye F, Yang C, Wang J, Liu H, Zheng Z. Comparison of Percutaneous Vertebroplasty and Balloon Kyphoplasty for the Treatment of Single Level Vertebral Compression Fractures: A Meta-analysis of the Literature. *Pain Physician* 2015; 18: 209-222.
- [7] Suh SP, Kim CW, Jo YH, Kang CN. Height Restoration after Balloon Kyphoplasty in Rheumatoid Patients with Osteoporotic Vertebral Compression Fracture. *Asian Spine J* 2015; 9: 581-586.
- [8] Chang X, Lv YF, Chen B, Li HY, Han XB, Yang K, Zhang W, Zhou Y, Li CQ. Vertebroplasty versus kyphoplasty in osteoporotic vertebral compression fracture: a meta-analysis of prospective comparative studies. *Int Orthop* 2015; 39: 491-500.
- [9] Goz V, Koehler SM, Egorova NN, Moskowitz AJ, Guillermo SA, Hecht AC, Qureshi SA. Kyphoplasty and vertebroplasty: trends in use in ambulatory and inpatient settings. *Spine J* 2011; 11: 737-344.
- [10] Edidin AA, Ong KL, Lau E, Schmier JK, Kemner JE, Kurtz SM. Cost-effectiveness analysis of treatments for vertebral compression frac-

- tures. *Appl Health Econ Health Policy* 2012; 10: 273-284.
- [11] Dong R, Chen L, Tang T, Gu Y, Luo Z, Shi Q, Li X, Zhou Q, Yang H. Pain reduction following vertebroplasty and kyphoplasty. *Int Orthop* 2013; 37: 83-87.
 - [12] Zhang K, Shen Y, Ren Y, Zou D. Prevention and treatment of bone cement-related complications in patients receiving percutaneous kyphoplasty. *Int J Clin Exp Med* 2015; 8: 2371-2377.
 - [13] Nooh A, Abduljabbar FH, Abduljabbar AH, Jarzem P. Pulmonary Artery Cement Embolism after a Vertebroplasty. *Case Rep Orthop* 2015; 2015: 582769.
 - [14] Ha KY, Kim YH, Yoo SR, Molon JN. Bone Cement Dislodgement: One of Complications Following Bone Cement Augmentation Procedures for Osteoporotic Spinal Fracture. *J Korean Neurosurg Soc* 2015; 57: 367-370.
 - [15] Wang CH, Ma JZ, Zhang CC, Nie L. Comparison of high-viscosity cement vertebroplasty and balloon kyphoplasty for the treatment of osteoporotic vertebral compression fractures. *Pain Physician* 2015; 18: E187-194.
 - [16] Churojana A, Songsaeng D, Khumtong R, Suwanbundit A, Saliou G. Is intervertebral cement leakage a risk factor for new adjacent vertebral collapse? *Interv Neuroradiol* 2014; 20: 637-645.
 - [17] Wang LJ, Yang HL, Shi YX, Jiang WM, Chen L. Pulmonary cement embolism associated with percutaneous vertebroplasty or kyphoplasty: a systematic review. *Orthop Surg* 2012; 4: 182-189.
 - [18] Baek SW, Kim C, Chang H. The relationship between the spinopelvic balance and the incidence of adjacent vertebral fractures following percutaneous vertebroplasty. *Osteoporos Int* 2015; 26: 1507-1513.
 - [19] Ren HL, Jiang JM, Chen JT, Wang JX. Risk factors of new symptomatic vertebral compression fractures in osteoporotic patients undergone percutaneous vertebroplasty. *Eur Spine J* 2015; 24: 750-758.
 - [20] Movrin I, Vengust R, Komadina R. Adjacent vertebral fractures after percutaneous vertebral augmentation of osteoporotic vertebral compression fracture: a comparison of balloon kyphoplasty and vertebroplasty. *Arch Orthop Trauma Surg* 2010; 130: 1157-1166.