

## Original Article

# Effects of percutaneous kyphoplasty combined with pedicle screw fixation on aged osteoporotic thoracolumbar burst fracture

Wei Jiang<sup>1</sup>, Yuqing Jiang<sup>2</sup>, Haibo Li<sup>2</sup>, Xiaobin Qian<sup>2</sup>, Youjia Xu<sup>1</sup>

<sup>1</sup>Department of Orthopedics, The Second Affiliated Hospital of Soochow University, Suzhou, Jiangsu Province, China; <sup>2</sup>Department of Orthopedics, Second Hospital of Changzhou City, Nanjing Medical University, China

Received April 29, 2016; Accepted August 6, 2016; Epub October 15, 2016; Published October 30, 2016

**Abstract:** This study aimed to explore the clinical effects of percutaneous kyphoplasty combined with pedicle screw fixation on aged osteoporotic thoracolumbar burst fracture. 160 patients with aged osteoporotic thoracolumbar burst fracture treated at our hospital during January 2012 and January 2015 were enrolled. According to the digital meter method, they were randomly divided into two groups, the observational group underwent the therapy of percutaneous kyphoplasty combined with pedicle screw fixation and the control group received the treatment of pedicle screw fixation. The visual analogue scale (VAS), JOA score, Oswestry disability index (ODI) score, anterior flange height and vertebral body Cobb angle were recorded in follow-up visit at different time periods before and after operation. All patients underwent follow-up examinations for 12-24 months at home or at outpatient by therapists, averaged  $15.92 \pm 2.04$  months. The VAS scores at 1, 3 and 7d after operation were significantly lower in observational group than that of control group. The Oswestry disability index (ODI) scores at 1 week, 1 month and 2 months after operation were significantly lower in observational group than that of control group. The JOA scores at 5, 10 and 20d after operation were significantly higher in observational group than that of control group. The anterior flange height at 2 and 6 months after operation were significantly more in observational group than that of control group. The vertebral body Cobb angle at 3 and 6 months after operation were significantly lower in observational group than that of control group, with a statistically significant difference ( $P < 0.05$ ). In conclusion, percutaneous kyphoplasty combined with pedicle screw fixation therapy on aged osteoporotic thoracolumbar burst fracture are markedly effective to decrease the pain after operation and reduce the bedridden time. In addition, the thoracolumbar stability is stronger, and the anterior flange height, vertebral body Cobb angle were less changed after treatment. Thus, this method is suitable to be widely used in future.

**Keywords:** Percutaneous kyphoplasty, pedicle screw fixation, osteoporosis, thoracolumbar burst fracture

## Introduction

Aged osteoporotic thoracolumbar burst fracture is usually caused by trauma [1, 2], as for the already reduced density of vertebral bones, the inter vertebral disc hardness is more than that of vertebral body, which leads to end-plate fracture, the vertebral pulp and devastated end-plate break into vertebral body, the trabecular bone inner vertebral body is damaged [3]. The conventional pedicle screw fixation therapy can effectively recover the vertebral height of injured vertebral body [4], however, the vertebral pulp, devastated end-plate and trabecular bone inner vertebral body cannot reach the complete recovery, the vertebral body gap will be formed [5]. Another problem is the healing

time for aged osteoporotic thoracolumbar burst fracture is relatively long and a long time in bed will generate much more complications [6], so how to prevent the adverse effects induced by the aforementioned therapy is one puzzle that the clinicians face. Therefore, in this study we study the clinical effects of percutaneous kyphoplasty combined with pedicle screw fixation on aged osteoporotic thoracolumbar burst fracture, now it is reported as follows.

## Materials and methods

### General materials

Accepting criteria: ① All the patients had the obvious history of mild trauma; ② Osteoporosis

**Table 1.** Comparison of general materials between two groups

Category	Observational group	Control group	P
Sex (male/female)	49/31	53/27	
Age	68.51±9.17	69.92±6.27	>0.05
Injure cause			
Trauma in traffic accident	23	22	>0.05
Falling injury	15	16	>0.05
Heavy object crushing	22	20	>0.05
Tumble injury	17	15	>0.05
Segmental occurring of Fractures			
T <sub>10</sub> vertebral body	9	6	>0.05
T <sub>11</sub> vertebral body	4	7	>0.05
T <sub>12</sub> vertebral body	8	8	>0.05
L <sub>1</sub> vertebral body	12	11	>0.05
L <sub>2</sub> vertebral body	24	25	>0.05
L <sub>3</sub> vertebral body	13	14	>0.05
L <sub>4</sub> vertebral body	8	11	>0.05
Passing time from admisSion to operation	3.54±2.28d	3.13±1.52d	>0.05
Operation time	81.34±13.68	63.72±14.96	<0.05
Intraoperative blood lose	184.69±20.77	157.28±19.04	<0.05

was diagnosed after bone density examination; ③ Pain in the back, limited activity, pressing pain in injured spine; ④ Thoracolumbar lateral side x-ray photograph was taken before operation, MRI examination showed as new thoracolumbar burst fracture, which was accompanied with distinct degrees of vertebral body compression, back wall of vertebral body was intact and no broken bones were inside vertebral body; ⑤ There were no oppression on spinal nerves or injure manifestation; ⑥ Without disorders of important organs such as heart, brain, liver, kidney etc.; ⑦ Without diseases in blood coagulation; ⑧ Without psychological problems; 160 patients with aged osteoporotic thoracolumbar burst fracture treated at our hospital during January 2012 and January 2015 were enrolled in this study, 102 male cases and 58 female cases were included, aged 58-86 and averaged 69.71±8.35. As for the causes of injury, 55 cases were caused by trauma in traffic accident, 31 cases by falling injury, 42 cases by heavy object crushing and 32 cases by tumble; the segmental occurring of fractures were like these: 15 cases were T<sub>10</sub>, 11 cases were T<sub>11</sub>, 16 cases were T<sub>12</sub>, 23 cases were L<sub>1</sub>, 49 cases were L<sub>2</sub>, 27 cases were L<sub>3</sub> and 19 cases were L<sub>4</sub>. The passing time from admission to operation were 1-7d, averaged 3.26±2.04d. According to the digital meter

method, they were randomly divided into two groups, the observational group underwent the therapy of percutaneous kyphoplasty combined with pedicle screw fixation and the control group received the treatment of pedicle screw fixation. There were no significant differences in general materials, such as sex, age, injure cause, segmental occurring and disease course etc., without a statistically significant difference ( $P>0.05$ ). After admission, patients and family members signed informed consent and operation agreement; the study received permission of the Medical Ethics Committee and was supervised by ethics committees during the whole course. General materials can be seen in **Table 1**.

### Methods

Related examinations were completed before operation. Operation treatment can be carried out when patients' conditions were stable. The patients in observational group received general anesthesia, placed at prone position, be X-rayed by C arm machine, the positions of fracturebipedicular and its upper and bottom were determined and marked. One 8-10 cm long cut was made at post middle location, cut open skin, subcutaneous tissue, deep fascia and supraspinous ligament layer-by-layer until to

## Aged osteoporotic thoracolumbar burst fracture

**Table 2.** Comparison of VAS scores at 1, 3, 7 and 14d before and after operation between two groups

Group	Cases	Pre-operation	1d postoperation	3d postoperation	7d postoperation	14d postoperation
Observational group	80	7.35±0.81	4.33±0.92	3.14±0.89	2.21±0.82	2.13±0.88
Control group	80	7.42±0.75	5.79±0.83	4.77±0.74	3.54±0.93	2.46±0.92
T value		0.4837	2.9375	3.0216	3.2284	0.6159
P value		>0.05	<0.05	<0.05	<0.05	>0.05

**Table 3.** Comparison of ODI scores at 1 week, 1, 2 and 3 months before and after operation between two groups

Group	Cases	Pre-operation	7d postoperation	1month postoperation	2 months postoperation	3 months postoperation
Observational group	80	36.54±3.79	25.24±4.96	10.23±3.07	5.72±1.86	3.75±1.52
Control group	80	35.47±4.28	30.17±3.35	16.44±2.78	8.49±2.03	3.93±1.78
T value		0.8361	4.0253	4.7729	2.6395	0.7335
P value		>0.05	<0.05	<0.05	<0.05	>0.05

**Table 4.** Comparison of JOA scores at 5, 10 and 20d before and after operation and in the last follow-up between two groups

Group	Cases	Pre-operation	5d postoperation	10d postoperation	20d postoperation	Last follow-up
Observational group	80	14.05±3.19	21.79±3.74	23.34±2.06	25.98±2.79	27.46±3.03
Control group	80	13.83±4.06	18.17±4.28	20.71±3.62	22.33±3.64	27.09±2.65
T value		0.9338	3.2846	5.0382	4.3391	0.7483
P value		>0.05	<0.05	<0.05	<0.05	>0.05

expose vertebral fractures and two adjacent vertebral articular joints. Pedicle screw was conventionally inserted and screw-rod was put inside, puncture needle was gradually inserted through vertebral fractures unipedicular deep into 1/3 position of anterior vertebral body under X-ray fluoroscopy; when puncture needle reached desirable location, rotate and drawout needle core and put it into the guide pin, CPMM-modulating bone cement was injected through working passage; the condition of injected bone cement was observed by X-ray and the injection volume and rate were determined and well-controlled. After taking out the working passage, wash the cut, seal it layer-by-layer. The control group received therapy of single posterior pedicle screw fixation; the methods were applied as in the observational group.

### *Treatment after operation*

Administration of antibiotics, mannitol and dexamethasone for 3d after operation, anti-osteoporosis treatment was also applied at same time, oral caltrate Dor intravenous calcium sup-

plement was acceptable. Ambulation time decision for patients in two groups depends on specific circumstances; x-ray examination was reviewed after 1, 2, 4 and 8 weeks of operation.

### *Observational index*

The VAS scores at 1, 3 and 7d after operation were observed in two groups; The JOA scores at 5, 10, 20d and the last follow-up after operation were also recorded; The Oswestry disability index (ODI) scores at 1 week, 1 month and 2 months after operation were assessed; The anterior flange height at 1d, 2 and 6 months before and after operation, the vertebral body Cobb angle at 1d, 3 and 6 months were examined.

### *Statistical methods*

Data base was established with SPSS19.0 software, by which statistical analysis through count data (%) using  $\chi^2$  test is applied in this study,  $P < 0.05$  were considered with statistical significance.

**Table 5.** Comparison of anterior flange height at 1d, 2 months and 6 months before and after operation between two groups

Group	Cases	Pre-operation	1d postoperation	2 months postoperation	6 months postoperation
Observational group	80	10.78±3.39	27.35±5.26	26.03±4.97	25.82±5.11
Control group	80	10.16±4.03	27.04±4.89	24.11±3.21	23.94±5.83
T value		0.3382	0.6828	2.9379	3.7372
P value		>0.05	>0.05	<0.05	<0.05

**Table 6.** Comparison of vertebral body Cobb angle at 1d, 3 months and 6 months before and after operation between two groups

Group	Cases	Pre-operation	1d postoperation	3 months postoperation	6 months postoperation
Observational group	80	23.71±3.27	4.37±1.49	7.93±3.26	8.22±2.51
Control group	80	23.43±2.94	4.58±1.62	9.38±4.05	10.35±4.68
T value		0.7562	0.3924	2.6541	3.3958
P value		>0.05	>0.05	<0.05	<0.05

## Results

All the patients were underwent follow-up examination for 12-24 months at home or at out-patient by therapists, averaged 15.92±2.04 months. There were no significant differences in VAS scores at 14d before or after operation between two groups, without a statistically significant difference ( $P>0.05$ ). However, the VAS scores at 1, 3 and 7d after operation were significantly lower in observational group than that of control group, with a statistically significant difference ( $P<0.05$ ), see **Table 2**.

There were no significant differences in Oswestry disability index (ODI) scores before and after operation between two groups, without a statistically significant difference ( $P>0.05$ ); Nevertheless, the ODI scores at 1 week, 1 month and 2 months after operation were significantly lower in observational group than that of control group, with a statistically significant difference ( $P<0.05$ ), see **Table 3**.

There were no significant differences in JOA scores before and after operation between two groups, without a statistically significant difference ( $P>0.05$ ); The JOA scores at 5, 10 and 20d after operation were significantly higher in observational group than that of control group, with a statistically significant difference ( $P<0.05$ ), see **Table 4**.

There were no significant differences in anterior flange height at 1d before and after operation between two groups, without a statistically

significant difference ( $P>0.05$ ); The anterior flange height at 2 and 6 months after operation were significantly more in observational group than that of control group, with a statistically significant difference ( $P<0.05$ ), see **Table 5**.

There were no significant differences in vertebral body Cobb angle at 1d before and after operation between two groups, without a statistically significant difference ( $P>0.05$ ); However, the vertebral body Cobb angle at 3 and 6 months after operation were significantly lower in observational group than that of control group, with a statistically significant difference ( $P<0.05$ ), see **Table 6**.

## Discussion

Aged osteoporotic thoracolumbar burst fracture is usually caused by trauma, for the old patients with osteoporosis, burst fracture would affect the quality of life seriously if timely effective treatment is not accessible [7]. Conservative and surgery treatment are the major methods for treating aged osteoporotic thoracolumbar burst fracture at present [8]. For the conservative treatment, relatively long in-bed time is required, however, this is not suitable for aged patients with osteoporotic thoracolumbar burst fracture and osteoporosis [9]. Patients with senile osteoporosis fracture need more time to recover and long in-bed time may induce other complications, in addition, calcium loss would increase for limited activities [10]. Most patients with osteoporotic thoracolumbar burst fracture have no manifestations of spinal ste-

nosis and spinal cord compression, spinal cord is some stable [11]. In surgery therapy, posterior pedicle screws used to restore vertebral body height, but bone coloboma may accompany within vertebral body, namely shell-like change, which has high incidence in elderly patients with osteoporosis, furthermore, as for less calcium phosphate deposit, vertebral body gap cannot heal, vertebral body height may decline again.

A large body of studies suggest that, percutaneous vertebroplasty (PVP) can effectively relieve the pain resulting from vertebral fracture, facilitating functional exercises under the protection for waist as soon as possible, reducing complications induced by long in-bed time, in the meanwhile, improving overall surrounding bone environment to accelerate the growth of bones and enhance the bone intensity [12-14]. For the analgesic mechanism underlying PVP, our study proposes that bone cement filling in the gap of loosened vertebral body increases its intensity and stabilizes injured vertebra; alternatively, bone cement diffusion plays the function of adhesion for trabecular bone fracture and heals the ambient little fractures; polymerization reaction of bone cement can generate high level heat to make nerve endings within or ambient vertebral body to be necrosis and reduce sensitivity for pain in nerve [15].

The indication of PVP surgery is thoracolumbar osteoporotic fractures accompanied by severe pain, patients are bed-ridden and cannot be relieved with drug treatment; soluble osseous benign or malignant tumor associated with severe pain, osteonecrosis vertebral fractures etc.; For osteoporotic vertebral burst fracture accompanied by pain, choice of surgery treatment is especially important. Although PVP technique can relieve pain effectively, PVP alone cannot recover and sustain vertebral body height, pedicle screw fixation can solve the problem of occupation within vertebral canal, recover the height and array of injured vertebral body, but in respect of vertebral fractures in patients with osteoporosis, the therapy of pedicle screw fixation alone cannot reach satisfactory effect [16]. Because of the osteoporosis, complications such as internal fixation prolapse or loose appear frequently, which directly influence the recovery of aged patients, secondary fractures may even occur in severe cases.

Therefore, in this study we study the clinical effects of percutaneous kyphoplasty combined with pedicle screw fixation on aged osteoporotic thoracolumbar burst fracture. There is no related literature reporting the combination of these two surgical techniques. Our study shows that the clinical effects of percutaneous kyphoplasty combined with pedicle screw fixation therapy on aged osteoporotic thoracolumbar burst fracture are markedly effective. In the first place, compared to conventional posterior pedicle internal fixation therapy, the former can rapidly relieve pain, which is consistent with above viewpoints; besides, the ODI scores at 1 week, 1 month and 2 months after operation were significantly lower in observational group than that of control group; The JOA scores at 5, 10 and 20d after operation were significantly higher in observational group than that of control group; The anterior flange height at 2 and 6 months after operation were significantly more in observational group than that of control group; The vertebral body Cobb angle at 3 and 6 months after operation were significantly lower in observational group than that of control group, with a statistically significant difference ( $P < 0.05$ ), all of these evidence demonstrate the clinical effect of PVP combined with vertebral pedicle screw fixation therapy in observational group.

Of particular note is the therapy of percutaneous kyphoplasty combined with pedicle screw fixation is not suitable for all kinds of patients with osteoporosis vertebral fractures, this study indicates that this therapy is not suitable for patients accompanied by severe vertebral body compression fractures, in this type of fracture, middle and posterior column than 3/4 of vertebral body, in this situation, the vertebral anterior column is compressed severely, middle and posterior column are pulled, which result in vertebral instability; in stable vertebral compression fractures, middle and posterior column are less damaged, compression of anterior column is less than 1/2, PVP alone can obtain desirable effect; patients who can be effectively cured by drug treatment.

Overall, the clinical effects of percutaneous kyphoplasty combined with pedicle screw fixation therapy on aged osteoporotic thoracolumbar burst fracture are markedly effective, which not only decreases the pain after operation effectively, but also reduces the bedridden time, in addition, the thoracolumbar stability is



stronger, and the anterior flange height, vertebral body Cobb angle were less changed after treatment. Thus, this method is suitable to be widely used in clinic.

## Disclosure of conflict of interest

None.

**Address correspondence to:** Dr. Youjia Xu, Department of Orthopedics, The Second Affiliated Hospital of Soochow University, 1055 Sanxiang Road, Suzhou 215004, Jiangsu Province, China. E-mail: xuyouji-asahsu@163.com

## References

- [1] Singh K, Heller JG, Samartzis D, Price JS, An HS, Yoon ST, Rhee J, Ledlie JT, Phillips FM. Open vertebral cement augmentation combined with lumbar decompression for the operative management of thoracolumbar stenosis secondary to osteoporotic burst fractures. *J Spinal Disord Tech* 2005;18: 413-419.
- [2] Pang J, Guo HL, Ding DF, Wu YY, Zhao YF, Gu XF, Zheng YX. Changes of mesenchymal stromal cells mobilization and bone turnover in an experimental bone fracture model in ovariectomized mice. *Int J Clin Exp Pathol* 2015; 8: 10228-10238.
- [3] Parkinson IH, Badiei A, Stauber M, Codrington J, Muller R, Fazzalari NL. Vertebral body bone strength: The contribution of individual trabecular element morphology. *Osteoporos Int* 2012; 23: 1957-1965.
- [4] Chen YL, Chen WC, Chou CW, Chen JW, Chang CM, Lai YS, Cheng CK, Wang ST. Biomechanical study of expandable pedicle screw fixation in severe osteoporotic bone comparing with conventional and cement-augmented pedicle screws. *Med Eng Phys* 2014; 36: 1416-1420.
- [5] Boccaccio A, Kelly DJ, Pappalettere C. A mechano-regulation model of fracture repair in vertebral bodies. *J Orthop Res* 2011; 29: 433-443.
- [6] Freedman BA, Serrano JA, Belmont PJ Jr, Jackson KL, Cameron B, Neal CJ, Wells R, Yeoman C, Schoenfeld AJ. The combat burst fracture study—results of a cohort analysis of the most prevalent combat specific mechanism of major thoracolumbar spinal injury. *Arch Orthop Trauma Surg* 2014; 134: 1353-1359.
- [7] Chen C, Lv G, Xu B, Zhang X, Ma X. Posterior short-segment instrumentation and limited segmental decompression supplemented with vertebroplasty with calcium sulphate and intermediate screws for thoracolumbar burst fractures. *Eur Spine J* 2014; 23: 1548-1557.
- [8] Chen JF, Lee ST. Percutaneous vertebroplasty for treatment of thoracolumbar spine bursting fracture. *Surg Neurol* 2004; 62: 494-500; discussion 500.
- [9] Chang MC, Liu CL, Chen TH. Polymethylmethacrylate augmentation of pedicle screw for osteoporotic spinal surgery: A novel technique. *Spine (Phila Pa 1976)* 2008; 33: E317-324.
- [10] Rubin C, Recker R, Cullen D, Ryaby J, McCabe J, McLeod K. Prevention of postmenopausal bone loss by a low-magnitude, high-frequency mechanical stimuli: a clinical trial assessing compliance, efficacy, and safety. *J Bone Miner Res* 2004; 19: 343-351.
- [11] Heini PF. The current treatment—a survey of osteoporotic fracture treatment. Osteoporotic spine fractures: The spine surgeon's perspective. *Osteoporos Int* 2005; 16 Suppl 2: S85-92.
- [12] Mathis JM, Barr JD, Belkoff SM, Barr MS, Jensen ME, Deraumont H. Percutaneous vertebroplasty: a developing standard of care for vertebral compression fractures. *AJNR Am J Neuroradiol* 2001; 22: 373-381.
- [13] Kobayashi K, Shimoyama K, Nakamura K, Murata K. Percutaneous vertebroplasty immediately relieves pain of osteoporotic vertebral compression fractures and prevents prolonged immobilization of patients. *Eur Radiol* 2005; 15: 360-367.
- [14] Rousing R, Andersen MO, Jespersen SM, Thomsen K, Lauritsen J. Percutaneous vertebroplasty compared to conservative treatment in patients with painful acute or subacute osteoporotic vertebral fractures: Three-months follow-up in a clinical randomized study. *Spine (Phila Pa 1976)* 2009; 34: 1349-1354.
- [15] Golz T, Graham CR, Busch LC, Wulf J, Winder RJ. Temperature elevation during simulated polymethylmethacrylate (pmma) cranioplasty in a cadaver model. *J Clin Neurosci* 2010; 17: 617-622.
- [16] Yang Z, Tan J, Xu Y, Sun H, Xie L, Zhao R, Wang J, Jiang H. Treatment of mm-associated spinal fracture with percutaneous vertebroplasty (pvp) and chemotherapy. *Eur Spine J* 2012; 21: 912-919.