

# Effects of Percutaneous Kyphoplasty on Bone Metabolism and Oxidative Stress in Elderly Patients with Osteoporotic Spinal Fractures

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## ABSTRACT

**Objective:** To investigate the effects of percutaneous kyphoplasty on bone metabolism and oxidative stress in elderly patients with osteoporotic spinal fractures.

**Study Design:** An experimental study.

**Place and Duration of Study:** Department of Orthopedics, ZhangYe People's Hospital Affiliated to HeXi University, from February 2016 to October 2017.

**Methodology:** A total of 100 elderly patients with osteoporotic spinal fractures were randomly divided into the observation group treated with percutaneous kyphoplasty (PKP) and the control group treated with percutaneous vertebroplasty (PVP), with 50 cases in each group. One month after surgery, the content of serum bone metabolic markers bone gla protein (BGP), carboxyl-terminal collagen I crosslinks ( $\beta$ -CTX), bone alkaline phosphatase (BALP) and tartrate-resistant acid phosphatase (TRACP), oxidative stress markers malondialdehyde (MDA), total antioxidant capacity (TAC) and superoxide dismutase (SOD) were compared between the two groups. Visual analogue scale (VAS) and the Oswestry Disability Index (ODI) were used to evaluate the degree of pain and functional status of the two groups, and the Cobb angles were measured in both groups.

**Results:** One month after surgery, the level of the serum bone metabolic marker BGP in the observation group was higher than the control group ( $p < 0.001$ ), and the levels of  $\beta$ -CTX, BALP and TRACP in the observation group were lower than the control group (all  $p < 0.001$ ). The level of the serum oxidative stress marker MDA in the observation group was lower than the control group ( $p < 0.001$ ), and the levels of TAC and SOD in the observation group were higher than the control group (all  $p < 0.001$ ). There were no significant differences in VAS scores and ODI values between the two groups ( $p = 0.806$  and  $0.913$ , respectively). Cobb's angle of the injured vertebrae in the observation group was smaller than the control group ( $p < 0.001$ ).

**Conclusion:** Compared with PVP, PKP is more effective in treating elderly patients with osteoporotic spinal fractures. It can effectively optimise bone metabolism, promote fracture healing, and reduce the oxidative stress reactions after surgery, with a relatively larger application value.

**Key Words:** *Percutaneous vertebroplasty, Percutaneous kyphoplasty, Osteoporosis, Spinal fractures, Bone metabolism, Oxidative stress.*

## INTRODUCTION

With age, the human body shows a progressive decline in bone strength, resulting in the loss of bone mass and, to a large extent, increasing in the incidence of osteoporotic spinal fractures.<sup>1</sup> Spinal fracture is a common complication of osteoporosis and often seen in the elderly. In the clinical treatment of elderly patients with osteoporotic spinal fractures, the main therapeutic principles are to relieve pain, promote fracture healing and improve functional activities.<sup>2,3</sup>

Conservative treatments of patients with osteoporotic spinal fractures usually include staying in flat bed, physical therapy and functional training, and medical therapy; but these methods are unable to relieve patients' sustained and severe pain quickly and effectively. Due to the further compression on the injured vertebra after the patient is up and about, pain and kyphosis may worsen, resulting in a smaller chest volume, disorders of ventilation, chronic hypoxia, cardiopulmonary dysfunction and significantly increased mortality.<sup>4,5</sup>

In recent years, the newly-emerged percutaneous vertebroplasty (PVP) and the percutaneous kyphoplasty (PKP), developed on this basis, have the advantages of minimally invasive surgery, fast pain relief and full improvement of kyphosis, and open up a new way for the treatment of such refractory diseases.<sup>6</sup>

The purpose of this study was to analyse the effects of PKP on bone metabolism and oxidative stress in elderly patients with osteoporotic spinal fractures.

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## METHODOLOGY

This study was conducted at the Department of Orthopedics, ZhangYe People's Hospital Affiliated to HeXi University, from February 2016 to October 2017. A total of 100 elderly patients with osteoporotic spinal fractures were selected as research object. Inclusion criteria were patients aged above 60 years who met the diagnostic criteria of osteoporosis, confirmed as osteoporotic spinal fractures by the preoperative X-ray and magnetic resonance imaging (MRI) examinations, fresh vertebral compression fractures, without damage of the pedicle of the vertebral arch, and intact cortex of the posterior marginal bone of the vertebra. Exclusion criteria were patients with secondary osteoporotic compression fractures, vertebral fractures caused by primary or metastatic tumours, and patients who could not tolerate surgery or cooperate with the doctor due to disorders of consciousness. The subject was approved by the medical Ethics Committee of the Hospital, and all patients have signed an informed consent.

A total of 100 patients were randomly divided into two groups by numerical form. There were 50 cases in each group, which were the control group and the observation group. The control group was treated with PVP. The patients were placed in a prone position and lateral pillows were placed horizontally under the manubrium and the anterior superior iliac spine, to maintain the thoracolumbar spine hyperextension. Surface projection of the pedicle of the vertebral arch of the injured vertebra was positioned with a C-arm and marked. After routine disinfection and draping, local anaesthesia was performed with a mixture of 10 ml 2% lidocaine injection, 10 ml 0.75% ropivacaine injection and 20 ml normal saline. Puncturing was performed in an angle of about 15 degrees between the direction above the anteroposterior pedicle of the vertebral arch and the sagittal plane under the C-arm X-ray monitoring. The puncture needle passed through the pedicle of the vertebral arch and gradually entered the body so as to make the needle reach upto one-third of the vertebra. Check the position of the puncture needle and remove the core after the position was well confirmed. The poly methyl methacrylate (PMMA) bone cement was stirred into a paste and was slowly injected into the injured vertebra under the X-ray monitoring. The injection was stopped when the bone cement was seen to infiltrate along the trabecular space and a burr-like edge was found on the bone cortex. If the bone cement in the vertebra diffused to the posterior edge of the vertebra or the bone cement leaked out, the injection would be stopped immediately. The puncture needle was pulled out after the bone cement completely solidified. The puncture point was pressed for a few minutes with sterile gauze and the wound was bound up after no bleeding was observed.

The observation group was treated with PKP. Patient's position, and the methods of anaesthesia and puncture were the same as the control group. After the puncture, the working cannula was replaced. A bone drill was inserted into the vertebra along the working cannula and was placed at 2~3cm from the anterior wall of the vertebra, to establish a working channel. Then the bone drill was removed and a guide wire was used to probe the working channel. A balloon was placed along the working channel and the developer was slowly injected into the expanded balloon under the X-ray monitoring. The pressure was stopped when the vertebra restored to a satisfactory height. Then the developer and the balloon were withdrawn. PMMA bone cement was stirred into a paste and was slowly pushed into the injured vertebra with a push rod under the X-ray monitoring. Injection was stopped when the bone cement was seen to infiltrate along the trabecular space and a burr-like edge was found on the bone cortex. Subsequent operations were also consistent with the control group.

One month after surgery, blood samples 3~5ml were taken from the two groups of patients in the cubital vein. After anticoagulation and low-speed centrifugation, the supernatant serum was taken and stored in a cryogenic environment for use. Radioimmunoassay was used to determine the content of serum bone metabolic markers bone gla protein (BGP), carboxyl-terminal collagen I crosslinks ( $\beta$ -CTX), bone alkaline phosphatase (BALP) and tartrate-resistant acid phosphatase (TRACP). Enzyme-linked immunosorbent assay (ELISA) was used to determine the content of oxidative stress markers malondialdehyde (MDA), total antioxidant capacity (TAC) and superoxide dismutase (SOD). One month after surgery, visual analogue scale (VAS) and the Oswestry Disability Index (ODI) were used to evaluate the degree of pain and functional status of the two groups, and the Cobb angles were measured in both groups.

SPSS 22.0 software was used for data analysis. Measurement data were expressed as mean  $\pm$  standard deviation and the independent samples t-test was used for comparison. A difference with a p-value less than 0.05 was considered statistically significant.

## RESULTS

Of the 100 subjects, 44 (44.00%) were males and 56 (56.00%) were females; the age ranged from 61 to 80 years, mean 73.23  $\pm$  2.05 years.

One month after surgery, the level of the serum bone metabolic marker BGP in the observation group was higher than the control group ( $p < 0.001$ ), and the levels of  $\beta$ -CTX, BALP and TRACP in the observation group were all lower than the control group (all  $p < 0.001$ , Table I).

**Table I:** Comparison of serum bone metabolic indexes.

Groups	n	BGP (µg/L)		β-CTX (ng/mL)		BALP (pg/mL)		TRACP (pg/mL)	
		Mean ±SD	p-value	Mean ±SD	p-value	Mean ±SD	p-value	Mean ±SD	p-value
Control group	50	2.82 ±1.02	<0.001	0.29 ±0.07	<0.001	51.71 ±4.81	<0.001	3.68 ±0.38	<0.001
Observation group	50	4.37 ±0.77		0.18 ±0.04		31.66 ±4.07		2.09 ±0.18	

**Table II:** Comparison of serum oxidative stress indexes in the two groups one month after surgery.

Groups	n	MDA (µmol/L)		TAC (kU/L)		SOD (nU/mL)	
		Mean ±SD	p-value	Mean ±SD	p-value	Mean ±SD	p-value
Control group	50	3.08 ±0.16	<0.001	10.91 ±0.67	<0.001	82.64 ±5.11	<0.001
Observation group	50	1.72 ±0.11		13.25 ±0.99		93.43 ±4.52	

**Table III:** Comparison of VAS scores, ODI values and the Cobb angle of the injured vertebra in the two groups one month after surgery.

Groups	n	VAS Scores (score)		ODI Values (%)		Cobb angle of the injured vertebra (°)	
		Mean ±SD	p-value	Mean ±SD	p-value	Mean ±SD	p-value
Control group	50	1.98 ±0.48	0.806	30.04 ±2.67	0.913	17.58 ±2.24	<0.001
Observation group	50	1.96 ±0.32		29.97 ±3.61		10.21 ±2.68	

One month after surgery, the level of the serum oxidative stress marker MDA in the observation group was lower than the control group ( $p < 0.001$ ), and the levels of TAC and SOD in the observation group were both higher than the control group (all  $p < 0.001$ , Table II).

One month after surgery, there were no significant differences in VAS scores and ODI values between the two groups ( $p = 0.806$  and  $0.913$ , respectively). Cobb's angle of the injured vertebrae in the observation group was smaller than the control group ( $p < 0.001$ , Table III).

### DISCUSSION

Elderly patients usually have severe calcium deficiency, so the incidence of osteoporosis is relatively high in elderly patients. They have a lower bone density and a thinner cortex, which increases the incidence of concurrent compression fractures in the spine, not only affecting the patients' health, but also reducing the patients' quality of life.<sup>7,8</sup> Patients with osteoporotic spinal compression will have a strong sense of pain and thoracic stenosis will occur, leading to cardio-pulmonary impairment and even death in severe cases.<sup>9,10</sup> In recent years, PVP and PKP, two minimally invasive surgical methods, have shown the advantages of high safety, simple operation, less trauma and fewer complications, and have been widely used in the treatment of patients with osteoporotic spinal fractures.<sup>11,12</sup>

Osteoporosis is a metabolic disease involving increased bone resorption and decreased bone formation. When the bone resorption increases, the trabecular bone microstructure will change and bone calcium mobilization will increase, directly causing back pain and other associated symptoms.<sup>13,14</sup> Detection of bone metabolic markers in the patient's serum can directly reflect the balance of bone formation/bone resorption, and thus can be used to judge the therapeutic effect and the incidence of long-term fracture.<sup>15</sup> The content of

BGP, β-CTX, BALP, TRACP and other bone metabolic markers can objectively reflect the progress of fracture healing.<sup>16,17</sup> The results of this study showed that one month after surgery, the level of the serum bone metabolic marker BGP in the observation group was higher than the control group, and the levels of β-CTX, BALP and TRACP in the observation group were all lower than the control group. It suggested that percutaneous kyphoplasty (PKP) can more effectively increase the activity of osteoblasts, and at the same time properly inhibit the activity of osteoclasts, making the overall fracture process progress toward the direction of bone deposition. The effectiveness and feasibility of PKP were thus objectively confirmed.

After an acute fracture, the patient suffers from both psychological and physical shock and is prone to systemic oxidative stress. The release of large amounts of oxygen radicals and the appearance of oxidative metabolites at the fracture end are not conducive to revascularisation and bone deposition.<sup>18</sup> Some studies have shown that oxidative stress may promote bone destruction, up-regulate the bone destruction indexes and lead to the occurrence of low bone mass in fracture patients, breaking the balance between bone repair and bone destruction and causing the occurrence and development of osteoporosis.<sup>19,20</sup> MDA, TAC and SOD are common oxidative stress markers.<sup>21</sup> This study found that one month after surgery, the level of the serum oxidative stress marker MDA in the observation group was lower than the control group, and the levels of TAC and SOD in the observation group were both higher than the control group. It suggested that the therapeutic effect of percutaneous kyphoplasty (PKP) was closely related to its inhibition of systemic oxidative stress reactions and its restoration of the body's oxidative/antioxidative balance.

The results of this study also showed no significant differences in VAS scores and ODI values between the

two groups one month after surgery. It suggested that both PVP and PKP can effectively relieve the patient's back pain and improve the patient's dysfunction. This may be due to the analgesic effects of PMMA bone cement used in PVP and PKP. At the same time, the dispersion and solidification of PMMA bone cement can increase the bone strength of the vertebra and enhance the stability of the spinal system, thereby reducing the neuropathic pain caused by small movements at the fracture site.<sup>22,23</sup> After further comparison, it was found that the Cobb's angle of the injured vertebra in the observation group was smaller than the control group one month after surgery. This suggested that PKP was superior to PVP in restoring the height of the vertebra. This may be due to the use of an expansion balloon in PKP. The expanded balloon can effectively support the collapsed endplate, so as to achieve the purposes of restoring the height of the vertebra and correcting kyphosis.

## CONCLUSION

Compared with PVP, PKP is more effective in treating elderly patients with osteoporotic spinal fractures. PKP can effectively optimise bone metabolism, promote fracture healing, and reduce the oxidative stress reactions after surgery, with a relatively large application value.

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