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Comparative Study of Percutaneous Kyphoplasty and Hyperextension Reduction Combined with Percutaneous Vertebroplasty in the Treatment of Osteoporotic Thoracolumbar Compression Fractures in the Elderly

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Abstract: *Objective:* This paper aims to explore the clinical effects of percutaneous kyphoplasty (PKP) and hyperextension reduction combined with percutaneous vertebroplasty (PVP) in elderly patients with osteoporotic thoracolumbar compression fractures (OVCF). *Methods:* A sample of 62 elderly OVCF patients was selected. The admission time was from June 2022 to June 2023. They were randomly divided into a study group (n = 31) and a control group (n = 31) using computer software lottery method. Patients in the control group were treated with PKP, while patients in the study group were treated with hyperextension reduction combined with PVP. The operation time, hospitalization time, the number of fluoroscopy, treatment costs, visual analog pain score (VAS), vertebral body height, and Cobb angle of the injured vertebra were compared between the two groups. *Results:* The operation time, hospitalization time, number of fluoroscopy, and treatment costs of the patients in the study group were all lower than those in the control group ($P < 0.05$). The VAS scores of the two groups after surgery were lower than those before surgery, and there was no significant difference between the groups ($P > 0.05$). After surgery, the vertebral body heights in both groups were more significant than before surgery, and the Cobb angle of the injured vertebra was smaller than before surgery. There was no significant difference between the groups ($P > 0.05$). *Conclusion:* PKP and hyperextension reduction combined with PVP treatment in elderly patients with OVCF can relieve pain and restore vertebral body height and Cobb angle. However, hyperextension reduction combined with PVP treatment can shorten the operation time and hospitalization time, with low treatment cost, which has the potential value to be widely applied.

Keywords: PKP; Hyperextension reduction; PVP; Osteoporotic thoracolumbar compression fractures; Elderly

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1. Introduction

Osteoporosis has a higher incidence among older people, which can lead to loss of bone mass, increased bone

fragility, trabecular bone degeneration, and other pathological changes. Patients have a high risk of osteoporotic thoracolumbar compression fractures (OVCF) under the influence of external forces [1]. The conventional clinical treatment for OVCF in older people is conservative. However, the treatment cycle is long and it can easily cause complications such as deep vein thrombosis of the lower limbs and pulmonary infection [2]. Percutaneous kyphoplasty (PKP) and hyperextension reduction combined with percutaneous vertebroplasty (PVP) are new clinical options for treating OVCF in elderly patients. PKP has the advantages of being minimally invasive and highly effective. Hyperextension reduction combined with PVP is relatively simple and can shorten the patient's postoperative recovery time [3]. This study selected 62 elderly patients with OVCF to explore the clinical value of PKP and hyperextension reduction combined with PVP treatment.

2. Materials and methods

2.1. General information

This study's relevant procedures and sample selection plan were submitted to the Medical Ethics Committee for approval. 62 samples of elderly OVCF patients were selected. The admission time was from June 2022 to June 2023. They were randomly divided into study group (n = 31) and control group (n = 31) using the computer software lottery method. There were 17 males and 14 females in the study group, with an age range of 65–79 years, and an average of 72.82±2.96 years, the disease duration ranged from 2 to 15 days, with an average of 8.52±1.29 days. There were 19 males and 12 females in the control group. The age range was 66–78 years old, with an average of 72.75±3.04 years. The disease duration was 3–15 days, with an average of 8.64±1.22 days. The general information of the two groups of patients was comparable ($P > 0.05$).

Inclusion criteria included patients diagnosed with OVCF by imaging examination, patients over 65 years old, and patients who know the research content and procedures, and sign the consent document.

Exclusion criteria were patients with vertebral compression fractures not caused by osteoporosis, patients with coagulation dysfunction, and patients who are unable to cooperate in completing the study.

2.2. Methods

Patients in the control group were treated with PKP. They underwent a C-arm machine examination before surgery to accurately locate the diseased pedicle and mark the skin tissue in the corresponding area. The doctor instructed the patient to maintain a prone position, and performed local skin disinfection and infiltration anesthesia. According to the pre-marked position, the needle was punctured through the midpoint of the vertebral pedicle outward and upward. The needle was slowly inserted under the guidance of the C-arm machine so that the needle tip reached the injured vertebra. In the area behind the vertebral body, the needle core was withdrawn. The solid vertebral body drill was started and slowly drilled through the direction of the casing to the area in front of the injured vertebra. A balloon was placed along the casing and expanded to restore the height of the injured vertebra. After the operation, the balloon was withdrawn to form a cavity inside the injured vertebra. Bone cement was slowly injected under C-arm machine fluoroscopy, the injection was stopped after the bone cement was distributed to the posterior edge of the vertebral body, bone cement leakage was avoided during the operation. The syringe was withdrawn after the bone cement solidified, and the patient was instructed to remain prone. After about 10 minutes, it was confirmed that there was no abnormality, and the patient was escorted back to the ward.

Patients in the study group were treated with hyperextension reduction combined with PVP. The specific operation plan is as follows. The first procedure was hyperextension reset. The doctor instructed the patient to maintain a prone position. An air cushion was placed under the injured vertebrae to raise the injured vertebrae

by about 5cm. Sandbags were placed under the chest and iliac spine to keep the abdomen suspended. The head and legs were elevated by about 20cm at a wide angle. The spine was extended on the back, and the doctor pressed the affected area with moderate force with both hands to standardize the reduction operation of the injured vertebra. After completing the above operations, the doctor adjusted the patient to a general prone position and performed PVP treatment. This was followed by PVP treatment. A C-arm machine examination was performed before surgery to accurately locate the diseased pedicle and mark the skin tissue in the corresponding area. The doctor selected the midpoint of the vertebral pedicle to puncture the needle slightly toward the outer and upper area so that the needle tip reached the front area of the diseased vertebral body through the vertebral pedicle. The bone cement was prepared and slowly injected using a puncture cannula. The injection was stopped after the bone cement was distributed to the posterior edge of the vertebral body. Bone cement leakage must be avoided during the operation. After the bone cement solidified, the syringe was withdrawn and the patient was instructed to stay prone for about 10 minutes. After confirming that there were no abnormalities, the patient was escorted back to the ward. After surgery, the doctor guided the patient to perform rehabilitation training and cooperate with the intervention of osteoporosis drugs treatment.

2.3. Evaluation criteria

The criteria below were evaluated in the two groups.

(1) The operation time, hospitalization time, number of fluoroscopy, and treatment costs were compared between the two groups.

(2) The visual analog pain score (VAS) of the two groups of patients was compared before surgery, three days after surgery, and one month after surgery. The score ranges from 0 to 10. The higher the score, the more severe the pain.

(3) The vertebral body height and Cobb angle of the injured vertebra were compared between the two groups before surgery and three days after surgery.

2.4. Statistical methods

SPSS23.0 software was used to analyze the research data, measurement data mean ± standard deviation (SD) was used as a test, count data % was used as x^2 test and $P < 0.05$ means that there is a statistical difference.

3. Results

3.1. Comparison of operation time, hospitalization time, number of fluoroscopies, and treatment costs

The operation time, hospitalization time, number of fluoroscopy, and treatment costs of the patients in the study group were all lower than those in the control group ($P < 0.05$). The results are presented in **Table 1**.

Table 1. Comparison of operation time, hospitalization time, number of fluoroscopies, and treatment costs between the two groups (mean ± SD)

Group	Operation time (minutes)	Length of stay (days)	Number of fluoroscopy (times)	Treatment cost (yuan)
Study group (n = 31)	30.55±2.38	8.14±1.02	9.76±1.18	19227.48±102.75
Control group (n = 31)	39.97±3.56	10.29±1.88	11.49±2.75	23795±227.86
t value	12.248	5.597	3.219	101.742
P value	0.000	0.000	0.002	0.000

3.2. Comparison of VAS scores

The VAS scores of both groups after surgery were lower than before surgery, and there was no significant difference between the groups ($P > 0.05$), as shown in **Table 2**.

Table 2. Comparison of VAS scores between the two groups (mean ± SD)

Group	Before surgery	Three days after surgery	One month after surgery
Study group ($n = 31$)	6.04±1.15	2.86±0.44 *	2.45±0.42 *
Control group ($n = 31$)	5.98±1.17	2.91±0.38 *	2.53±0.49 *
t value	0.204	0.479	0.690
P value	0.839	0.634	0.493

*$P < 0.05$ compared with preoperative

3.3. Comparison of vertebral body height and Cobb angle of injured vertebra

Based on **Table 3**, the height of the vertebral body in both groups after surgery was more significant than before surgery, and the Cobb angle of the injured vertebra was smaller than before surgery. There was no significant difference between the groups ($P > 0.05$).

Table 3. Comparison of vertebral body height and Cobb angle of injured vertebra between two groups (mean ± SD)

Group	Height of front edge of injured vertebra (mm)		Midline height of injured vertebra (mm)		Cobb angle of injured vertebra (°)	
	Before surgery	Three days after surgery	Before surgery	Three days after surgery	Before surgery	Three days after surgery
Study group ($n = 31$)	14.42±2.35	20.79±2.96 *	12.64±2.05	19.77±2.96 *	26.11±4.25	17.84±1.57 *
Control group ($n = 31$)	14.38±2.42	20.82±2.91 *	12.71±2.01	19.68±2.92 *	26.07±4.32	17.96±1.63 *
t value	0.066	0.040	0.136	0.121	0.037	0.295
P value	0.948	0.968	0.892	0.904	0.971	0.769

*$P < 0.05$ compared with preoperative

4. Discussion

The leading causes of OVCF in older people are bone decalcification, trabecular bone degeneration, and reduced bone density caused by osteoporosis. The strength of the patient's vertebral body decreases to varying degrees, and the ability to withstand load is weakened, leading to fractures under the action of external forces. Typical symptoms of OVCF in older people are pain and mobility impairment, which can seriously impact patients' lives. Therefore, effective treatment plans are needed to restore the anatomical structure of the vertebral body, and stabilize and strengthen the vertebral body [4,5].

The conventional clinical treatment plan for OVCF in older people is a conservative treatment plan such as bed rest, anti-osteoporosis drugs, and brace fixation. Its main disadvantages are long treatment cycles and slow onset of effect. Long-term bed rest can cause complications such as deep vein thrombosis [6,7]. PVP is a treatment plan for OVCF in elderly patients that has been widely used clinically in recent years. During the treatment, a treatment channel is established, and bone cement is injected into the injured vertebra, which can restore the height and normal physiological angle of the injured vertebra. The surgical operation is minimally invasive, and the postoperative recovery time is short, with good fixation effect [8]. Hyperextension reduction before PVP surgery can fully and effectively stretch the folded ligament tissue in the front area of the injured

vertebra, thereby restoring the tension of the annulus fibrosus and longitudinal ligament of the intervertebral disc, partially restoring the height of the injured vertebra, and reducing pain during PVP surgery, with low risk of bone cement leakage [9]. PKP is an improved surgical model of PVP. During the PKP operation, a balloon reduces the compressed vertebral body and constructs a cyst cavity. Bone cement injection can be completed under lower pressure, achieving good surgical results, and reducing the cost of bone cement. There is a risk of leakage, but the operation time is long, and the treatment cost is high [10,11].

The results of this study showed that the VAS scores, vertebral body height, and Cobb angle of the injured vertebra of the two groups of patients after surgery were all better than those before surgery. There was no significant difference between the groups. The operation time, hospitalization time, number of fluoroscopy, and treatment costs of the patients in the study group were all lower than those in the control group. In the control group, it is suggested that both PKP and hyperextension reduction combined with PVP treatment can effectively treat OVCF in older people. However, hyperextension reduction combined with PVP surgery takes a shorter time, and the treatment cost is lower than that of the control group. This may be due to that the hyperextension reduction operation is less difficult and non-invasive, and the patient's cooperation is high. It can complete the preliminary reduction of the injured vertebra before surgery, which helps to reduce the resistance of bone cement infusion, thereby reducing the number of intraoperative fluoroscopy, shortening the operation and postoperative recovery time, and reducing treatment costs [12,13]. PKP is a modified surgical plan of PVP, which is completed through balloon expansion, and can achieve ideal therapeutic effects. However, the operation time is long with high treatment cost [14,15].

Based on the above analysis, both PKP and hyperextension reduction combined with PVP treatment in elderly OVCF patients can relieve pain, and restore vertebral body height and Cobb angle. However, hyperextension reduction combined with PVP treatment can shorten the operation and hospitalization time, and lower the treatment cost, thus having high clinical application value.

Disclosure statement

The author declares no conflict of interest.

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