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Original Article

Efficacy and complications of different surgical modalities of treating osteoporotic spinal compression fracture in the elderly

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Abstract: Purpose: To explore the efficacy and complications of different surgical modalities in the treatment of osteoporotic spinal compression fractures (OSCFs) in the elderly. Methods: This retrospective study included 98 elderly patients with OSCFs who received surgical treatment in the Changsha Hospital of Traditional Chinese Medicine from March 2018 to July 2020. Based on different surgical treatments, the patients were divided into a percutaneous kyphoplasty (PKP) group (n=51) and a percutaneous vertebroplasty (PVP) group (n=47). The intraoperative blood loss, operation time, the amount of bone cement per vertebral body, length of hospitalization, and fracture healing time were recorded and compared between the two groups. The original anterior wall height and middle height of the compressed fractured vertebra were then evaluated and compared at 3 time points, namely before operation, 2 days after operation, and 6 months after operation. Pain, spinal function improvement and Cobb's angle were evaluated and compared between the two cohorts of patients before operation and 3 months after operation. Adverse reactions and bone cement permeability were recorded and compared between the two groups. Patients' quality of life quality was evaluated using the 36-Item Short-Form Health Survey (SF-36) before treatment and 12 months after treatment. Treatment satisfaction was evaluated. Results: Intraoperative blood loss, the average use of bone cement per vertebral body and length of hospitalization were similar between the groups (P>0.05). However, the PKP group had significantly longer operation time and fracture healing time than the PVP group (P<0.05). Vertebral 3D volume, as well as anterior wall and middle vertebra heights increased significantly at 6 months after surgery in both groups (all P<0.05). In addition, anterior wall and middle vertebra heights increased more in the PVP group than in the PKP group. The Visual Analogue Scale (VAS) and Oswesrty Disability Index (ODI) scores, as well as Cobb's angle decreased in both groups at 3 months after treatment (all P<0.05). The Cobb's angle and VAS score of the PVP group showed more significant reductions (all P<0.05). The PKP group had a higher incidence of adverse reactions and bone cement leakage rate than the PVP group (all P<0.05). However, no distinct difference was determined between the two groups in terms of patients' quality of life at 12 months after surgery. Treatment satisfaction was significantly higher in the PVP group than the PKP group. Conclusion: For the treatment of senile OSCFs, both PVP and PKP have the advantages of little trauma and quick recovery. PVP has an edge over PKP with significantly shorter operation time, lower possibility of bone cement venous leakage and adjacent cone fracture, and higher surgical safety.

Keywords: PKP, PVP, senile osteoporotic spinal compression fracture, efficacy, complications

Introduction

In elderly patients, osteoporosis is more prevalent than any other disease, due to drug intake, possibly unhealthy living habits, and an inevitable decrease in bone density with age [1]. Osteoporosis can easily cause compression and deformation of the vertebral body, spine flexion, muscle spasm, and fatigue, which brings severe pain to patients and can easily lead to compression fracture under external forces [2, 3]. Elderly patients with osteoporotic spinal compression fractures (OSCFs) should choose a treatment plan with minimal trauma, short operation time, and high safety. However, traditional conservative treatment and surgery will inevitably bring some adverse effects to patients, such as not enough pain relief, long

and grinding treatment, as well as complications like pressure sores, pneumonia, and urinary tract infections, which will predispose patients to secondary injury, severely lowering their quality of life [4]. With aging of the population, the incidence of OSCFs among the elderly is increasing constantly [5]. Therefore, how to better treat elderly patients with OSCFs has important clinical significance.

At present, surgical treatment is mostly conducted among OSCFs patients in clinical practice to reasonably fix the fracture and promote rehabilitation. However, treatment effect varies when different clinical treatments are adopted [6], among which percutaneous vertebroplasty (PVP) and percutanous kyphoplasty (PKP) are the most commonly used in the treatment of OSCFs, pyramidal hemangioma or lymphoma, and palliative treatment of thoracolumbar traumatic fractures [7, 8]. PVP was first reported by Galibert in 1987 for the treatment of hemangioma [9]. It has been gradually accepted by doctors and patients because of minimal trauma and rapid effect, and for senile OSCFs by virtue of its rapid analgesic effect. PKP is also a new minimally invasive spinal surgery technology developed rapidly in recent decades. It can directly inject bone cement and other fillers into the lesional site to enhance the hardness and stability of the vertebral body [10].

This study aimed to seek the most reasonable method for the treatment of elderly patients with OSCF by performing PVP or PKP respectively, and further verify the clinical value of PVP by comparing multiple indexes with PKP.

Materials and methods

Clinical materials

We retrospectively included 98 elderly patients with OSCFs who came to the Changsha Hospital of Traditional Chinese Medicine for surgical treatment from March 2018 to July 2020. Among them, 58 were female patients and 40 were male with an average age of (70.22±8.53) years old and an average course of disease of (4.81±2.23) days. Patients were divided into a PKP group (n=51) and PVP group (n=47 cases) according to different surgical treatment plans. Inclusion criteria: Diagnosis of OSCF by bone mineral density measurement; Age ≥55 years old; Tolerance of surgery; No obvious spinal cord injury or nerve compression. Exclusion criteria: Spinal cord and nerve injury; Severe organ dysfunction; Comminuted spinal fracture; Those who refused surgical treatment. All patients provided written informed consent to participate. This experiment was approved by the Changsha Hospital of Traditional Chinese Medicine ethics committee (201811) and was conducted in accordance with the *Declaration of Helsinki*.

Surgical methods

(1) After admission, all elderly patients with OSCFs were first treated with conventional treatments, including anti-inflammatory and analgesic therapy, to ensure that patients had adequate rest and pain relief. X-ray and MRI examinations were performed according to surgical needs to determine the size of the patient's pedicle and the prescribed position. We then observed the patient's posterior vertebral body wall and analyzed the results after completion. In the context of understanding the underlying diseases, corresponding therapeutic interventions were carried out to evaluate the surgical tolerance of elderly patients.

(2) PKP group: The patient was placed in the prone position with the abdomen free ventrally. Routine disinfection was performed and the affected vertebrae were covered with a towel with the aid of a C-arm X-ray machine. Following local anesthesia, two core puncture needles were inserted into the vertebral body through percutaneous bilateral punctures in the direction of 15°-20° to the sagittal plane of the human body, and the position of the puncture needle was adjusted so that it was located in the posterior wall of the vertebral body and did not exceed the inner edge of the pedicle. Subsequently, we removed the inner core and inserted the vertebral body clockwise to drill to the anterior 1/3 of the vertebral body. the vertebral body drill was removed and an inflated balloon was placed. The contrast agent was then injected into the balloon and stopped when the balloon pressure was stable or the vertebral body was well repositioned. After the completion of both sides, bone cement and water were prepared in a ratio 2:1 and slowly injected into the vertebral body to fill the cavity. After the bone cement hardened, the puncture needles were unscrewed and the wound was sutured. Routine anti-infective care was given to patients after operation.

(3) PVP group: The patient was placed in the prone position with the abdomen free ventrally. After routine disinfection, the affected vertebrae were covered with a towel with the aid of a C-arm X-ray machine. After local anesthesia, one cored puncture needle was inserted into the vertebral body through a unilateral pedicle approach in the direction of 15°-20° to the sagittal plane of the human body, and the position of the puncture needle was adjusted so that it was located in the front 1/3 of the vertebral body. Subsequently, we removed the inner core, and injected a small amount of contrast agent. While it was evenly distributed in the vertebral body with no rapid drainage of the venous plexus, bone cement mixed with water at a ratio of 2:1 was slowly injected it into the vertebral body until it reached the posterior wall. After the bone cement hardened, the puncture needles were unscrewed, and the wound was closed. Postoperatively, patients were treated with routine anti-infective care.

After the operation, both groups of patients were required to lie supine for 24 hours. They were encouraged to get out of bed and walk appropriately and were given uniform calcium for anti-osteoporosis treatment.

Outcome measures

(1) The intraoperative blood loss, operation time, and the bone cement amount used per vertebral body were recorded and compared between the two groups. (2) Hospitalization time and fracture healing time were compared. (3) The original anterior wall height A, middle height M, and posterior wall height P of the compressed fracture vertebra were evaluated and compared using X-ray at 3 time points (before operation, 2 days after operation, and 6 months after operation). First, the anterior wall height a0, middle height m0, and posterior wall height p0 of the lateral X-ray VCF vertebral body were measured, then the corresponding parts of the upper vertebral body anterior wall height a1, intermediate height m1, and posterior wall height p1, lower vertebral body anterior wall height a2, intermediate height m2 and posterior wall height p2 were measured. Compression fracture vertebral body original anterior wall height A=(a1+a2)/2, the middle height M=(m1+m2)/2, the rear wall height P=(p1+p2)/2. (4) The changes in low back pain before and 3 months after surgery were assessed using the Visual Analogue Scale (VAS) [11]. On a scale of 0 (no pain) to 10 points (most severe pain), a higher score indicates more severe pain. (5) The improvement of patients' spinal function after 3 months of operation was evaluated by the Oswestry Disability Index (ODI) [12]. Each item is scored from 0 to 5, with 0 indicating normal functional activities, and 5 indicating the most severe limitation of functional activities. (6) Three Cobb's angles were evaluated before and after surgery for analysis. (7) The evaluation of patients' life quality before and 12 months after treatment employed the 36-Item Short-Form Health Survey (SF-36) [13]. SF-36 includes 8 domains of physiological function, role physical, social function, bodily pain, vitality, mental health, role emotion and general health. Physiological function, physical role, bodily pain and general health are converted into a physical component summary (PCS) score, while vitality, social function, emotional function, and mental health are converted into a mental component summary score (MCS), with a 50-point average. PCS score or MCS score less than 50 points means that physical or mental health is below average. (8) The complications of patients in both groups were recorded and compared, including adjacent vertebral fractures, lung infections, sacrococcygeal bedsores, and lower limb venous thrombosis. (9) All patients underwent spinal X-ray and CT examination 24 hours after surgery, and the same attending physician in the radiology department was asked to evaluate the bone cement leakage (covering intervertebral disc leakage, venous leakage, paravertebral leakage, and intraspinal leakage). (10) Patients' satisfaction with the treatment was divided into very satisfied, satisfied, and dissatisfied, and was compared between the two groups after treatment. Treatment satisfaction = (very satisfied + satisfied) cases/total number of cases × 100%.

Statistical methods

The SPSS 19.0 statistical software was used to statistically analyze the results. Counted data (n [%]) was analyzed using the χ^2 test. For measured data expressed as mean ± standard deviation, the comparison between groups was performed by independent t test and that before and after treatment within a group was carried out by paired t test. The post-hoc test

Table 1. General information

Factor	PKP Group (n=51)	PVP Group (n=47)	t/X^2	P
Gender			0.237	0.626
Male	22 (43.14)	18 (38.30)		
Female	29 (56.86)	29 (61.70)		
Age (years old)			0.009	0.926
≥.9	31 (60.78)	29 (61.70)		
<70	20 (39.22)	18 (38.30)		
BMI (kg/m^2)	22.42±1.03	22.69±1.08	1.267	0.208
Course of disease (d)	4.79±2.26	4.83±2.19	0.088	0.929
Smoking history			0.113	0.737
YES	20 (39.22)	20 (42.55)		
NO	31 (60.78)	27 (57.45)		
Underlying disease			0.618	0.734
Hypertension	18 (35.29)	17 (36.17)		
Diabetes	20 (39.22)	21 (44.68)		
Hyperlipidemia	13 (25.49)	9 (19.15)		
Fracture site			0.009	0.926
Lumbar spine	31 (60.78)	29 (61,70)		
Thoracic vertebrae	20 (39.22)	18 (38.30)		
Cone compression			0.894	0.640
Mild	15 (29.41)	14 (29.79)		
Moderate	20 (39.22)	22 (46.81)		
Severe	16 (31.37)	11 (23.40)		

Table 2. Comparison of surgery-related conditions between groups

Factors	PKP Group (n=51)	PVP Group (n=47)	t	P
Intraoperative blood loss (ml)	9.76±1.23	9.42±1.21	1.378	0.172
Operation time (min)	28.06±3.11	17.34±1.22	22.11	<0.001
Cone cement dosage (ml)	3.57±0.78	3.84±0.81	1.681	0.096

was performed by the LSD test. P<0.05 indicated that a difference was significant.

Results

Comparative general information

The two groups of patients (58 females and 40 males) were comparable in terms of general data as gender, disease course, and age. (All P>0.05). See **Table 1**.

Comparative intraoperative blood loss, operation time, and amount of bone cement per vertebral body

There was no significant difference in intraoperative blood loss between the two groups (P>0.05). The operation time was longer in the PKP group compared to the PVP group (P<0.05). PVP group used more bone cement per vertebral body than PKP group, but the difference was statistically insignificant (P>0.05). See **Table 2**.

Comparison of hospitalization time and fracture healing time

The hospitalization time and fracture healing time of the PKP group were 22.56±1.27 days and 8.01±1.78 weeks respectively, while those of the PVP group were 22.38± 1.24 days and 6.32±1.23 weeks respectively. There was no difference in the hospitalization time (all P>0.05). However, there was a statistically significant difference in the fracture healing time between the two groups (P<0.05), with shorter duration in the PVP group. See **Table 3**.

Comparison of vertebral body height before and after operation

In both groups, the anterior wall and middle vertebra heights at 3 days and 6 months after surgery were greater than those before surgery (P<0.05). In comparison with the PKP group, the anterior wall and middle vertebra heights were higher in the PVP group (P<0.05). See **Figure 1**.

Comparison of VAS score, ODI score, and Cobb's angle before and after surgery

Compared to those before treatment, VAS, ODI, and Cobb's angle decreased significantly in both groups after treatment (all P<0.05). Intergroup comparison revealed that, the Cobb's angle and VAS score of the PVP group decreased more compared to the PKP group (all P<0.05), while no significant difference was observed in the ODI score between the two groups (P>0.05). See **Figure 2**.

Table 3. Comparison of hospitalization time and fracture healing time between groups

Factor	PKP Group (n=51)	PVP Group (n=47)	t	P
Hospitalization time (days)	22.56±1.27	22.38±1.24	0.709	0.481
Fracture healing time (weeks)	8.01±1.78	6.32±1.23	5.423	<0.001

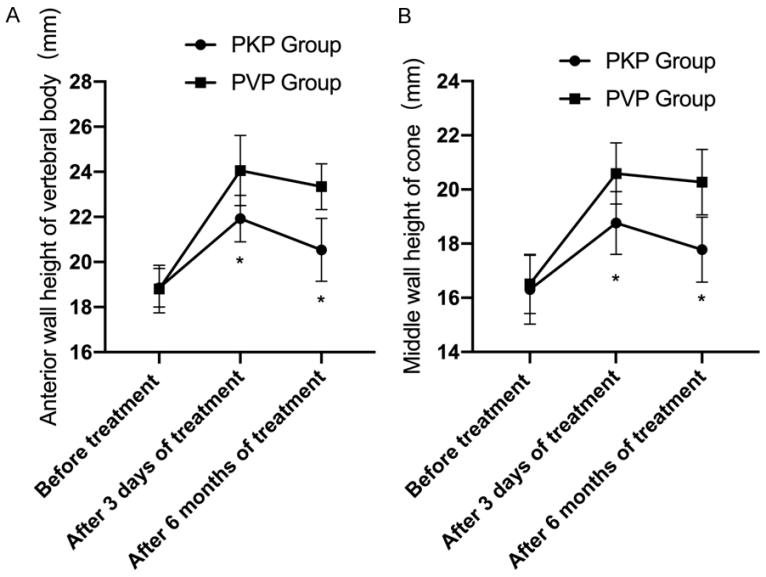

Figure 1. Comparison of the height of the vertebral body before and after surgery. A: Anterior wall height of the vertebral body; B: Middle wall height of the vertebral body. *P<0.05 (paired t test).

Comparison of complications

After treatment, the number of patients in the PKP group with advere effects of adjacent vertebral fractures, pulmonary infections, sacrococcygeal bedsores, and lower extremity venous thrombosis were 7, 2, 1 and 1 respectively with a complication rate of 21.57%. The number of patients with these adverse effects in the PVP group were 1, 1, 1, and 0, respectively, with a complication rate of 6.38%. The incidence of complications was lower in the PKP group compared to the PVP group (P<0.05). See **Table 4**.

Comparison of bone cement leakage

The PKP group had a higher postoperative bone cement venous leakage rate than the PVP group (P<0.05). No notable difference was found in intervertebral disc leakage and paravertebral leakage rates between the two groups (P>0.05). Neither group had leakage of bone cement in the spinal canal. See **Table 5**.

Comparative quality of life before and after surgery

There was no significant difference in PCS and MCS scores between the two groups before treatment (P>0.05). Twelve months after treatment, PCS and MCS scores increased in both groups, but with no significant difference between them (P>0.05). See **Figure 3**.

Comparative treatment satisfaction

The number of patients who were very satisfied, satisfied, and dissatisfied with the treatment was 21, 20, and 10, respectively in the PKP group, and was 27, 18, and 2 respectively in the PVP group. Data above suggested a significantly higher treatment satisfaction in the PVP group compared with the PKP group (95.74% *vs* 80.39%, P<0.05). See **Table 6**.

Discussion

Osteoporosis is a common disease among the middle-aged and elderly, especially in females. Statistics show that about 54% of menopausal women suffer from abnormal bone mineral density, and the odds of developing vertebral fractures over 50 years old is about 32% [14]. Senile osteoporosis is mainly treated with internal medicine. However, for patients who have been diagnosed with spinal fractures, the pain relief is insufficient, the treatment cycle is long, accompanied by possible complications. Therefore, patients with such fractures are often treated by surgery, which can not only relieve pain in a timely and effective manner, but also reduce complications and improve the quality of life [15, 16].

PVP and PKP are commonly used clinical surgical modalities in treating elderly OSCFs with high surgical safety and good postoperative pain relief, from which patients can obtain restored vertebral body function and improve mobility [17]. In this study, 98 elderly patients with OSCFs were assigned to two groups (PKP

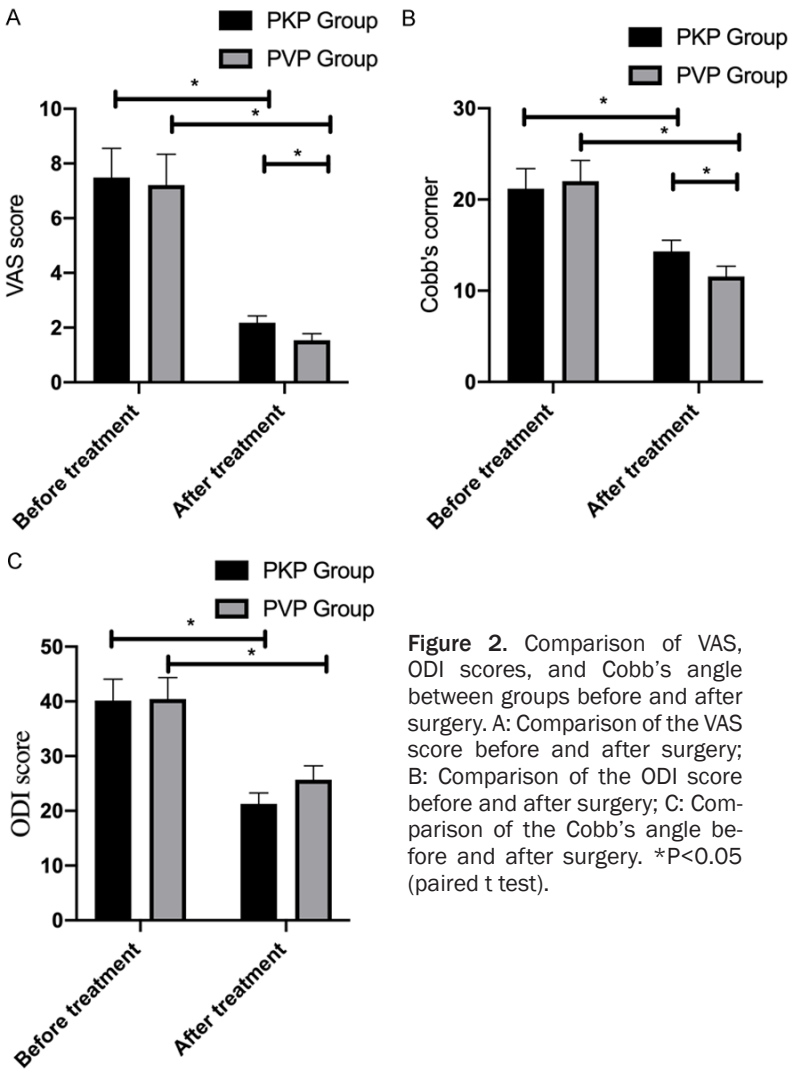

Figure 2. Comparison of VAS, ODI scores, and Cobb's angle between groups before and after surgery. A: Comparison of the VAS score before and after surgery; B: Comparison of the ODI score before and after surgery; C: Comparison of the Cobb's angle before and after surgery. *P<0.05 (paired t test).

Table 4. Comparison of adverse reactions between groups [n, (%)]

Adverse reaction	PKP Group (n=51)	PVP Group (n=47)	X^2	P
Adjacent vertebral fracture	7 (13.73)	1 (2.13)	4.388	0.036
Pulmonary infections	2 (3.92)	1 (2.13)	0.265	0.607
Sacrococcygeal bedsore	1 (1.96)	1 (2.13)	0.003	0.954
Venous Thrombosis of Lower Extremity	1 (1.96)	0	-	-
Complication rate	11 (21.57)	3 (6.38)	4.606	0.032

and PVP based on different surgical modalities) for clinical effect comparison. First, we compared the basic operation conditions of two groups of patients. The results revealed that the operation time of the PKP group was significantly longer than that of the PVP group, while no marked difference was found in intraoperative blood loss and bone cement volume between the two groups. PVP is a surgery in which bone cement is percutaneously injected into the affected vertebrae through pedicle approach under the guidance of the imaging system, which is mainly used in clinical practice for patients with large trabecular bone space, complete posterior wall of vertebral body, mild kyphosis of fractured vertebral body, and less than 75% of vertebral body compression. During PVP, attention should be paid to prevent the bone cement leakage [18]. PKP, on the other hand, relies upon implanting an expander or balloon into the affected vertebrae, which is mainly used for patients with an intact posterior wall of the vertebral body and severe kyphosis of a fractured vertebral body in clinical practice [19]. For OSCFs, the ideal goal is to restore the stiffness of the fractured spine, enhance the strength of the vertebral body, and reduce patients' pain [20]. Therefore, we compared the post-treatment cone height, as well as VAS and ODI scores, and the results showed an overall improvement in both groups. However, the data in the PVP group were superior to the PKP group, suggesting that PVP may be more effective in the treatment of elderly patients with OSCFs. Evidence [21] has also pointed out that PVP treatment had a significant analgesic effect on spinal compression fractures. It is believed that the sensory nerve endings in the diseased vertebrae and surrounding tissues were destroyed by the thermal effect of bone cement and this could also play an analgesic effect, which could explain the significant

Table 5. Comparison of bone cement leakage between two groups

Factor	PKP Group (n=51)	PVP Group (n=47)	X^2	P
Venous leakage rate	22 (43.14)	7 (14.89)	9.365	0.002
Intervertebral disc leakage rate	3 (5.88)	2 (4.26)	0.133	0.714
Paravertebral leakage rate	4 (7.84)	2 (4.26)	0.548	0.459

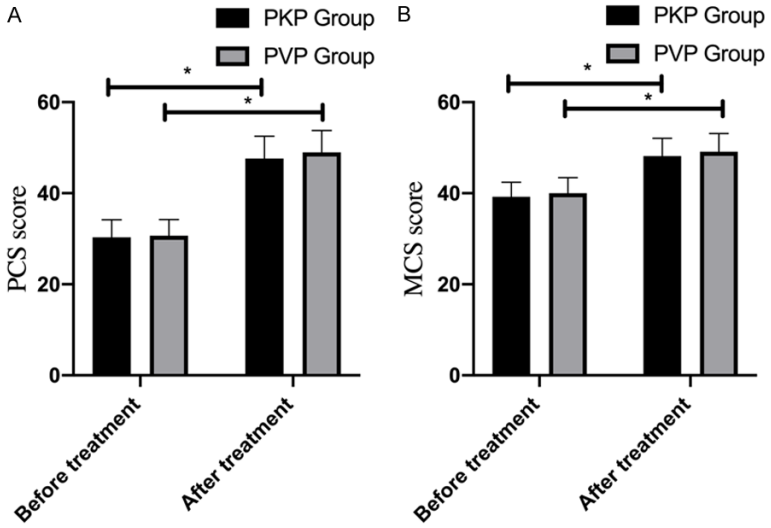

Figure 3. Comparison of life quality between groups before and after surgery. A: Comparison of the PCS score; B: Comparison of the MCS score. *P<0.05 (paired t test).

Table 6. Comparison of treatment satisfaction between groups

Satisfaction	PKP Group (n=51)	PVP Group (n=47)	X^2	P
Very satisfied	21 (41.18)	27 (57.45)	-	-
Satisfied	20 (39.22)	18 (38.30)	-	-
Dissatisfied	10 (19.61)	2 (4.26)	-	-
Treatment satisfaction	41 (80.39)	45 (95.74)	5.365	0.021

improvement in the VSA score in patients treated by PVP. We also compared the time of hospitalization and fracture healing. The results indicated that although there was no significant difference in hospitalization time, the fracture healing time was shorter in the PVP group compared with the PKP group, suggesting that patients in the PVP group may have better prognoses.

Due to the certain risk of fractures in the osteoporotic vertebral body, simply restoring the strength of the original vertebral body is not sufficient. The ideal state is to raise strength to the normal level of the vertebral body, while the stiffness only needs to be restored to the original and initial level. This is because stiffness exceeding the initial level means increased stress compared with the adjacent osteoporotic vertebral body, which will also increase the risk of fracture and degeneration [22, 23]. Therefore, we then compared the risk of adverse reactions between the two groups, and results identified a significantly higher adjacent cone fracture rate in the PKP group. It was shown that PVP treatment contributes to less bone cement fluidity entering the spinal canal than PKP, which not only helps reduce bone cement leakage rate, ensure vertebral body and spine stability and protects physiologic functions of the lower back, but also reduces the pressure on the adjacent vertebral body, and avoids the occurrence of re-fractures [24]. Subsequently, we observed a statistically lower bone cement venous leakage rate in the PVP group, suggesting that its safety may be better than PKP. In addition, PVP surgery uses high-viscosity cement. Research [25] indicates that viscous bone cement has special physical and chemical properties, and its liquid phase after mixing was significantly shorter than that of low-viscosity bone cement. It had the characteristics of instantaneous high viscosity and low fluidity, which could significantly reduce the incidence of bone cement leakage, shorten the operation time, relieve patient's unhealthy emotions such as intraoperative tension, and reduce the occurrence of complications to a certain extent. Finally, in terms of the quality of life of patients, all patients recovered well with better conditions, with no significant difference between the two groups. The results of treatment satisfaction indicated that the fracture healing time of the PVP group was notably shorter versus the PKP group.

In summary, this study indicated that in terms of treating elderly patients with OSCFs, both PVP and PKP had the advantages of mild trauma and rapid recovery, whereas PVP had an edge over PKP with much shorter operation time, lower possibility of bone cement leakage and adjacent cone fractures, shorter fracture healing time, higher treatment satisfaction, and higher surgical safety. However, there are still some defects in this study. First, there is a lack of comparison with other surgical options other than PVP and PKP. The small sample size may lead to the contingency of experimental results. We will further conduct multi-center, large-sample studies, and compare the two surgical modalities with other surgical plans in follow-up studies to screen out the most suitable surgical plan for elderly patients with OSCFs.

Disclosure of conflict of interest

None.

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References

[1] Guo Y, Jia X, Cui Y, Song Y, Wang S, Geng Y, Li R, Gao W and Fu D. Sirt3-mediated mitophagy regulates AGEs-induced BMSCs senescence and senile osteoporosis. Redox Biol 2021; 41: 101915.

[2] Luo D, Ren H, Li T, Lian K and Lin D. Rapamycin reduces severity of senile osteoporosis by activating osteocyte autophagy. Osteoporos Int 2016; 27: 1093-1101.

[3] Oinuma T, Sakuma M and Endo N. Secular change of the incidence of four fracture types associated with senile osteoporosis in Sado, Japan: the results of a 3-year survey. J Bone Miner Metab 2010; 28: 55-59.

[4] Boonen S, Dejaeger E, Vanderschueren D, Venken K, Bogaerts A, Verschueren S and Milisen K. Osteoporosis and osteoporotic fracture occurrence and prevention in the elderly: a geriatric perspective. Best Pract Res Clin Endocrinol Metab 2008; 22: 765-785.

[5] Zhao H, He Y, Yang JS, Bao W, Chen J, Liu JJ, Li QD, Liu P, Qian B, Zhao YT and Hao DJ. Can paraspinal muscle degeneration be a reason for refractures after percutaneous kyphoplasty? A magnetic resonance imaging observation. J Orthop Surg Res 2021; 16: 476.

[6] Wang F, Wang LF, Miao DC, Dong Z and Shen Y. Which one is more effective for the treatment of very severe osteoporotic vertebral compression fractures: PVP or PKP? J Pain Res 2018; 11: 2625-2631.

[7] Buchbinder R, Johnston RV, Rischin KJ, Homik J, Jones CA, Golmohammadi K and Kallmes DF. Percutaneous vertebroplasty for osteoporotic vertebral compression fracture. Cochrane Database Syst Rev 2018; 4: CD006349.

[8] Health Quality Ontario. Vertebral augmentation involving vertebroplasty or kyphoplasty for cancer-related vertebral compression fractures: a systematic review. Ont Health Technol Assess Ser 2016; 16: 1-202.

[9] Galibert P, Deramond H, Rosat P and Le Gars D. Preliminary note on the treatment of vertebral angioma by percutaneous acrylic vertebroplasty. Neurochirurgie 1987; 33: 166-168.

[10] Filippiadis DK, Marcia S, Masala S, Deschamps F and Kelekis A. Percutaneous vertebroplasty and kyphoplasty: current status, new developments and old controversies. Cardiovasc Intervent Radiol 2017; 40: 1815-1823.

[11] Hirata RP, Thomsen MJ, Larsen FG, Stottrup N and Duarte M. The effects of pain and a secondary task on postural sway during standing. Hum Mov Sci 2021; 79: 102863.

[12] O'Connor M, Sillevis R and Erickson MR. Pain neuroscience education delivered by a student physical therapist for a patient with persistent musculoskeletal pain. Am J Case Rep 2021; 22: e932212.

[13] Baykal Sahin H, Kalaycioglu E and Sahin M. The effect of cardiac rehabilitation on kinesiophobia in patients with coronary artery disease. Turk J Phys Med Rehabil 2021; 67: 203-210.

[14] Malle O, Borgstroem F, Fahrleitner-Pammer A, Svedbom A, Dimai SV and Dimai HP. Mind the gap: incidence of osteoporosis treatment after an osteoporotic fracture-results of the Austrian branch of the International Costs and Utilities Related to Osteoporotic Fractures Study (ICUROS). Bone 2021; 142: 115071.

[15] Zleik N, Weaver F, Harmon RL, Le B, Radhakrishnan R, Jirau-Rosaly WD, Craven BC, Raiford M, Hill JN, Etingen B, Guihan M, Heggeness MH, Ray C and Carbone L. Prevention and management of osteoporosis and osteoporotic fractures in persons with a spinal cord injury or disorder: a systematic scoping review. J Spinal Cord Med 2019; 42: 735-759.

[16] de Vries BCS, Hegeman JH, Nijmeijer W, Geerdink J, Seifert C and Groothuis-Oudshoorn CGM. Comparing three machine learning approaches to design a risk assessment tool for

future fractures: predicting a subsequent major osteoporotic fracture in fracture patients with osteopenia and osteoporosis. Osteoporos Int 2021; 32: 437-449.
[17] Hackbarth CB, Vogl TJ, Naguib N, Albrecht MH and von Knebel-Doeberitz PL. Long-term evaluation of pain reduction after vertebroplasty and kyphoplasty. Acta Radiol Open 2021; 10: 20584601211028994.
[18] An Z, Chen C, Wang J, Zhu Y, Dong L, Wei H and Wu L. Logistic regression analysis on risk factors of augmented vertebra recompression after percutaneous vertebral augmentation. J Orthop Surg Res 2021; 16: 374.
[19] Li Y, Feng X, Pan J, Yang M, Li L, Su Q and Tan J. Percutaneous vertebroplasty versus kyphoplasty for thoracolumbar osteoporotic vertebral compression fractures in patients with distant lumbosacral pain. Pain Physician 2021; 24: E349-E356.
[20] Sun Y, Ma H, Yang F, Tang X, Yi P and Tan M. Clinical efficacy and safety of zoledronic acid combined with PVP/PKP in the treatment of osteoporotic vertebral compression fracture: a systematic review and meta-analysis of randomized controlled trials. Biomed Res Int 2021; 2021: 6650358.
[21] Dai SQ, Qin RQ, Shi X and Yang HL. Percutaneous vertebroplasty versus kyphoplasty for the treatment of neurologically intact osteoporotic Kummell's disease. BMC Surg 2021; 21: 65.
[22] Wilson DR, Myers ER, Mathis JM, Scribner RM, Conta JA, Reiley MA, Talmadge KD and Hayes WC. Effect of augmentation on the mechanics of vertebral wedge fractures. Spine (Phila Pa 1976) 2000; 25: 158-165.
[23] Chang JZ, Bei MJ, Shu DP, Sun CJ, Chen JB and Xiao YP. Comparison of the clinical outcomes of percutaneous vertebroplasty vs. kyphoplasty for the treatment of osteoporotic Kummell's disease:a prospective cohort study. BMC Musculoskelet Disord 2020; 21: 238.
[24] Zuo XH, Zhu XP, Bao HG, Xu CJ, Chen H, Gao XZ and Zhang QX. Network meta-analysis of percutaneous vertebroplasty, percutaneous kyphoplasty, nerve block, and conservative treatment for nonsurgery options of acute/subacute and chronic osteoporotic vertebral compression fractures (OVCFs) in short-term and long-term effects. Medicine (Baltimore) 2018; 97: e11544.
[25] Zhang ZF, Huang H, Chen S, Liu DH, Feng YH, Xie CL and Jiao F. Comparison of high- and low-viscosity cement in the treatment of vertebral compression fractures: a systematic review and meta-analysis. Medicine (Baltimore) 2018; 97: e0184.