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Original Article

Effect of percutaneous vertebroplasty on the treatment of osteoporotic spinal fractures in elderly patients and risk factors for postoperative lower extremity deep vein thrombosis

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Abstract: Objective: To evaluate the effectiveness of PVP (PVP) in treating osteoporotic spinal fractures in the elderly and analyze the risk factors for postoperative deep vein thrombosis (DVT) in the lower extremities. Methods: A total of 100 elderly patients with osteoporotic spinal fractures, treated between August 2019 and July 2021, were divided into two groups: PVP (research group, n=50) and conservative treatment (control group, n=50). Outcome measures, including injured vertebrae, pain levels, and treatment outcomes, were retrospectively analyzed. Patients who underwent PVPs were further categorized based on the presence of lower extremity DVT one month post-surgery. Logistic regression analysis was used to identify risk factors for post-surgical lower limb DVT. Results: PVP resulted in a significantly smaller posterior convexity angle of the injured spine and higher anterior, midline, and posterior edges of the injured spine compared to conservative treatment (P<0.001). Patients in the research group had significantly lower visual analogue scale (VAS) scores and higher treatment efficiency compared to those in the conservative treatment group (all P<0.05). Nine cases of lower extremity DVT were observed after PVP. Logistic regression analysis identified age, body mass, smoking, and diabetes as independent risk factors for post-surgical lower extremity DVT. Conclusion: PVP improves spinal function and relieves pain in elderly patients with osteoporotic fractures. However, age, body mass, smoking, and diabetes are independent risk factors for postoperative lower extremity DVT.

Keywords: PVP, osteoporotic spinal fracture, elderly, treatment outcomes, lower extremity deep vein thrombosis, risk factor

Introduction

The elderly are the primary population affected by osteoporosis due to the deterioration of physical function and poor bone quality. Osteoporosis is a systemic bone disease that can lead to traumatic fractures of the spinal bones and is clinically classified as primary or secondary osteoporosis. Spinal fractures account for approximately 5% of all fracture types and are most common in osteoporotic spine fractures, which can cause severe pain, disability, and significantly compromise quality of life [1]. A study indicated that the incidence of osteoporotic spinal fractures in people aged 50 years or older was approximately 307 per 100,000 per year, with the incidence in people aged 85 to 89 years being almost eight times higher than of those aged 60 years.

Currently, traditional clinical treatment methods include extracorporeal stenting and conservative treatment [2]. The most commonly used drugs in western medicine for clinical treatment are bisphosphonates, calcitonin, and estrogen. Despite their ability to significantly increase bone mass, these drugs have serious side effects, such as increased incidence of hypocalcemia, breast cancer, and cardiovascular disease [3]. Traditional Chinese medicine (TCM) treatments mostly include Chinese herbs for internal use, external treatments, acupunc-

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ture, and tui-na. However, these treatments require long-term bed rest and are prone to complications such as deep vein thrombosis (DVT) and pressure sores in the lower extremities [4].

Patients often have underlying medical conditions that prevent tolerance to traditional incisional internal fixation and anesthesia. They are also at risk for postoperative loosening of fixation and vertebral collapse due to osteoporosis. Percutaneous vertebroplasty (PVP) is a procedure that involves injecting medical-grade bone cement into the fractured vertebrae under light sedation or general anesthesia, where the cement hardens in the bone space to support the fracture site [1, 5]. In addition, the operation of PVP is straightforward, with a short operation time and relatively low cost. A preoperative CT scan of the injured spine is routinely performed to understand the morphology and distribution of the fracture as well as the bone quality of the peri-vertebral wall of the injured spine. The risk of cement leakage can be reduced by careful operation, multiple fluoroscopies, close observation, and prediction of the flow direction of the cement, and adjustment of the injection speed as needed. Clinically relevant research suggests its higher efficacy and safety as a minimally invasive technique for managing osteoporotic spinal fractures in the elderly [6]. Lower extremity DVT is one of the most significant postoperative complications of spine fractures. It refers to the formation of a thrombus in the deep veins of the lower extremity, which can lead to pulmonary embolism, heart failure, pulmonary hypertension, and sudden death, severely affecting the patient's prognosis [7]. Studies have shown that the incidence of DVT in patients with spinal fractures can range from 15-40%, depending on the specific patient population and treatment approach [8]. DVT is a concerning complication as it can lead to potentially life-threatening pulmonary embolism if left untreated. Previous studies have reported varying results, with some showing increased DVT rates after vertebroplasty [9]. Furthermore, the specific risk factors for post-vertebroplasty DVT development have not been thoroughly investigated. To enhance patient prognosis and improve treatment efficiency, this study was performed. We evaluate the effectiveness of PVP in the treatment of osteoporotic spinal fractures in the elderly and analyze risk factors for postoperative DVT in the lower extremities.

Materials and methods

Ethical statement

This experiment was conducted in accordance with the ethical guidelines for clinical research outlined in the Declaration of Helsinki and was approved by the ethics committee of the Suzhou Hospital of Integrated Traditional Chinese and Western Medicine (MU20210101).

Participants

Through searching the electronic medical record system of the Suzhou Hospital of Integrated Traditional Chinese and Western Medicine between August 2019 and July 2021, a total of 100 elderly patients with osteoporotic spinal fractures were included, after excluding 23 patients who did not meet the inclusion criteria. These patients were assigned to receive either PVP (research group, n=50) or conservative treatment (control group, n=50). **Figure 1** has details of the study design.

Inclusion and exclusion criteria

Inclusion criteria

1) Patients with bone density values meeting the World Health Organization's diagnostic criteria for osteoporosis [10]. 2) Patients whose conditions met the relevant clinical diagnostic criteria and were diagnosed with osteoporotic spinal fractures by X-ray, computed tomography (CT), or magnetic resonance imaging (MRI) [11]. 3) Patients with normal cognitive function that allowed cooperation with treatment. 4) Patients without relevant contraindications for treatment. 5) Patients aged ≥65 years. 6) Patients with complete clinical data. 7) Patients with proper evaluation for lower extremity DVT and full records.

Exclusion criteria

1) Patients with infectious diseases. 2) Patients with spinal cord damage or nerve root damage. 3) Patients with malignant tumors or hematologic diseases. 4) Patients with other important organ-related diseases. 5) Patients with severe organ damage and blood disorders. 6) Patients

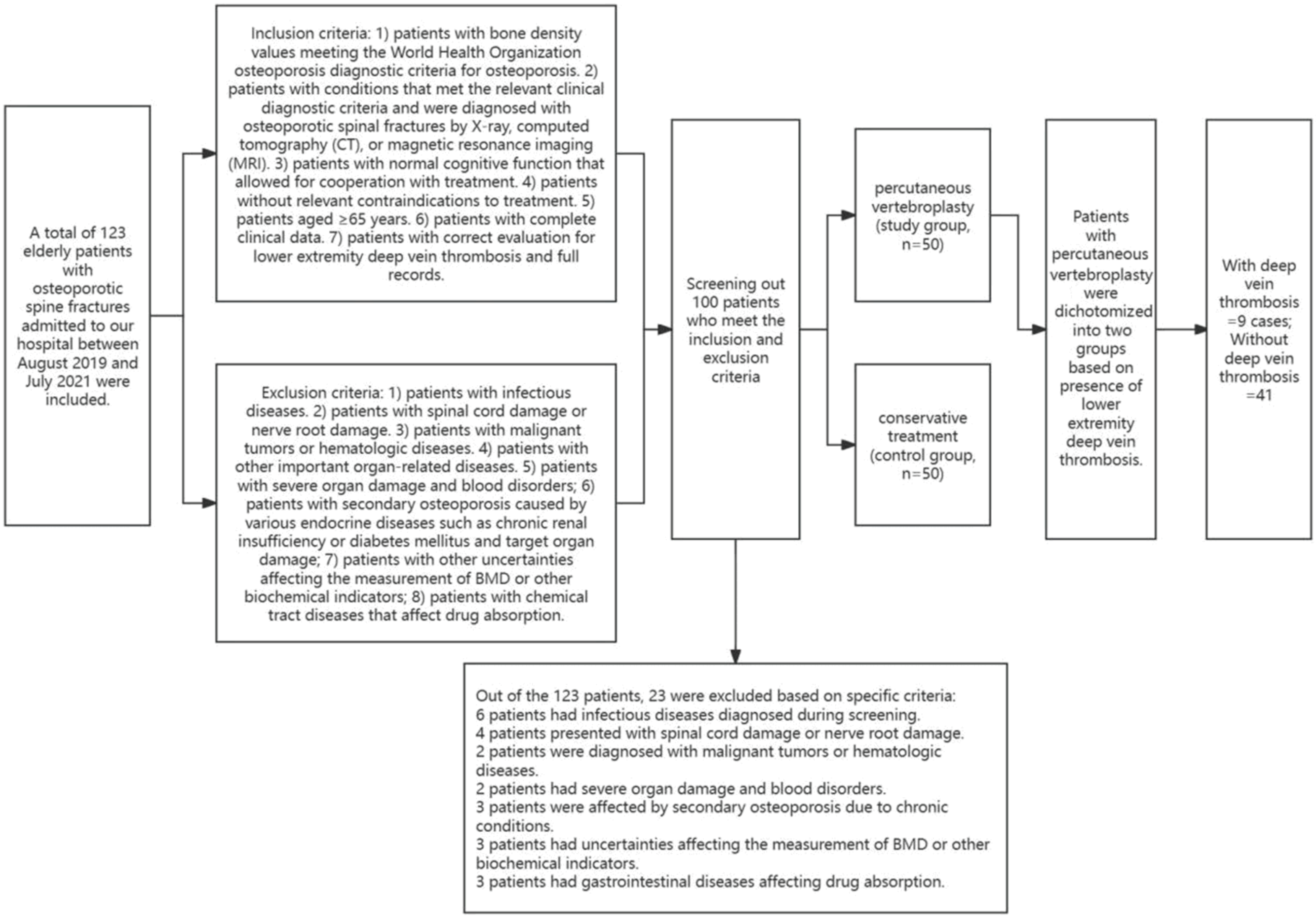

Figure 1. Flow chart.

with secondary osteoporosis caused by various endocrine diseases such as chronic renal insufficiency or diabetes mellitus and target organ damage. 7) Patients with conditions that could affect the measurement of bone mineral density or other biochemical indicators. 8) Patients with gastrointestinal tract diseases that affect drug absorption.

Data collection

All data for this study were obtained from the hospital's electronic record system. Data included general information such as age, gender, and body mass index, as well as details on the condition of the injured spine, pain levels, occurrence of lower extremity DVT, and treatment outcome. This information was used for statistical analysis to investigate the efficacy and prognosis of PVP.

Groups [12]

Patients in the control group received conservative treatment. They were instructed to maintain absolute bed rest, were given analgesics for pain relief, and received medications such as active vitamin D, anti-bone resorption drugs, calcium supplements, bone mineralization drugs, and bone formation promoters. Specifically, patients received one Osteotriol Gel Pill (State Drug Administration: J20150011, 0.25 μg/capsule) twice daily, and one oral calcium carbonate D3 tablet (State Drug Administration: H10950029, 1.5 g/capsule, equivalent to 600 mg of calcium) daily. Additionally, they were administered 200 mg of Celecoxib capsules (Pfizer Ltd.) daily. Reset pads were placed at the fracture site, with the height adjusted according to the patient's condition. After 2-3 months, patients were allowed to perform lower back rehabilitation exercises once the pain was reduced and their condition was stable.

Patients in the research group received PVP. The patient was instructed to adopt a prone position and was routinely given an intramuscular injection of 10 mg of dezocine (State Drug Quantifier H20080329, Yangtze River Pharmaceutical Group Co.) before surgery, followed by routine local sterilization and anesthesia. The location of the broken vertebra and its pedicle was determined by fluoroscopy on a C-arm X-ray machine. Local infiltration anesthesia was performed, and the outer edge of the elliptical cortex of the pedicle was marked as the puncture point. After routine disinfection and draping, a small incision of about 0.5 cm was made along the marked point. The puncture point was tilted inward about 10-15° into about 1/3 of the vertebral body under C-arm-assisted fluoroscopy, and the contralateral side was punctured using the same method. The amount of bone cement injected was determined according to the size of the vertebral body and the degree of pressure on the vertebral body. The bone cement was infused bilaterally and sequentially to allow slow diffusion into the cortical area, and the injection was controlled to prevent leakage of the bone cement from the vertebral body. After the bone cement hardened, the puncture needle was removed, the wound was routinely compressed to stop bleeding, and the wound was bandaged. Postoperatively, patients were routinely given antibiotics, anti-osteoporotic drugs, and nutritional support [13, 14].

Postoperatively, patients in the research group were evaluated for the occurrence of lower extremity DVT and were sub-divided into two groups based on its presence or absence. Postoperative observation was performed for one month. The risk factors for the occurrence of lower extremity DVT after surgery were analyzed.

Outcome measures

<u>*Primary outcome measures*</u>

Injured spine condition: The conditions of the injured spine before and after treatment were recorded, including the posterior convex angle of the injured spine and the heights of the anterior, midline, and posterior edges of the injured spine.

Pain: Pain levels of all patients were recorded before treatment, 10 days after treatment, and 1 month after treatment, using the Visual Analogue Scale (VAS). The scale was scored out of 10 points: ≤3 points indicated mild pain, with slight pain but no effect on daily life; 4-6 points indicated moderate pain, with obvious but tolerable pain; ≥7 points indicated severe and unbearable pain. The score was proportional to the severity of pain.

Table 1. Comparison of patient characteristics ($\overline{x}\pm sd$)

		Control group (n=50)	Research group (n=50)	t	P
Sex	Male	20	19	-	-
	Female	30	31	-	-
Age (year)	-	65-78	66-79	-	-
	Mean	69.98±3.87	69.87±3.94	0.141	0.888
BMI (kg/m^2)		23.58±1.01	23.64±1.10	0.284	0.777
Duration of osteoporosis (d)	-	3-14	3-14	-	-
	Mean	8.58±2.14	8.29±2.31	0.651	0.517
Duration of spinal fracture (d)	-	0.6-7	0.6-7	-	-
	Mean	2.99±0.91	3.04±0.94	0.270	0.788
Comorbidities	Hypertension	29	29	-	-
	Diabetes mellitus	24	20	-	-
	Hyperlipidemia	17	19	-	-

BMI, body mass index.

Lower extremity DVT: Postoperatively, patients in the research group were evaluated for the occurrence of lower extremity DVT and were subdivided into two groups based on its presence. DVT screening consisted of routine lower extremity ultrasound examinations performed 1 month post-treatment. Ultrasound imaging was conducted by trained technicians and interpreted by experienced radiologists who were blinded to the patients' treatment assignments. The ultrasound examinations assessed for the presence of DVT in the proximal deep veins of the legs, including the common femoral, superficial femoral, and popliteal veins. The diagnosis of DVT was based on established sonographic criteria: incomplete compressibility of the vein, the presence of an intraluminal thrombus, and visualization of an abnormal flow pattern [15].

Risk factor analysis: The occurrence of lower extremity DVT after PVP was analyzed, and the possible correlation between its occurrence and factors such as age, sex, body mass index, operation time, intraoperative bleeding, smoking, use of hormones, hypertension, diabetes mellitus, and hyperlipidemia was assessed using logistic regression analysis to determine the risk factors.

<u>*Secondary outcome measures*</u>

Treatment outcomes: The treatment outcomes of patients in both groups were evaluated and categorized as cured (spinal deformity returned to normal or a basically normal state), improved (pain symptoms were effectively relieved after treatment), or ineffective (no improvement in symptoms after treatment). Total efficiency = (cured + improved) cases/total cases × 100%.

Statistical analysis

GraphPad Prism 8 software was used to process the images, and SPSS 26.0 software was adopted for data analysis. Measured data were expressed as mean ± standard deviation (SD) or median (interquartile range). For continuous data that followed a normal distribution and exhibited homogeneity of variance, an independent samples t-test was employed to compare the groups. Counted data were expressed as absolute values and relative frequencies (%) and tested using the chi-square test. Risk factors for the occurrence of lower extremity DVT after surgery were analyzed using multivariable logistic regression with the IBM SPSS 23 program. Statistical significance of the difference was indicated by P<0.05. Visual Analogue Scale (VAS) scores were analyzed using repeated measures ANOVA followed by post hoc Bonferroni test.

Results

Comparison of baseline information

Patient characteristics between the two groups were comparable (*P*>0.05) (**Table 1**).

Table 2. Comparison of injured vertebrae ($\overline{x}\pm sd$)

		Control group (n=50)	Research group (n=50)	t	P
Before treatment	Angle of posterior convexity of injured vertebra (°)	21.15±4.15	21.09±4.45	0.070	0.944
	Height of the anterior border of the injured spine (%)	68.47±6.25	68.41±6.15	0.048	0.962
	Height of the midline of the injured spine (%)	72.74±6.14	72.84±6.61	0.078	0.938
	Height of the posterior border of the injured spine (%)	71.48±5.74	71.59±6.03	0.093	0.926
After treatment	Angle of posterior convexity of injured vertebra (°)	15.48±2.01	8.14±1.14	22.461	<0.001
	Height of the anterior border of the injured spine (%)	69.15±5.74	84.74±2.74	17.332	<0.001
	Height of the midline of the injured spine (%)	75.94±4.56	84.25±2.87	10.906	<0.001
	Height of the posterior border of the injured spine (%)	73.86±4.21	83.64±2.89	13.543	<0.001

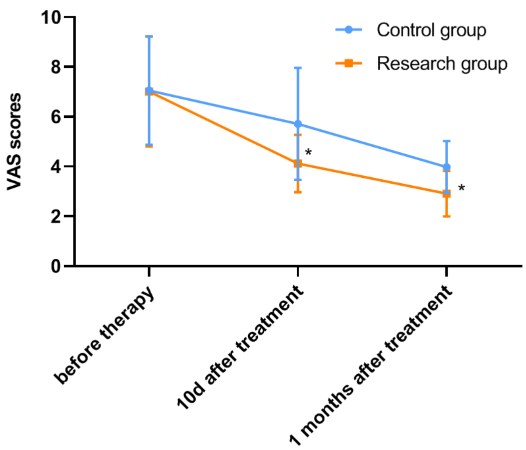

Figure 2. Comparison of VAS scores. Note: * indicates P<0.05. Patients with PVP had significantly lower VAS scores versus those with conservative treatment. VAS, Visual Analogue Scale.

Comparison of injured vertebrae

PVP resulted in a significantly smaller posterior convexity angle of the injured spine and higher anterior, midline, and posterior edges of the injured spine compared to conservative treatment ($P<0.05$) (**Table 2**).

Comparison of pain

A repeated measures ANOVA was performed to compare the effect of pain. There was a significant difference in VAS scores between the two groups (F(1, 98)=31.03, P<0001). In the control group, the VAS score was (7.05±2.18) before treatment, (5.71±2.25) 10 days after treatment, and (3.98±1.04) one month after treatment. In the research group, the VAS score was (7.01±2.21) before treatment, (4.12±1.15) 10 days after treatment, and (2.91±0.92) one month after treatment. Patients who underwent PVP had significantly lower VAS scores compared to those who received conservative treatment (**Figure 2**).

Comparison of treatment outcome

PVP was associated with significantly higher treatment efficiency compared to conservative treatment ($P<0.05$) (**Table 3**).

Comparison of lower extremity DVT

Nine cases of lower extremity DVT were reported following PVP (**Table 4**).

Risk factor analysis for patients undergoing PVP

Univariate analysis

The results of the univariate analysis showed that the differences in gender, operation time, intraoperative bleeding, hormone use, hypertension, and hyperlipidemia were not different between the two DVT groups (P>0.05), while the differences in age, body mass, smoking, and diabetes were significant between the two groups (P<0.05) (**Table 5**).

Multivariate analysis

Multivariate analysis showed that age, body mass, smoking, and diabetes were independent risk factors for lower extremity DVT (**Figure 3** and **Table 6**).

Univariate analysis for patients undergoing two different treatment methods

The results of the univariate analysis showed that the differences in treatment method, hypertension, diabetes, and hyperlipidemia were

Table 3. Comparison of treatment outcomes (%)

Group	Cured	Improved	Ineffective	Total efficiency
Control group (n=50)	18	20	12	76.00
Research group (n=50)	23	24	3	94.00
x^2		0.649		6.353
P		0.420		0.012

Table 4. Comparison of lower extremity deep vein thrombosis

		With deep vein thrombosis	Without deep vein thrombosis
Research group (n=50)	Case	9	41
	Proportion	18.00	82.00
Control group (n=50)	Case	5	45
	Proportion	10.00	90.00

significant between the two groups (P<0.05) (**Table 7**).

Multivariate analysis for patients undergoing two different treatment methods

Multivariate analysis showed that the treatment method and diabetes were independent risk factors for lower extremity DVT (**Table 8**).

Discussion

Elderly people experience a decline in body function and organ performance, and the reduction in bone mass compromises the normal bone structure, reduces bone density, and increases bone fragility, leading to osteoporosis. Consequently, an external force can easily cause a spinal fracture, severely impairing the respiratory and digestive system functions of elderly patients. Conservative treatment of spinal fractures includes pharmacologic and brace-assisted treatment, which avoid the invasive damage of surgery and alleviate patient pain but introduce high-risk complications, leading to poor prognosis.

PVP has been clinically shown to reduce the incidence of vertebral height loss, improve vertebral stability and strength, minimize trauma, prevent fractures, and provide a favorable prognosis compared to conservative treatment for osteoporotic spine fractures in the elderly [16].

Results of the present study demonstrated that PVP resulted in a significantly smaller posterior convexity angle of the injured spine and higher anterior, midline, and posterior edges of the injured spine compared to conservative treatment. Additionally, patients who underwent PVP had significantly lower VAS scores and higher treatment efficiency compared to those who received conservative treatment, consistent with the findings of Long et al. [17]. The reason for this is that PVP is a minimally invasive surgical method characterized by small incisions, mild pain, firm fixation, and precise healing [18]. It involves inserting a puncture needle into the lesion and injecting bone cement under a C-arm X-ray machine, which improves the strength and stability of the vertebral body and reduces spinal pressure, thereby promoting the recovery of vertebral function. Moreover, the temperature of the bone cement has a destructive effect on peripheral nerve cells, effectively mitigating nerve irritation and thereby decreasing pain level [19, 20].

Osteoporosis is caused by an imbalance in the dynamic process of bone remodeling, a physiological process in which osteoblasts form new bone and osteoclasts resorb existing bone matrix, essential for maintaining healthy bone tissue in adults [21, 22]. The deregulation of the hypothalamic-pituitary-target gland axis, decreased levels of estrogen and parathyroid hormone, and the release of inflammatory factors such as TNF-α into the serum promote the production of cytokines such as M-CSF, accelerating the proliferation and differentiation of osteoclasts. This leads to a continuous decrease in osteoblast activity, resulting in a negative balance of bone remodeling [23, 24]. Despite some improvement in the inflammatory response, conservative treatment fails to address the root cause of the fracture or compression problem. Additionally, the slow effect, long treatment course, and severe pain associated with conservative treatment result in poor treatment compliance and unsatisfactory outcomes.

In contrast, this study demonstrated that PVP effectively improved the condition of the injured spine, restored spinal function, significantly relieved pain, and enhanced patient prognosis,

Table 5. Univariate analysis of the risk of postoperative lower extremity deep vein thrombosis (%)

Research group (n=50)		With deep vein thrombosis (n=9)	Without deep vein thrombosis (n=41)	x^2	P
Age (years)	<70	2	28	6.527	0.011
	≥70	7	13	-	-
Sex	Male	4	15	0.193	0.660
	Female	5	26	-	-
BMI (Body Mass Index)	>24	6	9	7.027	0.008
	≤24	3	32	-	-
Operative time	>2 h	4	21	0.136	0.713
	≤2 h	5	20	-	-
Intraoperative bleeding	>500 ml	6	25	0.101	0.750
	≤500 ml	3	16	-	-
Smoking	Yes	5	8	4.983	0.026
	No	4	33	-	-
Hormones	Yes	3	18	0.338	0.561
	No	6	23	-	-
Hypertension	Yes	5	24	0.027	0.870
	No	4	17	-	-
Diabetes	Yes	8	12	10.930	0.001
	No	1	29	-	-
Hyperlipidemia	Yes	4	15	0.193	0.660
	No	5	26	-	-

BMI, body mass index.

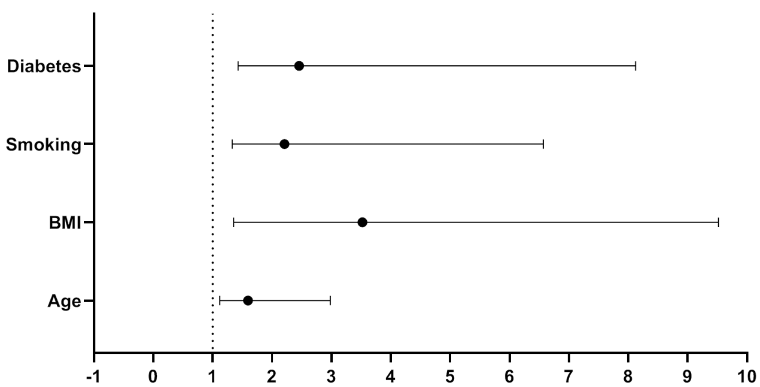

Figure 3. Forest plot of risk of postoperative lower extremity deep vein thrombosis. Age, body mass index, smoking, and diabetes were all independently associated with lower limb deep vein thrombosis.

Table 6. Multivariate analysis of the risk of postoperative lower extremity deep vein thrombosis

Factor	Regression coefficient β	Standard error (*SE*)	Wald x^2 value	OR	95% CI		P
Age	1.134	0.412	6.428	1.596	1.122	2.982	0.004
BMI	1.249	0.587	6.987	3.521	1.354	9.518	0.032
Smoking	1.214	0.526	6.762	2.210	1.331	6.569	0.029
Diabetes	1.137	0.459	7.871	2.456	1.431	8.123	0.024

BMI, body mass index.

consistent with previous studies [25, 26].

DVT of the lower extremity is a common complication of spinal compression fractures [27], causing pain, swelling, and even necrosis on the affected side. Thrombus dislodgement can lead to pulmonary embolism or even death [28, 29]. The incidence of lower extremity DVT in Asian patients with spinal cord injury has been increasing year by year [30]. According to Glotzbecker et al., the incidence of lower extremity DVT after spinal surgery ranges from 0.3% to 31%. The logistic regression analysis in this study identified age, body mass, smoking, and diabetes as independent risk factors for lower extremity DVT. Metabolism, organ function, and vascular elasticity decrease with age, leading to

Table 7. Univariate analysis of the risk of lower extremity deep vein thrombosis (%)

Research group + Control group (n=100)		With deep vein thrombosis (n=14)	Without deep vein thrombosis (n=86)	x^2	P
Age (years)	<70	5	51	2.719	0.099
	≥70	9	35	-	-
Sex	Male	6	33	0.102	0.750
	Female	8	53	-	-
BMI (Body Mass Index)	>24	7	24	2.747	0.097
	≤24	7	62	-	-
Treatment method	Conservative treatment	3	47	5.316	0.021
	PVP	11	39	-	-
Smoking	Yes	8	34	1.532	0.216
	No	6	52	-	-
Hypertension	Yes	11	43	3.957	0.047
	No	3	43	-	-
Diabetes	Yes	9	24	7.207	0.007
	No	5	62	-	-
Hyperlipidemia	Yes	8	26	3.885	0.049
	No	6	60	-	-

BMI, body mass index.

Table 8. Multivariate analysis of the risk of lower extremity deep vein thrombosis (%)

Factor	Regression coefficient β	Standard error (*SE*)	Wald x^2 value	P	OR	95% CI	
Treatment method	1.669	0.746	5.002	0.025	5.306	1.229	22.899
Hypertension	1.074	0.736	2.127	0.145	2.927	0.691	12.389
Diabetes	1.501	0.673	4.979	0.026	4.486	1.200	16.764
Hyperlipidemia	1.300	0.674	3.717	0.054	3.669	0.979	13.754

obstruction of venous blood return and eventually DVT in the lower extremities.

Obesity is also a known risk factor for arterial and venous thrombosis. Most obese patients suffer from dyslipidemia, which leads to lipid deposition in the vascular wall, vascular occlusion, and blood clotting. Obesity is a chronic inflammatory disease associated with disrupted interstitial homeostasis, which increases the risk of insulin resistance, dyslipidemia, altered blood pressure regulation, diabetes, cardiovascular disease, chronic kidney disease, cancer, and thrombosis [31]. Nicotine promotes platelet buildup and activation, while benzo(a) pyrene produced by burning tobacco accelerates platelet activation. The stress response caused by smoking impairs vascular endothelial function, promotes a hypercoagulable state, and increases blood viscosity. Reduced blood flow and elevated blood glucose levels in diabetic patients compared to the normal population further aggravate the hypercoagulable state. Insulin resistance and hyperinsulinemia directly damage venous endothelial cells and endothelial function in the lower extremities, leading to a chronic inflammatory response [32, 33]. Therefore, targeted interventions, including smoking cessation, weight loss, and body weight control, are necessary to effectively reduce the incidence of postoperative lower extremity DVT.

PVP enhances the stability of cemented masses injected into the vertebral cleft and reduces complications such as loosening, displacement, and recollapse of injured vertebrae. Treatment should consider the patient's general condition, life expectancy, activity capacity, and economic condition. Individualized treatment plans can include long-term anti-osteoporosis treatment, a reasonable postoperative diet, postoperative thoracolumbar support, and scientific based exercise.

There are also some technical considerations for PVP:

The tip of the puncture needle should be close to the endplate and should not break through it.

If leakage into the intervertebral space is detected, the direction of the puncture needle should be adjusted promptly, or the bone cement should be reinjected after it has solidified.

The integrity of the vertebral arch should be confirmed by CT examination before surgery, and the amount of bone cement injected should be minimized to avoid leakage into the spinal canal.

This study distinguishes itself from conventional clinical observational studies by employing logistic regression analysis to elaborate on risk factors, providing valuable insights for the prevention and treatment of patients. However, the study did not include in vivo, ex vivo, or animal experiments, and did not identify exact biomarkers and pathways. Based on the correlates identified in this study, such as age, weight, smoking, and diabetes, future research directions could include basic experimental design and protein space simulation.

The present study has several limitations. This retrospective study rely on existing data and the small sample size from a single center introduces selection bias, and further multi-institutional, large-sample studies are required to break down the types and specific sites of lower extremity DVT, providing more specific and reliable data.

In conclusion, PVP effectively improves the condition of the injured spine, restores spinal function, and relieves pain in elderly patients with osteoporotic spinal fractures. Lower extremity DVT is a common postoperative complication, with patient age, body mass index, smoking, and diabetes identified as independent risk factors for its development in elderly patients with osteoporotic spinal fractures after PVP.

Disclosure of conflict of interest

None.

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