Efficacy of Percutaneous Kyphoplasty and Percutaneous Pedicle Screw Fixation in Managing Osteoporotic Vertebral Compression Fractures in Middle-Aged and Elderly Individuals: A Comparative Study

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AIM: This study is aims to compare the clinical efficacy and safety of percutaneous kyphoplasty (PKP) and percutaneous pedicle screw fixation (PPSF) in managing osteoporotic vertebral compression fractures (OVCFs) among middle-aged and elderly individuals.
METHODS: A total of 142 patients aged 55–65 years were selected retrospectively from the Department of Orthopedics of our hospital from June 2021 to June 2023 and classified into PKP (n = 68) and PPSF (n = 74) groups. General data of patients were collected, and related perioperative indicators, Visual Analog Scale (VAS) scores, Oswestry Disability Index (ODI), Activities of Daily Living (ADL) scores, changes in Cobb angle of the fractured vertebrae, vertebral compression rate, as well as postoperative complications were compared between the two groups.
RESULTS: The PKP group showed shorter operation duration, reduced intraoperative blood loss, shorter hospital stay, and earlier compared to the PPSF group ($p < 0.001$). In comparison with the PPSF group, the PKP group endured much reduced pain, with improvements in spinal function and quality of life. On postoperative day 1, the PPSF group demonstrated superior restoration of vertebral height and deformity correction in relative to the other group ($p < 0.05$), with no significant difference in preoperative Cobb angle and vertebral compression rate ($p > 0.05$). The incidence of complications showed no significant differences between the two groups ($p > 0.05$).
CONCLUSIONS: The advantages of PKP lie in its ability to effectively relieve pain, improve spinal function, and enhance the quality of life. PPSF, meanwhile, is well-suited for the recovery of vertebral height and the correction of deformity in the early stage.

Keywords: PPSF; PKP; OVCFs; clinical efficacy

Introduction

Reduced bone density, decreased bone mass, and diminished bone quality are defining features of osteoporosis, a systemic metabolic disease that heightens the risk of fractures [1, 2]. While osteoporosis is more common in the elderly population, it can also affect middle-aged and young individuals [3]. Fractures resulting from osteoporosis can arise spontaneously, without external force, during routine activities or even following minor trauma [4].

Osteoporotic vertebral compression fractures (OVCFs) [5] represent one of the major complications of osteoporosis. These fractures can cause severe pain, spinal deformity, and functional impairment, significantly impairing the patients' quality of life [6]. Early surgical intervention, particularly in elderly individuals and those with severe consequences from fractures, can help restore vertebral height, correct deformities, and alleviate pain symptoms [7, 8].

Among the surgical methods used for treating thoracolumbar OVCFs, percutaneous pedicle screw fixation (PPSF) and percutaneous kyphoplasty (PKP) are currently the popular options [9, 10, 11]. The PKP procedures include locating the fractured vertebral pedicle in the prone position with C-arm fluoroscopy, performing local infiltration anesthesia, cutting skin, inserting a puncture needle, and placing an uninflated balloon containing contrast agent into the vertebral body with the assistance of fluoroscopy. After restoring the height of the vertebral body, bone cement is injected into the vertebral body after removing the balloon to prevent leakage of bone cement [12]. The procedures of PPSF encompass performing general anesthesia on the patient, marking the projection position of the vertebral pedicle, inserting a guide wire after cutting the skin, confirming the position of the guide wire under X-ray fluoroscopy, expanding a puncture channel along the guide wire, inserting a pedicle screw, installing a longitudinal connecting rod and extending it appropriately to achieve the reduction of the height of the vertebral body, and finally fixing the tail cap [13]. The PPSF method is a favorable option for elderly patients with compromised physical condition who cannot undergo major surgeries [14, 15]. For younger patients with high activity levels and complex fractures, PPSF not only delivers more stable support through internal fixation but also boosts the reliability of the fixation system by reinforcing bone cement [16, 17]. In general, the PPSF approach affords spinal stability.

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Despite the abundance of reports on treating OVCFs using these two distinct surgical methods, currently, there is still a lack of clear guidelines regarding the selection of an appropriate approach for patients in specific age groups, and direct comparative studies on their efficacy and safety are also lacking in literature. This study aimed to appraise and compare the efficacy and safety of PKP and PPSF in treating OVCFs patients in the age range of 55–65 years.

Materials and Methods

Study Participants

In this retrospective study, a total of 142 patients aged 55–65 years, who underwent treatment for OVCFs in the Department of Orthopedics in Suzhou Hospital of Integrated Traditional Chinese and Western Medicine (Jiangsu, China) during the period from June 2021 to June 2023, were selected. The individuals were subsequently classified into two groups, namely the PKP and the PPSF groups, in accordance with the particular surgical methods the subjects underwent. The subjects in the PKP group underwent percutaneous kyphoplasty, while the participants in the PPSF group received percutaneous pedicle screw fixation. The flowchart of patient selection and exclusion in this study is depicted in Fig. 1 (Ref. [18, 19]). This study was performed in compliance with the principles described in the Declaration of Helsinki and had been approved by the ethics committee of Suzhou Hospital of Integrated Traditional Chinese and Western Medicine (Ethics Approval No.: 2024010). All individuals had given their informed consent prior to participating in this study.

The inclusion criteria of the study were as follows: (i) age range of 55 to 65 years; (ii) thoracolumbar vertebral compression fracture with anterior vertebral height loss $\geq$20%; (iii) mild to moderate osteoporosis diagnosed through bone density examination [18]; (iv) an intact posterior wall in the fractured vertebra and absence of spinal canal stenosis, as proven by imaging examination, as well as a Thoracolumbar Injury Classification and Severity Score of $\geq$4 based on three variables [19]; (v) single-level vertebral fracture occurring immediately or within 3 months after the injury; and (vi) follow-up duration of more than 1 year with complete follow-up data.

Patients with the following conditions were excluded from this study: (i) presence of multiple fractures or two or more fractures at different sites; (ii) diagnosis of spinal tuberculosis, local or systemic infections, tumors, or pathological fractures; (iii) diagnosis of severe osteoporosis; (iv) cardiac or pulmonary dysfunction, which was surgically inoperable; and (v) coagulation disorders or bleeding tendencies.

Methods

PKP Procedure

Under C-arm fluoroscopy, the fractured vertebra pedicles were located and marked after positioning the patient in a prone position. The surgical area that had been routinely disinfected with iodine was then wiped with alcohol. A disposable sterile surgical drape was placed. Local infiltrative anesthesia was administered, and a 0.5 cm incision was made at the marked place of the fractured vertebra pedicle. Through the incision, a puncture needle was inserted at an inward tilt of 15°. Targeting the anterior-middle third of the fractured vertebra, the puncture needle was advanced with the assistance of fluoroscopy. Anteroposterior and lateral X-ray fluoroscopy were utilized to check the position of the needle. The working channel was widened in the direction of the puncture needle, which led to the extraction of the vertebral positioning needle. After that, a deflated balloon containing contrast medium was placed into the vertebral body through the working channel. Intraoperative X-ray fluoroscopy was employed to verify the integrity of the patient's spinal column's posterior wall and ensure satisfactory height restoration. The balloon was taken out, and the contrast medium was withdrawn. Subsequently, the mixed bone cement was injected into the fractured spinal column. X-ray fluoroscopy was employed to verify the correct dispersion of the bone cement and monitor whether it leaked into the spinal canal or intervertebral foramen. The working channel was removed once the bone cement had solidified, and sterile dressings were placed over the puncture site, followed by compression.

PPSF Procedure

General anesthesia was administered to all patients. Similar to the PKP reduction method, the surgical area of the patient was disinfected routinely, and a disposable sterile surgical drape was placed. The projection of the vertebral pedicles on both sides was marked, allowing for the determination of the position of the pedicle screws under fluoroscopy. By sequentially making incisions of approximately 1.5 cm at each marked point, the guide wire was inserted after incising the skin, subcutaneous tissue, and fascia. Following the confirmation of the correct position under X-ray fluoroscopy, the guide wire was advanced from the pedicle into the anterior-middle third of the vertebral body. The puncture channels were gradually expanded along the guide wire, allowing for the insertion of pedicle screws into the corresponding vertebral pedicles on both sides. The reduction of vertebral height was observed under fluoroscopy after the longitudinal connecting rod was installed through the working channel, and appropriately expanded. The tail cap was then securely fixed.

Postoperative management encompassed the monitoring of the patient's vital signs, observation of the surgical incision's condition, and assessment of leg sensation and movement. Regular dressing changes were implemented. Within 1 day after the procedure, X-ray examination was conducted to evaluate the patient's condition and determine the need for orthosis and appropriate ambulation. Regular follow-up appointments were scheduled at 3 months, 6 months, and 1 year after discharge. Medications, including

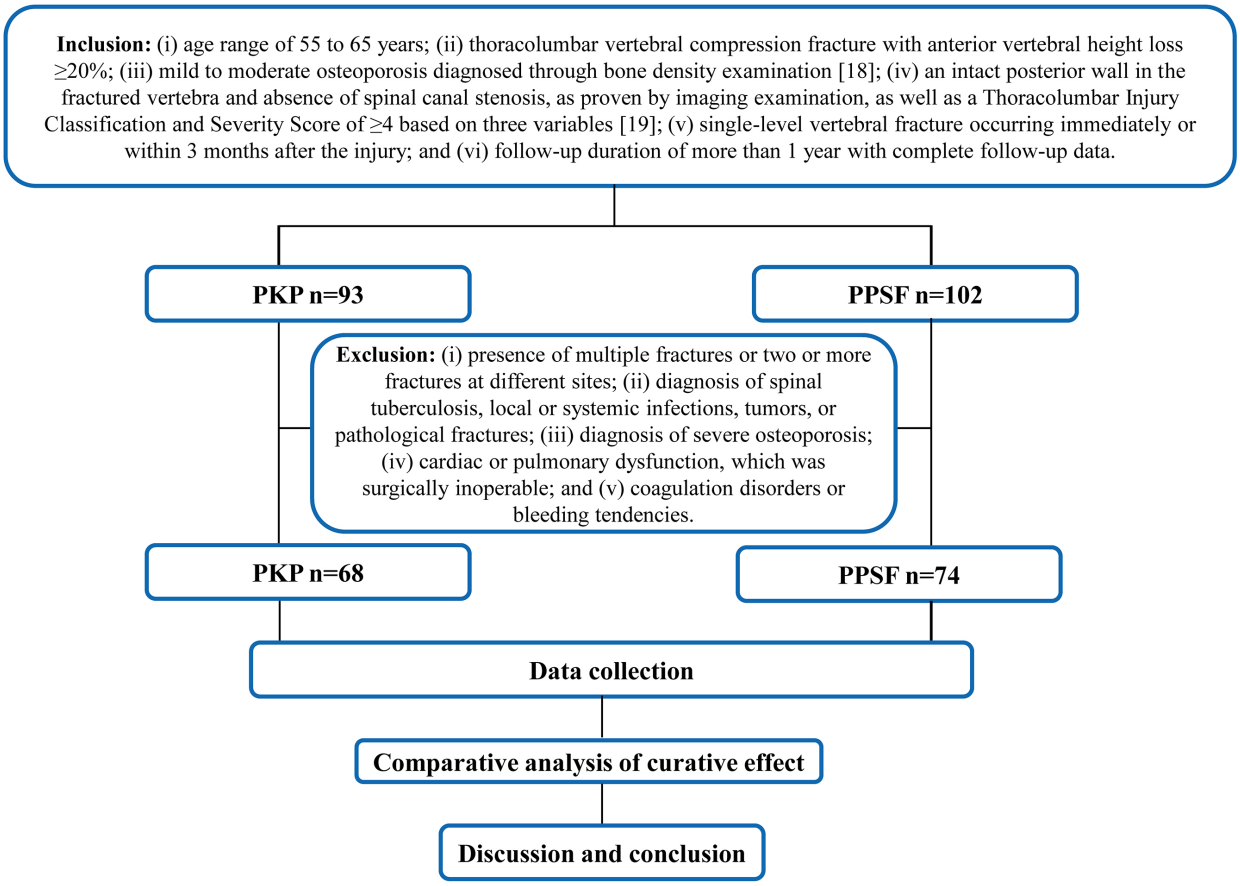

Fig. 1. The flowchart of patient selection and exclusion. PKP, percutaneous kyphoplasty; PPSF, percutaneous pedicle screw fixation.

salmon calcitonin nasal spray (1 spray per day for 3 months) and intravenous zoledronic acid (5 mg per year), were administered based on the physician's instructions.

Evaluation Indicators

(i) General information of the patients, including age, body mass index (BMI), gender, smoking status, alcohol consumption, fracture location, and time from injury to surgery.

(ii) Related perioperative indicators, including operation time, intraoperative blood loss, length of hospital stay, time to ambulation after surgery, and postoperative complications.

(iii) Visual Analog Scale (VAS): To evaluate the severity of chest and back pain using a scale from 0 to 10, with a higher score indicating a greater level of pain experienced by the patient [20].

(iv) Oswestry Disability Index (ODI): To assess the functional impairment of the injured vertebra using 10 questions, with a higher score indicating poorer spinal function; the score is calculated using this formula: actual score/highest score × 100% [21].

(v) Activities of Daily Living (ADL) score: To evaluate the patient's actual capability to perform daily tasks using 10 questions, with a higher score indicating a greater ability to live independently (total score = 100) [22].

(vi) Cobb angle of the fractured vertebra: To determine the Cobb angle of the kyphosis, two perpendicular lines are drawn on the upper and lower endplates of the fractured vertebra, and the angle formed between these lines is measured. The change in Cobb angle at different time points is observed [23]. The normal height of the anterior vertebral body of the fractured vertebra = sum of the heights of the upper and lower endplates of the vertebral body/2. The vertebral compression rate = (normal height of the anterior vertebral body – height of the anterior vertebral body of the fractured vertebra)/normal height of the anterior vertebral body) × 100%.

(vii) Postoperative complications, including adjacent vertebral fractures, fat liquefaction at the incision site, nerve injury, and bone cement leakage, that arose during the intraoperative period and within 1 year postoperatively.

Statistical Methods

Using IBM SPSS Statistics 25.0 software (SPSS Statistics Inc., Chicago, IL, USA), the data of the included participants were processed and analyzed. Firstly, the Kolmogorov-Smirnov test was conducted for all variables. For variables conforming to the normal distribution, except for gender, smoking, drinking, and fracture site, data were expressed as mean ± standard deviation. For cat-

egorical variables, data were presented in the form of n (%). The data between the two groups were analyzed and compared using independent sample *t*-test. Separately, *chi*-square test was utilized to analyze and compare data of gender, smoking, drinking, fracture site, and complications between the two groups. A comparison of data at different time points, before and after surgery, within the same group was conducted using repeated measures analysis of variance (ANOVA). A *p*-value of less than 0.05 was considered statistically significant.

Results

General Information

In the PKP group, there were 27 male individuals and 41 female individuals, with an average age of 59.53 ± 3.92 years. The subjects in this group had a mean bone density T score of –2.39 ± 0.18. Fractures were detected at four sites in this group subjects: T11 (12 cases), T12 (27 cases), L1 (21 cases), and L2 (8 cases). In the PPSF group, there were 29 male patients and 45 female patients, with a mean age was 60.22 ± 3.74 years. The subjects in the PPSF group had a mean bone density T score of –2.36 ± 0.22. Similarly, fractures were observed at four sites in this group of subjects: T11 (13 cases), T12 (30 cases), L1 (22 cases), and L2 (9 cases). In both groups, a distinct history of trauma was evident, and the lesions were concentrated in the thoracolumbar region. None of the patients displayed symptoms associated with spinal nerve involvement. The general information and preoperative evaluation criteria did not exhibit a statistically significant difference between groups ($p > 0.05$), indicating their comparability (Table 1).

Table 1. General information of PKP and PPSF groups.

Characteristics	PKP ($n = 68$)	PPSF ($n = 74$)	t/χ^2	p
Age	59.53 ± 3.92	60.22 ± 3.74	–1.026	0.307
Sex			0.004	0.950
Male	27	29		
Female	41	45		
BMI	21.46 ± 2.50	21.95 ± 2.66	–1.124	0.263
Bone density	–2.39 ± 0.18	–2.36 ± 0.22	–0.890	0.375
Smoking			0.001	0.980
Yes	21	23		
No	47	51		
Drinking			0.241	0.624
Yes	19	18		
No	49	56		
Fracture site			0.027	0.999
T11	12	13		
T12	27	30		
L1	21	22		
L2	8	9		

BMI, body mass index; PKP, percutaneous kyphoplasty; PPSF, percutaneous pedicle screw fixation.

Perioperative Indicators

In comparison to the PPSF group, the PKP group experienced a shorter operation duration (42.96 ± 5.68 min), reduced intraoperative blood loss (10.13 ± 2.59 mL), shorter hospital stay (4.71 ± 1.68 days), and shorter time between surgery and ambulation (4.41 ± 1.75 days). Conversely, the PPSF group experienced a longer operation duration (95.70 ± 8.82 min), higher intraoperative blood loss (49.81 ± 4.15 mL), longer duration of hospitalization (7.07 ± 1.82 days), and longer time to bear weight after surgery (6.96 ± 2.24 days) ($p < 0.001$) (Table 2).

VAS Scores

The results of repeated measures ANOVA showed that there were significant differences in VAS scores at different time points after surgery ($p < 0.001$), as well as significant differences in VAS scores between PKP and PPSF groups ($p < 0.05$). Nevertheless, there was no interaction between time and group, indicating that there was no significant difference in VAS scores between the two groups at different time points ($p > 0.05$) (Table 3).

ODI Scores

The results demonstrated that there were significant differences in ODI score at different time points after surgery ($p < 0.001$), and between PKP and PPSF groups ($p < 0.001$). In addition, there was an interaction between time and group, indicating that there was a significant difference in ODI score between the two groups at different time points ($p < 0.001$) (Table 4).

ADL Scores

The results showed that there were significant differences in ADL scores at different time points after surgery ($p < 0.001$), and between PKP and PPSF groups ($p < 0.001$). Furthermore, there was an interaction between time and group, indicating that there was a significant difference in ADL score between the PKP and PPSF groups across the different time points ($p < 0.001$) (Table 5).

Cobb Angle and Vertebral Compression Rate

No statistically significant difference was identified in the comparison of Cobb angle and vertebral compression rate of the fractured vertebrae between groups preoperatively ($p > 0.05$). Both groups showed a notable reduction in Cobb angle and vertebral compression rate on postoperative day 1 following the surgery. However, the PPSF group exhibited a greater reduction as opposed to the PKP group ($p < 0.05$) (Table 6).

Complications

Several cases of complications were noted in the PKP group: adjacent vertebral fracture (1 case), fat liquefaction around the incision site (1 case), nerve injury (2 cases), and bone cement leakage (2 cases). On the other hand, 2

Table 2. Perioperative indicators of PKP and PPSF groups.

Group	Operation duration (min)	Intraoperative blood loss (mL)	Duration of hospitalization (day)	Postoperative weight-bearing time (day)
PKP (n = 68)	42.96 ± 5.68	10.13 ± 2.59	4.71 ± 1.68	4.41 ± 1.75
PPSF (n = 74)	95.70 ± 8.82	49.81 ± 4.15	7.07 ± 1.82	6.96 ± 2.24
t	–41.942	–67.641	–8.015	–7.507
p	<0.001	<0.001	<0.001	<0.001

Data are expressed as mean ± standard deviation.

Table 3. VAS scores of PKP and PPSF groups across different time points.

Group	VAS scores				
	Preoperative	Postoperative day 1	Postoperative 3 months	Postoperative 6 months	Postoperative 1 year
PKP (n = 68)	5.32 ± 1.00	2.47 ± 1.07	1.56 ± 0.53	1.63 ± 0.49	1.43 ± 0.50
PPSF (n = 74)	5.27 ± 1.01	2.91 ± 0.97	1.65 ± 0.53	1.70 ± 0.61	1.45 ± 0.55
Time			F = 625.413, $p < 0.001$		
Group			F = 4.107, $p = 0.045$		
Time × Group			F = 2.123, $p = 0.077$		

Data are expressed as mean ± standard deviation.

VAS, Visual Analog Scale.

cases of adjacent vertebral fracture, 1 case of fat liquefaction around the incision site, and 3 cases of nerve injury were also observed in the PPSF group. The incidence of complications did not show a statistically significant difference between groups (8.82% *vs.* 8.11%) ($p > 0.05$) (Table 7).

Case Presentation

Patient A, a 62-year-old female, suffered from chest and back pain with limited mobility for 3 days due to an accidental fall. She was diagnosed with a compression fracture of the T12 vertebra and underwent PKP treatment. The results of preoperative and postoperative X-ray examination (as shown in Fig. 2A–D) showed smooth healing of the fracture, bone cement being injected in the right position, absence of loosening or displacement of the bone cement, and very minimal bone cement leakage. These signs indicate that PKP affords excellent therapy for this patient, effectively relieving pain and restoring the stability of the vertebral body. Patient B, a 57-year-old male, experienced chest and back pain with limited mobility for 2 days after a cycling accident. He was diagnosed with a fracture of the L1 vertebra and underwent PPSF treatment. From the preoperative and 1st day postoperative day X-ray images (Fig. 2E–H), it can be seen that the fracture after PPSF underwent smooth and optimal reduction, the pedicle screw was properly placed, the length and position of pedicle screw were appropriate, and there was no loosening or displacement of the bone cement. This shows that the PPSF procedure provided the patient with stable spinal support, which contributed to the healing and recovery of the fracture.

Discussion

Due to long-term participation in physical labor, the middle-aged and elderly population aged 55–65 are more vulnerable to osteoporosis [24], although bone density decline is not very severe. PKP is effective for treating vertebral compression fractures with different bone densities [25]. The mechanical strength and durability of PPSF depend on the grip strength between the screw and the bone interface. Severe osteoporosis can lead to a substantial decrease in the number of trabeculae, which reduces the grip strength of the pedicle screw and the surrounding bone tissue, leading to loosening and pulling out of the screw. Severe osteoporosis is a relative contraindication for internal fixation [26]. In this study, comparison of the clinical efficacy and safety of PKP and PPSF in treating OVCFs in the middle-aged and elderly patients was conducted, yielding meaningful results through the analysis of various indicators.

In terms of perioperative indicators, the subjects of the PKP group experienced shorter operation duration, lower intraoperative blood loss, shorter hospital stay, and shorter weight-bearing time after surgery in relative to PPSF group, which are consistent with previous research results [27, 28]. PKP is a relatively simple operation, entailing a significantly shorter operation duration and smaller incisions, which contribute to lesser intraoperative bleeding and trauma and thereby promote postoperative recovery. These advantages are of great significance for improving patients' treatment compliance and quality of life.

In terms of pain relief, postoperative VAS scores were significantly reduced in both groups, indicating that both surgical methods can effectively relieve pain. At the same

Table 4. ODI scores of PKP and PPSF groups across different time points.

Group	ODI scores				
	Preoperative	Postoperative day 1	Postoperative 3 months	Postoperative 6 months	Postoperative 1 year
PKP (n = 68)	68.99 ± 6.69	21.68 ± 2.57	18.07 ± 2.48	15.19 ± 1.52	14.37 ± 1.47
PPSF (n = 74)	68.91 ± 6.31	28.20 ± 2.67	20.55 ± 2.34	15.35 ± 1.57	14.59 ± 1.56
Time			F = 6196.117, $p < 0.001$		
Group			F = 54.124, $p < 0.001$		
Time × Group			F = 23.171, $p < 0.001$		

Data are expressed as mean ± standard deviation.

ODI, Oswestry Disability Index.

Table 5. ADL scores of PKP and PPSF groups across different time points.

Group	ADL scores				
	Preoperative	Postoperative day 1	Postoperative 3 months	Postoperative 6 months	Postoperative 1 year
PKP (n = 68)	55.10 ± 6.11	80.63 ± 7.45	92.69 ± 9.41	92.75 ± 6.35	92.44 ± 6.05
PPSF (n = 74)	55.20 ± 6.22	72.14 ± 8.78	87.57 ± 9.80	91.22 ± 6.49	91.69 ± 6.49
Time			F = 623.619, $p < 0.001$		
Group			F = 37.584, $p < 0.001$		
Time × Group			F = 7.891, $p < 0.001$		

Data are expressed as mean ± standard deviation.

ADL, Activities of Daily Living.

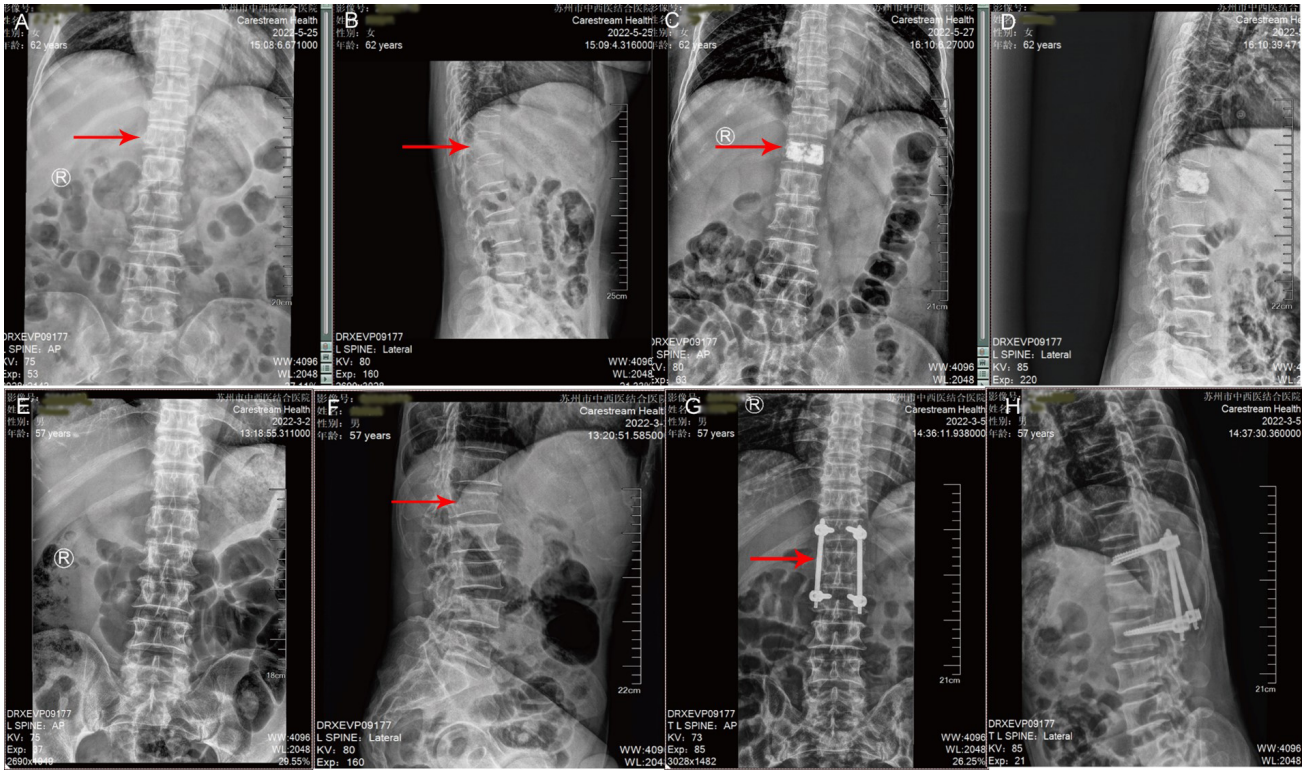

Fig. 2. Representative X-ray images of patients treated with PKP (A–D) and PPSF (E–H). X-ray images before and 1 day after surgery are shown. Red arrows: Injured vertebral body. (A,B) Preoperative X-ray image showing T12 vertebral compression fracture. (C,D) Postoperative X-ray images showing good fracture healing, proper position of bone cement, no loosening or displacement of bone cement, and minimal bone cement leakage. (E,F) Preoperative X-ray views showing L1 vertebral compression fracture. (G,H) Postoperative X-ray images showing good fracture reduction, proper placement of pedicle screws, appropriate length and position of pedicle screws, and no loosening or displacement of bone cement. Injured vertebral body is indicated by red arrow. PKP, percutaneous kyphoplasty; PPSF, percutaneous pedicle screw fixation.

Table 6. Cobb angle and vertebral compression rate of PKP and PPSF groups before and after surgery.

Group	Cobb angle (°)		Vertebral body compression rate	
	Preoperative	Postoperative day 1	Preoperative	Postoperative day 1
PKP (n = 68)	14.30 ± 4.78	8.57 ± 1.90*	35.11 ± 6.07	15.31 ± 4.26*
PPSF (n = 74)	15.09 ± 4.08	7.52 ± 1.69*	35.12 ± 5.37	10.45 ± 5.23*
t	–1.067	3.510	–0.007	6.034
p	0.288	0.001	0.994	<0.001

Data are expressed as mean ± standard deviation. * indicates significant difference following treatment in contrast to before the treatment.

Table 7. Complications experienced by subjects in the PKP and PPSF groups.

Group	Adjacent vertebral fracture	Fat liquefaction in wounds	Nerve injury	Bone cement leakage	Overall incidence
PKP (n = 68)	1 (1.47)	1 (1.47)	2 (2.94)	2 (2.94)	6 (8.82)
PPSF (n = 74)	2 (2.70)	1 (1.35)	3 (4.05)	0 (0.00)	6 (8.11)
χ^2					0.023
p					0.878

Data are expressed as count (percentage).

time, PKP is more effective in reducing pain than PPSF. This is consistent with the conclusion of another study that PKP allows for rapid pain relief during the early postoperative phase [29]. However, in the long run, the two surgical methods have similar effects on pain relief, suggesting the selection of an appropriate surgical method lies in the comprehensive consideration of the short-term and long-term needs of patients with regard to pain relief.

In terms of the recovery of spinal function, ODI scores were remarkably improved in both groups, with PKP contributing to more substantial improvement in spinal function during the early postoperative period, which is probably related to its capacity for quick pain relief and rapid healing for ambulation in patients. Other studies have shown that early functional recovery is indispensable for patients' life quality and mental health [30, 31].

Both surgical methods can effectively improve the quality of life of patients, with PKP manifesting more pronounced improvement in this regard. This further confirms that PKP can help patients more quickly recover their ability to live independently in the early postoperative period and improve their quality of life. This can be attested to by other clinical studies emphasizing the positive impact of early improvement in quality of life on patient recovery [32, 33].

The PPSF group had better improvement in vertebral height and correction of deformity on the first day after surgery, which is consistent with the greater stable spinal support afforded by the surgical method through internal fixation [34, 35]. However, no remarkable discrepancy was identified between the surgical methods in terms of Cobb angle and vertebral compression ratio before surgery, indicating that both methods are equally effective in treating OVCFs.

Regarding postoperative complications, the PKP group had 1 case of adjacent vertebral fracture, 1 case of fat liquefaction around the incision, 2 cases of nerve injury, and 2 cases of cement leakage; the PPSF group had 2 cases of adjacent vertebral fracture, 1 case of fat liquefaction around the incision, and 3 cases of nerve injury. The incidence of complications in the two groups was not significantly different. In the PKP group, cement leakage may be related to improper pressure and speed control during cement injection, and the operator needs to be more cautious during the operation; nerve injury may be related to nerve damage during puncture, suggesting that the operator should improve their surgical skills and increase the accuracy in puncture. In the PPSF group, adjacent vertebral fracture may be related to changes in the biomechanical structure of the spine caused by internal fixation, and further attention to this aspect should be paid during the postoperative rehabilitation and follow-up; nerve injury may be related to the complexity of the surgical procedure and traction on surrounding tissues, underscoring the importance of protecting nerve tissue during the operation. These complications have important implications for patient outcomes and health care costs. From the perspective of patient outcomes, complications can prolong recovery time, exacerbate pain, increase discomfort, and reduce quality of life. In some cases, the primary complications observed may give rise to the secondary adverse effects, which add considerably to the medical burden. For instance, adjacent vertebral fractures can cause spinal deformity and dysfunction, which require additional treatment and rehabilitation interventions; and nerve damage can affect daily activities. At the same time, complications can also increase psychological burden, and affect treatment confidence and satisfaction. In terms of health care costs, the management of complications requires additional medical resources and expenses, such as further examinations, treatment, and extended hospital stay, which all contribute to higher costs. In order to reduce the incidence and impact of complications, several steps should be implemented: (i) conduct preoperative evaluation on patients; (ii) select the appropriate patient and

timing; (iii) implement operation with high standards and stringency; (iv) improve skills, reduce trauma and risk; and (v) conduct close postoperative observation of the condition, and manage complications in a timely manner. Future studies should explore the optimization of surgical protocol and perioperative management, with the primary goals of reducing the incidence of complications, improving treatment efficacy and quality of life, and reducing health care costs.

The advantages of PKP are as follows: (i) inducing relatively small surgical trauma; (ii) involving a relatively simple operation; (iii) enabling rapid pain relief; (iv) allowing for early elevation in patient's life quality; (v) relatively low requirements for patient's physical condition. However, it may not be as effective as PPSF in restoring the height of the vertebrae and correcting deformity. Comparatively speaking, PPSF are better at improving vertebral height and correcting deformity, while providing more stable spinal support. However, it features a longer operation duration, greater trauma, more intraoperative blood loss, a longer period of hospitalization, and a longer time for achieving weight-bearing following surgery, as well as requires patients indicated for this surgery to be in excellent physical health condition.

There are several inherent limitations of this study that we should acknowledge. Firstly, this study is of a retrospective design, which makes it susceptible to selection bias. Secondly, given the retrospective nature of this study, the selection of patients into this study may be influenced by a number of factors, including but not limited to physician preferences, patient's visit time, and medical conditions at the time, etc. Under the influence of these factors, the study sample collected may not be fully representative of the general population, and thus, the generalizability of the study findings can be adversely impacted. For example, in this study, patients were divided into PKP and PPSF groups based on the surgical modalities they underwent, but the choice of surgical modalities may not be completely random, but rather influenced by a combination of factors. This may result in differences between the two groups of patients in some unmeasured variables, which may affect the interpretation of current results. In addition, integrity and accuracy of data gathered from retrospective studies is a major point of concern because missing or inaccurate data can affect the assessment of outcomes. To reduce the impact of these limitations, future studies may consider prospective design to ensure a balance of baseline characteristics between the two groups of patients through randomization. At the same time, management of medical records should be strengthened to ensure the accuracy and completeness of the data.

Conclusions

In summary, PKP and PPSF have their own advantages and limitations in treating OVCFs in the middle-aged and elderly patients. For patients with poor physical health condition, who cannot tolerate extensive surgery, and seek early pain relief and improved quality of life, PKP stands as a better choice. Since PKP surgery is less invasive and relatively simple to operate, it can quickly relieve pain and help patients resume to their normal daily life early. However, for young patients who have higher activity levels and more complex fractures, or those who place greater emphasis on vertebral height recovery and deformity correction, PPSF may be a more suitable approach. Of note, PPSF provides more stable support through internal fixation, which can better restore vertebral height and correct deformities, and cater to patients' needs for spinal stability. In addition, the patient's bone density should be considered prior to subjecting the patient to PPSF. Severe osteoporosis may affect the grip strength of the screw and bone tissue following PPSF, causing screw loosening and pull-out; therefore, PKP stands as a more appropriate strategy in the case of osteoporosis. In conclusion, selecting the most suitable surgical method from among the PKP and PPSF lies in a comprehensive weighing of their advantages and disadvantages according to the specific conditions of patients, including their physical condition, fracture type, activity type, and bone density, so as to form a more personalized approach for achieving the best treatment effect.

Availability of Data and Materials

All experimental data included in this study can be obtained by contacting the first author if needed.

Author Contributions

JL designed and conducted the research and wrote the paper; XT designed the research and supervised the report; WZ contributed to the experimental protocol design; DC designed the research and provided clinical advice; JC contributed to the experimental data collection. All authors contributed to important editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This investigation was performed in compliance with the principles described in the Declaration of Helsinki and had been approved by the ethics committee of Suzhou Hospital of Integrated Traditional Chinese and Western Medicine (Ethics Approval No.: 2024010). All individuals had given their informed consent prior to participating in this study.

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Conflict of Interest

The authors declare no conflict of interest.

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