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Original Article

Unilateral Pedicular Puncture with Lateral Injection for Osteoporotic Vertebral Compression Fractures in the Upper and Middle Thoracic Vertebrae: A Technical Report and Efficacy Comparison

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Abstract

Background: Percutaneous vertebroplasty (PVP) for upper and middle thoracic osteoporotic vertebral compression fractures (OVCFs) is challenged by technical difficulties and safety concerns, which drive the need for innovative techniques to optimize its efficacy. The purpose of this study was to delineate the technical characteristics of a novel methodology and to conduct a comparative analysis of its efficacy against bilateral transpedicular puncture PVP.

Methods: A retrospective study was conducted on consecutive patients undergoing PVP for upper/middle thoracic OVCFs at the Second Affiliated Hospital of Chongqing Medical University (Chongqing, China) between January 2019 and December 2024. Patients were allocated to either the unilateral transpedicular puncture lateral injection (UTPLI) or the conventional bilateral transpedicular puncture (BTP) group based on the surgical timeline, with earlier cases undergoing BTP and later ones UTPLI. Baseline characteristics, operative time, estimated blood loss, cement volume, visual analogue scale (VAS), Oswestry disability index (ODI), vertebral and segmental kyphosis angles, anterior/middle/posterior vertebral heights, and postoperative cement distribution indices were recorded and compared between the two groups. Data were analyzed with SPSS software (version 26.0) using Chi square, *t* tests, and non-parametric tests.

Results: A total of 57 patients were enrolled (UTPLI group=21, BTP group=36). The UTPLI group had a shorter operation time (18.00±9.00 min vs. 25.00±9.00 min, P=0.002) and less estimated blood loss (3.93±1.22 mL vs. 5.13±1.37 mL, P=0.002). No significant intergroup differences were found in VAS, ODI, kyphosis angles (vertebral, segmental, thoracic), vertebral heights (anterior, middle, posterior), baseline data, bone cement leakage, cement dispersion index, or spatial distribution scores, either preoperatively or postoperatively (P>0.05).

Conclusion: The UTPLI technique is a viable alternative to BTP PVP for upper and middle thoracic OVCFs. It reduced operative time and blood loss while achieving comparable outcomes.

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Keywords ● Thoracic vertebra ● Vertebroplasty ● Osteoporosis ● Compression fractures ● Bone cements

What's Known

- In current treatments for osteoporotic vertebral compression fractures, controversies persist regarding the choice between surgical and conservative approaches, as well as between bilateral and unilateral surgical procedures.

What's New

- This study presents a more economical, novel unilateral pedicular puncture with lateral injection that achieves good curative effects in the middle and upper thoracic vertebrae by using basic surgical instruments.

Introduction

As the aging population progresses, the number of people suffering from osteoporosis is increasing. Consequently, the occurrence of osteoporotic vertebral compression fractures (OVCFs) is also on the rise. Elderly patients with osteoporosis often experience symptoms of low back pain or back pain accompanied by limited mobility following mild trauma or even for unknown reasons. Even coughing may lead to the onset of symptoms. Movement of the lumbar and dorsal regions leads to aggravation of symptoms, and some patients may even develop intercostal neuralgia. This situation has seriously affected patients' quality of life.[1, 2]

Currently, the treatments for OVCFs are divided into conservative treatment and surgical treatment. Conservative treatment requires patients to remain in bed for a prolonged period, with an inevitable consequence being an increased incidence of various complications, such as deep vein thrombosis, bedsores, and pulmonary and urinary tract infections. The other treatment modality is surgical treatment. Currently, the most commonly used methods for OVCFs are percutaneous vertebroplasty (PVP) and percutaneous kyphoplasty (PKP).[3, 4] Surgery can relieve patients' pain symptoms and enable them to avoid complications associated with prolonged bed rest.[5, 6] Both PKP and PVP can be divided into unilateral puncture and bilateral puncture. There is still no consensus on which method is more advantageous. Some scholars believe that bilateral puncture provides better bone cement distribution, more obvious symptom improvement, and a lower incidence of vertebral refracture, thus being superior to unilateral puncture.

However, other researchers hold the view that unilateral puncture has a shorter operative time, lower radiation dose, and less intraoperative bleeding, and is therefore superior to bilateral puncture. Of course, both methods have their own shortcomings. Bilateral puncture has a longer operation time, more blood loss, and higher surgical costs, while unilateral puncture carries a higher risk of spinal cord nerve injury and a faster decrease in postoperative vertebral height.[7-10] Therefore, we designed a new method and combined the advantages of unilateral puncture (fewer steps, minimal trauma, and shorter operative time) with those of bilateral puncture (excellent bone cement distribution). This study aimed to delineate the technical characteristics of a novel methodology and to conduct a comparative analysis of its efficacy against bilateral transpedicular puncture PVP.

Materials and Methods

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Chongqing Medical University. The ethical approval code was No2025IIT113. Informed consent was obtained from all individual participants included in the study.

Patients

Consecutive patients who underwent PVP for upper and middle thoracic (T1-T10) OVCFs at the Second Affiliated Hospital of Chongqing Medical University (China) between January 2019 and December 2024 were screened for eligibility. The sample size was determined based on the annual incidence of OVCFs at our hospital (one of the Top 100 Hospitals in China) and logistical feasibility. All PVP procedures were performed by a single spine surgeon; patients were therefore allocated to either the unilateral transpedicular puncture lateral injection (UTPLI) group or the conventional bilateral transpedicular puncture (BTP) group. This study was not randomized; instead, patients were assigned according to a technology-transition design, with all those treated after the UTPLI launch date receiving UTPLI (later-period cases) and those treated before that date having undergone BTP (early-period cases).

Inclusion Criteria

Patients were eligible for inclusion if they met the following criteria: severe back pain and/or intercostal neuralgia exacerbated by thoracic vertebral movement; a visual analogue scale (VAS) score greater than 5; low signal intensity on T1-weighted magnetic resonance imaging (MRI) and high signal intensity on T2-weighted imaging of the affected vertebral bodies; vertebral height loss exceeding 15%; and a bone mineral density T-score below -2.5.

Exclusion Criteria

The exclusion criteria were as follows: poor general physical condition; imaging evidence of a breach in the posterior vertebral body wall; vertebral fracture secondary to a tumor or infection; abnormal blood coagulation function; or neurological disorders severely impairing consciousness or communication.

Surgical Techniques

All patients underwent surgeries performed by the same experienced spine surgeon (Xiaolin Chen). Local anesthesia was achieved with 1% lidocaine (Hubei Tiansheng Pharmaceutical

Co., Ltd., China): a 1 cm intradermal wheal was raised, followed by layer-by-layer infiltration from subcutaneous tissue down to the facet surface; 10 mL was deposited on each facet. All patients were placed in the prone position with the abdomen suspended. The involved vertebral bodies of patients were located under fluoroscopy.

The Bilateral Transpedicular Puncture Group

The surgical technique of traditional bilateral puncture PVP was previously reported.[11, 12]

The Unilateral Transpedicular Puncture Lateral Injection Group

The puncture in this study followed the conventional bilateral transpedicular pathway, although only a unilateral puncture was ultimately performed. The puncture trajectory was meticulously planned based on preoperative radiographic assessments. Typically, the entry point is localized at either the 2 o'clock or 10 o'clock position of the pedicular circumference, with a puncture trajectory involving a 10-20° caudal tilt and 10-30° lateral angulation. Following local anesthetic administration, the puncture needle (Shanghai Kinetic Medical Technology Co., Ltd., China) was advanced under fluoroscopic guidance until reaching the medial pedicular border and vertebral body posterior wall. Subsequently, a guidewire (Shanghai Kinetic Medical Technology Co., Ltd., China) was introduced, the puncture needle was withdrawn, and the working cannula

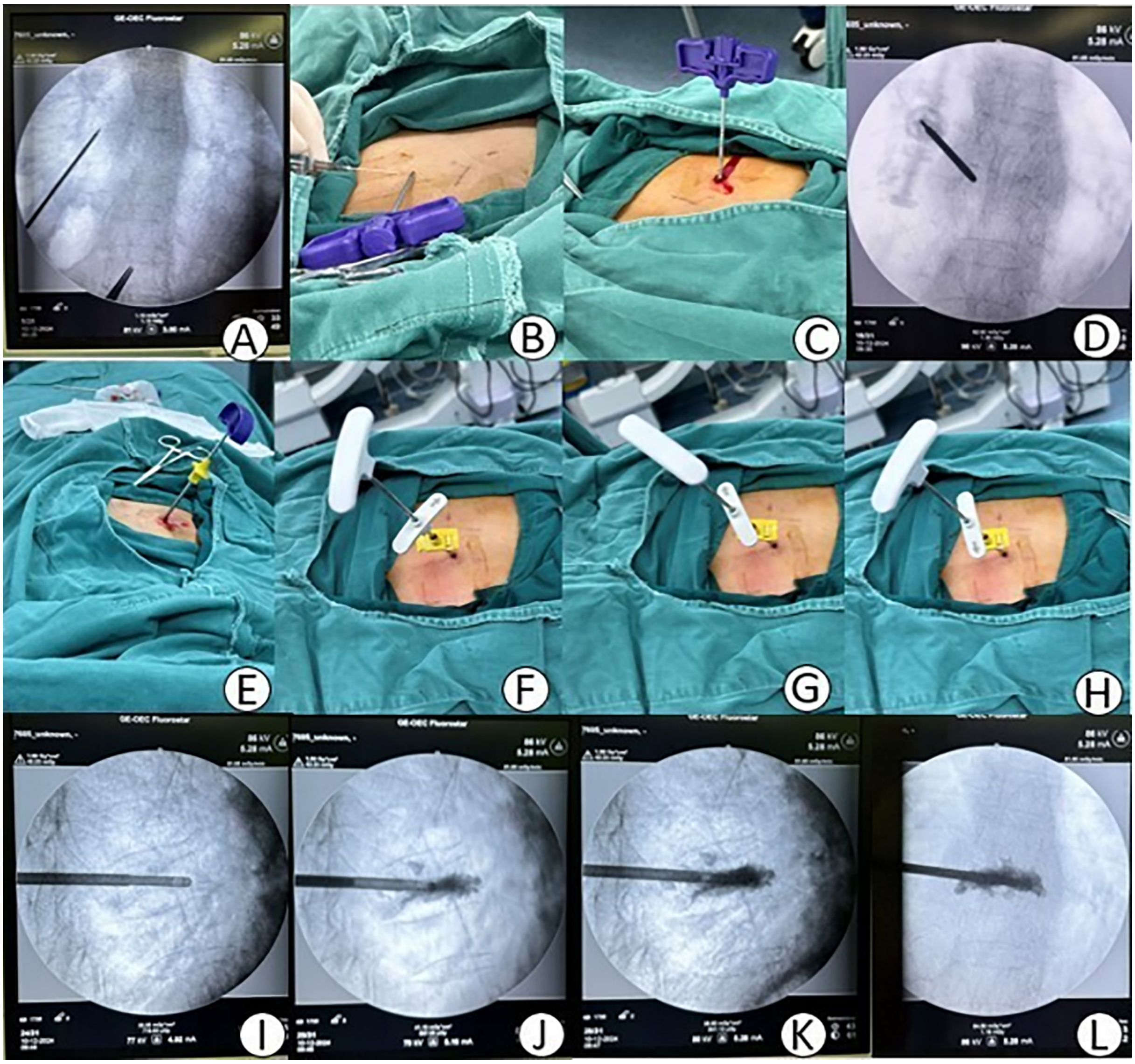

Figure 1: The figure shows the surgical flowchart. A: The pedicle of the injured vertebral body is located under fluoroscopy. B. Local anesthesia is administered at the puncture site. C: The puncture needle is inserted and fixed on the bone surface. D: The puncture angle and depth are observed and adjusted under fluoroscopy. E: A working cannula is inserted to establish a passage. F-H. Bone cement is injected, with the injection direction adjusted as needed. I-L: The distribution of bone cement is satisfactory under fluoroscopy.

was placed along the guidewire, with its final positioning confirmed within the vertebral body. Continuous fluoroscopic monitoring enabled real-time trajectory adjustments during needle advancement. The working channel was carefully dilated, and its terminal position was verified to be beyond the posterior vertebral wall. When required, a bone drill was used for channel preparation.

Under fluoroscopic guidance, the insertion depth of the injector was measured instrumentally through the working cannula. The injector tip was to be precisely positioned within the anterior third of the vertebral body while ensuring it did not cross the vertebral midline. When the bone cement reached a drawable state, it was injected via the side-open bone cement injectors. The initial cement injection was directed toward the contralateral side using the side-open injectors. Subsequent cement injection was guided by adjusting the lateral-port orientation of the injector under lateral fluoroscopy to achieve either superomedial or inferomedial injection vectors, continuing until radiographically confirmed optimal cement distribution was attained. The distribution of bone cement on the operative side could be optimized either by orienting the injector orifice toward the operative side or by replacing it with a front-opening injector.

If the bone cement leakage outside the vertebral body was observed, the injection was to be suspended, and the bone cement injector was to be withdrawn appropriately. After the distribution of the bone cement was satisfactory, the injection was stopped, and the cement was allowed to solidify. Subsequently, the working cannula was removed, and the area was disinfected, and the incision was covered with sterile dressings (figures 1, 2).

Postoperative Management

All patients received identical postoperative medication and care: mannitol (Southwest Pharmaceutical Co., Ltd., China) 25 g intravenous drip every 12 hours for 24 hours after surgery, and flurbiprofen axetil (Beijing Tide Pharmaceutical Co., Ltd., China) 50 mg intravenous drip every 12 hours for 24 hours after surgery, after which both were discontinued. In line with enhanced recovery after surgery (ERAS) principles, patients were encouraged to ambulate wearing a soft lumbar corset 2 hours after surgery. Typical cases of the UTPLI group and the BTP group are presented in figure 3.

Evaluation

Demographic and surgical data, including sex, age, body mass index (BMI), mean time from symptom onset, length of hospital stay, surgical segments, operative time, cement volume, estimated blood loss, and bone cement leakage, were collected through medical record review. The volume of blood loss was estimated by using the gauze and the infiltration area of the gauze during the operation. Patients were assessed using the VAS and Oswestry disability index (ODI), both preoperatively and on the first postoperative day. Patients were examined with X-ray and CT both preoperatively and on the first postoperative day (figure 4). The vertebral kyphotic angle was measured as the angle between the superior and inferior endplates of the fractured vertebra. The segmental kyphotic angle was measured as the angle between the superior endplate of the vertebra above the injured vertebra and the inferior endplate of the vertebra below the injured vertebra. The thoracic kyphotic angle was measured as the angle between the superior endplate of T4 and the inferior endplate of T12.

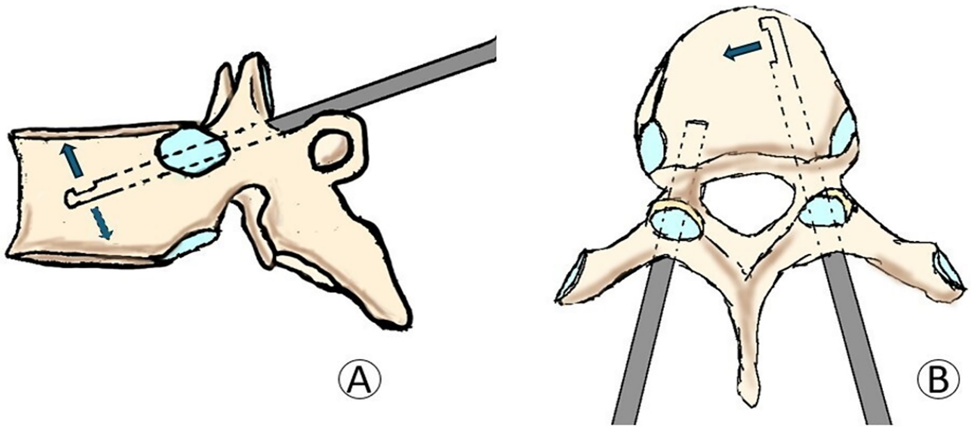

Figure 2: The figure illustrates the process of bone cement injection. A: With the opening of the injector facing upwards, the bone cement is injected into the upper part of the vertebral body. B: With the injector opening facing the contralateral side, bone cement is injected into the contralateral part of the vertebral body. For the pedicle on the surgical side, bone cement can be injected through a front-opening injector.

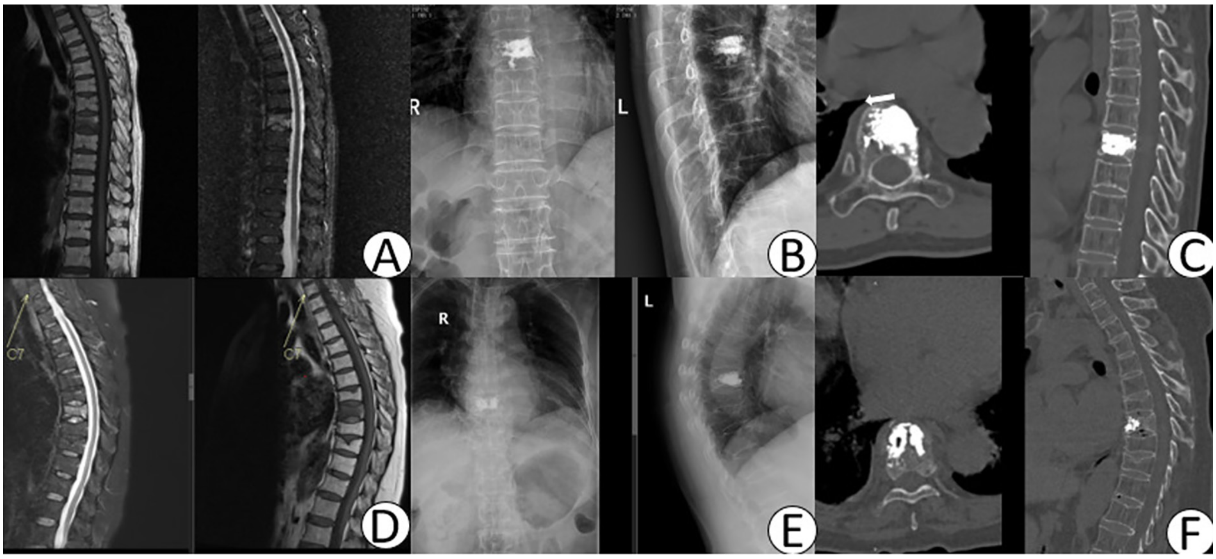

Figure 3: A 74-year-old female patient was diagnosed with a T7 OVCF treated with UTPLI vertebroplasty. A: Preoperative T1WI and T2WI images of the patient's thoracic spine MRI showed vertebral body edema and compression. B: The anteroposterior X-ray film showed that the bone cement crossed the midline, while the lateral X-ray film showed that the bone cement reached the superior and inferior endplates. C: Axial and sagittal CT images showed satisfactory distribution and diffusion of bone cement from the puncture side to the contralateral side (i.e., from left to right). D-F: Another 70-year-old female patient was diagnosed with T8 OVCF treated with BTP vertebroplasty.

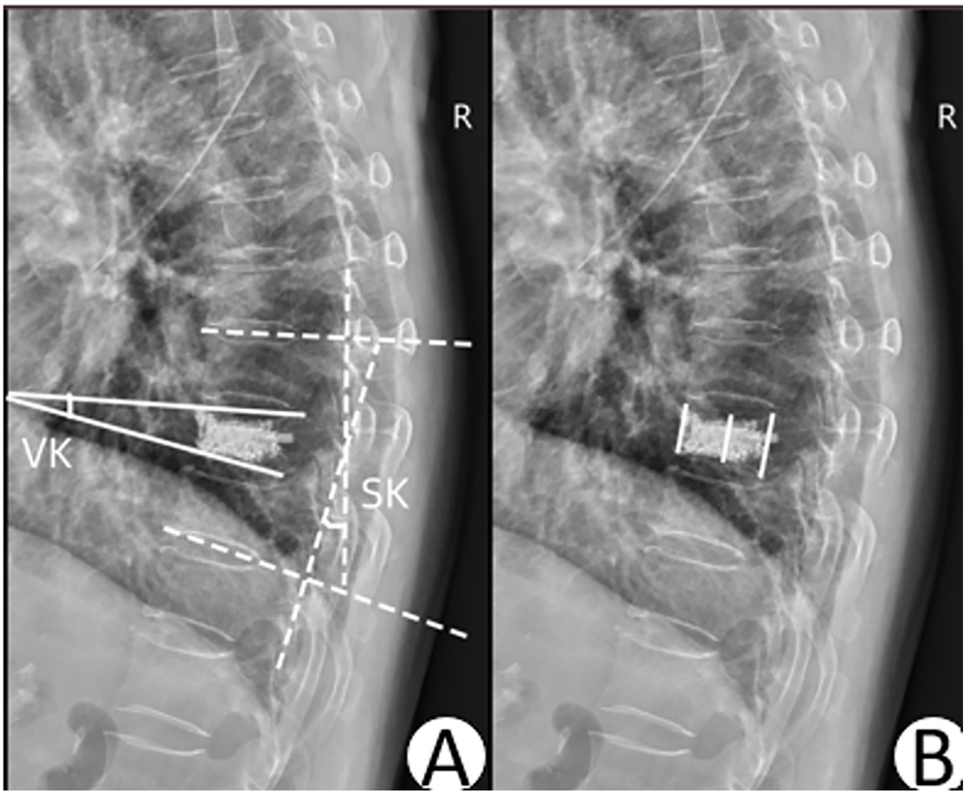

Figure 4: The figure illustrates the imaging parameter measurement. A: The measurement of the vertebral kyphotic angle and segmental kyphotic angle on X-ray lateral film is illustrated. B: The measurement of the anterior height, middle height, and posterior height on X-ray lateral film is demonstrated.

The anterior height, middle height, and posterior height were measured as the heights of the anterior, middle, and posterior edges of the vertebral body, respectively. The bone cement dispersion index and the scores of the spatial distribution of cement are selected to evaluate the distribution of bone cement, with the specific measurement methods referenced as described in the literature.[13, 14]

Statistical Analysis

All data were analyzed using SPSS software (IBM Corporation, USA; version 26.0). The Chi square test or Fisher's exact test was employed for the analysis of count data. Normally distributed data were evaluated using the independent-sample *t* test to compare the differences between the two groups. Non-normally distributed data and ordinal data were analyzed using a nonparametric test. A statistically significant difference was defined as P<0.05.

Results

A total of 57 patients were included in this study, of whom 21 were in the UTPLI group, and 36 were in the BTP group. The baseline data of the patients are shown in table 1. There was no significant difference in baseline data between the two groups. The operative time of the UTPLI group was 18.00±9.00 min, while that of the BTP group was 25.00±9.00 min. The operative time of the UTPLI group was shorter, and there was a significant difference between the two groups.

There were also differences in the volume of the bone cement. The bone cement volume in the UTPLI group was 3.50±1.75 mL, while that in the BTP group was 4.75±1.38 mL. The bone cement volume in the BTP group was higher than that in the UTPLI group. There was a difference in estimated blood loss between the two groups, and the blood loss in the UTPLI group was less than that in the BTP group. There was no significant difference between the two groups in terms of VAS and ODI scores before and after the operation. Moreover, there was a significant difference in VAS scores within each group before and after the operation, with VAS scores decreasing significantly after the operation. The detailed data are shown in table 2.

This study compared the changes in the vertebral kyphotic angle, segmental kyphotic angle, thoracic kyphotic angle, and the anterior, middle, and posterior vertebral body heights. The detailed data are shown in table 3. There were no statistically significant differences in bone cement leakage between the two groups.

Table 1: The baseline data of the two studied groups

Variable		UTPLI group (n=21)	BTP group (n=36)	P value
Sex	Male	3 (14.3%)	5 (13.9%)	0.967#
	Female	18 (85.7%)	31 (86.1%)	
Age (years, mean±SD)		74.33±7.64	73.28±10.99	0.672
BMI		22.96±4.74	21.98±3.08	0.348
Mean time from symptom onset (days)		12.00±13.00 (7.0-20.0)	16.50±23.00 (7.0-30.0)	0.613*
Length of hospital stay (days)		5.00±4.00(4.0-8.0)	7.00±4.00 (5.0-9.0)	0.097*
Surgical segments.	T3	1 (4.8%)	0 (0)	0.967*
	T4	1 (4.8%)	0 (0)	
	T5	3 (14.3%)	1 (2.8%)	
	T6	5 (23.8%)	3 (8.3%)	
	T7	7 (33.3%)	4 (11.1%)	
	T8	2 (9.5%)	13 (36.1)	
	T9	2 (9.5%)	9 (25.0%)	
	T10	0 (0)	6 (16.7%)	

Data are presented as mean±SD or median±interquartile range. *Mann-Whitney U test was used. #The Chi square test was used. The remaining data that followed a normal distribution were analyzed using the *t* test. P<0.05 was considered statistically significant.

Table 2: Surgical-related indicators and changes of symptoms before and after the operation

Variable		UTPLI group (n=21)	BTP group (n=36)	P value
Operation time (minutes)		18.00 (17.0-25.0)	25.00 (21.5-30.5)	0.002*
Cement volume (ml)		3.50±1.75	4.75±1.38	0.030
EBL (ml)		3.93±1.22	5.13±1.37	0.002
Bone cement leakage		3/21	7/36	0.730#
VAS	Preoperative	7.00 (7.0-8.0)	7.00 (7.0-8.0)	0.330*
	Postoperative	1.00 (1.0-2.0)	2.00 (1.0-2.0)	0.253*
ODI	Preoperative	28.90±1.91	28.78±1.74	0.801
	Postoperative	14.00±1.76	14.06±1.56	0.893

*Mann-Whitney U test was used; #The Chi square test was used; The remaining data that followed a normal distribution were analyzed using the *t* test; P<0.05 was considered statistically significant. VAS: Visual analogue scale; ODI: Oswestry disability index

Table 3: The pertinent radiological indices of patients pre and post-operation

Variable		UTPLI group (n=21)	BTP group (n=36)	P value
Vertebral kyphotic angle	Preoperative	8.30±2.60	8.85±7.80	0.508*
	Postoperative	6.90±3.85	6.75±4.00	0.655*
	Improvement	0.60±3.35	-0.95±5.88	0.079
Segmental kyphotic angle#	Preoperative	18.63±7.23	18.34±8.56	0.896
	Postoperative	18.06±6.19	16.62±7.98	0.479
	Improvement	-0.20 (-2.15-1.3)	-2.00 (-3.98-0.05)	0.103*
Thoracic kyphotic angle	Preoperative	39.78±14.47	44.11±14.02	0.226
	Postoperative	35.68±13.64	40.21±13.37	0.230
	Improvement	-4.30(-6.3–-0.24)	-4.7(-7.75–-0.2)	0.927*
AH&	Preoperative	0.798±0.140	0.829±0.179	0.488
	Postoperative	0.885±0.127	0.903±0.176	0.680
	Improvement	0.061(0.020-0.190)	0.059(1.001-0.097)	0.585*
MH&	Preoperative	0.721±0.151	0.792±0.161	0.103
	Postoperative	0.842±0.134	0.872±0.160	0.477
	Improvement	0.070 (0.012-0.259)	0.041 (0.005-0.152)	0.341
PH&	Preoperative	0.848 (0.807-0.936)	0.919 (0.874-0.962)	0.056*
	Postoperative	0.890 (0.843-0.998)	0.927 (0.911-0.980)	0.346*
	Improvement	0.054 (0.003-0.111)	0.125 (-0.012-0.045)	0.066*
The bone cement dispersion index		0.553±0.120	0.554±0.061	0.934
The scores of the spatial distribution of cement		8.00 (8.0-9.0)	9.00 (8.0-9.0)	0.647*
Improvement in the Cobb angle.		-0.22±4.20	-0.70±1.20	0.993

&The height is represented by the ratio of the height of the injured vertebra to the average height of the upper and lower vertebrae; *Mann-Whitney U test was used; The remaining data that followed a normal distribution were analyzed using the *t* test. P<0.05 was considered statistically significant.

No significant differences were observed between the two groups in terms of the bone cement dispersion index or the scores of the spatial distribution of cement. No severe complications such as nerve root injury, spinal cord injury, or bone cement infection occurred in either group.

Discussion

Based on the findings of this study, the UTPLI group had significantly shorter operative duration and less estimated blood loss. No significant differences were observed in symptom improvement or changes in relevant imaging parameters between the two groups preoperatively and postoperatively. Additionally, similar changes in VAS and ODI scores were noted in both groups, indicating that both surgical approaches were effective and achieved comparable therapeutic outcomes.

At present, the commonly adopted surgical methods include bilateral transpedicular puncture and unilateral puncture, each having its own pros and cons. The classical unilateral puncture method features a shorter operative time, less intraoperative bleeding, and lower surgical costs. However, its puncture pathway needs to be designed to reach or cross the midline of the vertebral body, with a relatively large external deviation angle of the puncture.[15, 16] This may increase the incidence of spinal cord injury and operation-related bone cement leakage.[17] Bilateral transpedicular puncture could result in a relatively more sufficient distribution of bone cement, which has advantages in the restoration and maintenance of spinal stability. Nevertheless, it has a longer operative time, more intraoperative bleeding, and higher surgical costs than the classic unilateral puncture.[7] Therefore, we hypothesized that a modified unipedicular approach—combining the conventional bilateral transpedicular puncture with innovative side-open injector placement and lateral cement injection—could achieve bilateral cement distribution comparable to classic bilateral vertebroplasty, while reducing the technical demands and associated risks inherent to traditional unipedicular techniques. This hybrid technique was anticipated to yield equivalent radiological parameters and clinical outcomes to standard bilateral procedures.

In this study, the operative time and the bone cement volume in the UTPLI group were less than those in the BTP group, and the same surgical effect could be achieved as that of the BTP group. The method proposed in this study is a novel technique. Compared with bilateral transpedicular puncture, this method has several advantages: shorter operative time, less estimated blood loss, and lower surgical costs. It performs puncture only through the unilateral pedicle path. The puncture path does not need to cross the midline of the vertebral body, and the puncture angle is smaller than that of the classic unilateral puncture.[18] The puncture path is located within the pedicle, resulting in a relatively lower risk of spinal cord injury and bone cement leakage during the puncture operation. Admittedly, similar to the classic unilateral puncture, poor distribution of bone cement in the contralateral pedicle of the vertebral arch is inevitable.[19]

In this study, it was found that this phenomenon was mainly concentrated in the ninth and tenth thoracic vertebrae, which might be related to the relatively large volume of these vertebral bodies. Meanwhile, it is worth noting that for patients with unilateral vertebral fracture injuries, the efficacy of this new surgical approach is remarkable. The controllable injection direction of the bone cement can better enable the bone cement to diffuse near the fracture line. It was also found that adjustment of the injection direction of the bone cement could compensate for some puncture errors.

It is well established that bone cement distribution influences surgical outcome.[20, 21] This study used the bone cement dispersion index proposed by Zhang and others and the scores of the spatial distribution of cement proposed by Sun and colleagues to evaluate the distribution of bone cement.[13, 14] Both methods evaluated the shape and distribution of bone cement in the three dimensions of length, width, and height.

No significant differences were observed between the two groups regarding pain relief, changes in relevant radiographic parameters, or bone cement distribution. These findings suggested that both techniques achieved comparable therapeutic efficacy postoperatively. However, we noted that with the latter method, due to the irregular distribution of bone cement, the prominent distribution of bone cement in a certain direction might affect the classification of bone cement-related index levels. Of course, it was also noted in the study that the degree of the dispersion of bone cement to the contralateral side also depends on the surgeon's personal experience and the accuracy of the intraoperative anteroposterior X-ray fluoroscopy.

It is noteworthy that all surgical procedures in this study were performed by a single spine surgeon with over 10 years of specialized experience in spinal surgery, thereby enhancing the comparability of our findings compared to studies involving multiple operators.

Nowadays, with the development of science and technology, the surgical instruments and surgical methods for vertebroplasty have witnessed diverse developments. In a study conducted by Huang and others, through the comparison of data from six databases, it was demonstrated that percutaneous curved vertebroplasty (PCVP) was superior to unilateral percutaneous vertebroplasty (UPVP) in terms of reducing bone cement leakage and alleviating long-term pain. PCVP is a modified technique of unilateral UPVP. It enables flexible injection of bone cement through a curved injector.[22]

In another study conducted by Zhou and others comparing PCVP with bilateral percutaneous kyphoplasty, it was concluded that PCVP had a lower incidence of refracture, less fluoroscopic irradiation, and a shorter operative time.[23] It is undeniable that this is indeed an innovative invention. However, the use of the relevant professional instruments has increased the economic burden on patients and raised the requirements for surgeons. In this study, the application of the lateral bone cement injection technique could also enable the bone cement to be distributed more effectively, and it only required less expensive side-opening bone cement injectors.

In China, the centralized procurement winning bid price for percutaneous curved kyphoplasty instruments is approximately $190, the winning bid price for PCVP instruments is around $109, while the winning bid price for the instruments is about $65. Our research recorded a mean operative time of 18.00±9.00 min for UTPLI, significantly shorter than the 23.04±3.45 min reported for PCVP, implying proportionally reduced intraoperative radiation exposure. The present UTPLI series (T3-T10) used 3.50±1.75 mL of cement per vertebra, a volume smaller than the 4.61±0.88 mL reported for the PCVP study that also included lumbar levels with inherently higher cement demand. PCVP studies have not reported learning curves; yet the curved injection cannula demands more steps and fluoroscopic checks than our straight lateral cannula, suggesting UTPLI is quicker to master.[23]

While surgical instruments are developing, surgical techniques are also evolving continuously. To avoid violation of facet joints, Zheng and others proposed extra-facet puncture for PVP. A total of 217 patients were included in the experiment. Through comparison between extra-facet puncture for PVP and traditional PVP, it was concluded that extra-facet puncture for PVP can reduce the risk of facet joint violation, and at the same time, bone cement distribution is more satisfactory.[24] It could be noted that in this study, the height of the fractured vertebral body and the correction of the vertebral kyphosis angle in some patients were relatively good after the operation, which might be related to the reduction caused by abdominal suspension. The vertebral body achieved postural reduction, and the injection of bone cement maintained this reduction. This view was consistent with the findings of a previous study by Zhao and colleagues.[25] The new method mentioned in this study, compared with the traditional BTP, can meet the objective requirement of minimizing the operative time for patients with relatively poor baseline conditions.

This study had several limitations. First, it was a single-center, retrospective study, and the level of evidence was not high. The non-randomized design and small sample size might have led to patient selection bias. Long-term follow-up was not conducted. Therefore, subsequent vertebral refracture, late changes in vertebral height or angle, and the potential development of chronic pain remain undocumented, leaving the long-term durability of cement reinforcement and the true incidence of late clinical failure unknown. Future prospective multicenter trials should include annual imaging assessments and patient-reported outcome measures for at least 5 years to clarify these important outcomes.

Conclusion

The present study demonstrated a novel and original PVP technique via the conventional BTP, utilizing a cost-effective lateral-port injection system and an operator-friendly lateral injection method. This technique demonstrated significant advantages, including reduced operative time and lower cement volume requirements, while achieving postoperative radiographic parameters and symptomatic improvement comparable to conventional BTP. The UTPLI technique might represent a viable alternative, if not a superior treatment option, for patients diagnosed with single-level OVCFs in the upper and middle thoracic spine.

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Authors' Contribution

F.H: Conceptualization, data curation, study design, data analysis, and drafting; YH.H: Data curation, and reviewing the manuscript; L.L: Study design and reviewing the manuscript; Y.Ch: Data analysis and reviewing the manuscript; Y.W: Data interpretation and reviewing the manuscript; X.Ch: Conceptualization, drafting and reviewing; ZH-Y: Data interpretation and reviewing the manuscript; All authors have read and approved the final manuscript and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Declaration of AI

The authors used the official version of DeepSeek V3.1 to proofread and optimize the spelling errors and grammar in the article. All conceptual content, data analysis, and interpretation were conducted solely by the authors.

Conflict of Interest

Xiao-Lin Chen reports that financial support was provided by the Chongqing Medical Scientific Research Project. The other authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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