

Pedicle Screw Fixation with Percutaneous Vertebroplasty for Traumatic Thoracolumbar Vertebral Compression Fracture

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ABSTRACT

Objective: This study aims to evaluate the clinical efficacy of percutaneous pedicle screw fixation (PPSF) combined with percutaneous vertebroplasty (PVP) for the treatment of the thoracolumbar vertebral compression fracture (VCF) without neurologic deficits. **Materials and Methods:** This was a prospective observational study. Between January 2015 and December 2018, 62 patients who had suffered from traumatic thoracolumbar (VCF) burst fractures without neurologic deficits were included in this study. The patients were divided into two groups as follows: patients who underwent PPSF combined with PVP (PPSF-PVP Group; n = 24) and patients who underwent only PPSF (PPSF Group; n = 38). The patients were (PPSF and PPSF-PVP Group) followed up for more than 9 months. The kyphotic angle, compression ratio, and visual analog scale (VAS) score for back pain were analyzed and compared between the two groups. **Results:** The patients were followed up for an average of 9.1 months. Hospital stay significantly decreased in PPSF-PVP Group ($P < 0.001$). The median VAS score significantly decreased after the surgery in both the groups ($P < 0.005$), and mean VAS scores in PPSF-PVP Group were significantly lower than those in PPSF Group. No significant ($P > 0.005$) changes in local kyphosis and the vertebral body height gains obtained at the end of the follow-up period in PPSF-PVP Group. However, local kyphosis increased significantly ($P < 0.005$) and the central and anterior vertebral body height decreased significantly ($P < 0.005$) when compared with the PPSF-PVP Group. **Conclusion:** PPSF combined with PVP procedure is a good choice for the treatment of traumatic thoracolumbar VCF; however, due to the lack of long-term follow-up data, concern still exists regarding the effects of pedicle screw procedure after PVP.

KEYWORDS: Pedicle screw fixation, percutaneous vertebroplasty, thoracolumbar fracture, vertebral trauma

INTRODUCTION

Roy-Camille *et al.* introduced the pedicle screw procedure in 1963.^[1] Traumatic spinal fractures mostly (60–70%) involve the thoracolumbar region. The thoracolumbar spine is most commonly fractured at either the T11 or L2 level, and it is biomechanically the weakest point in the spine.^[2–4] In clinical practice, thoracolumbar vertebral compression fracture (VCF) is managed either conservatively or surgically. Surgical indication and choice of technique depend on multiple factors including the severity of symptoms, the

degree of loss in vertebral body height, spinal canal compromise, and the integrity of the posterior spinal elements.^[5] Thoracolumbar VCF is usually unstable with no neurological side effects. Although conventional management, comprising mobilization with the help of physical therapy and pain control, was described to present acceptable results, the majority of patients still

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experience early/late complications such as decubitus, residual kyphosis, and late neurologic deficits.^[6,7]

Vertebroplasty, originally described by Galibert *et al.* in France, was used for the treatment of vertebral angiomas, but it is now most commonly used in treating compression fractures.^[8] The use of pedicle screw instrumentation has become the most popular management technique in spinal disorders. Surgery is the widely accepted treatment method for thoracolumbar VCF.^[9] Clinical studies have shown that combining percutaneous vertebroplasty (PVP) with polymethyl methacrylate (PMMA) and pedicle screw to treat thoracolumbar VCF could achieve maintenance of sagittal curve and correction of vertebral height in the injured vertebrae.^[10-13] PMMA involves risks of cement leakage,^[14,15] but any other side effects have not been adequately documented.

In the present study, the efficacy of percutaneous pedicle screw fixation (PPSF) and PPSF combined with PVP for traumatic thoracolumbar VCF has been compared. PPSF technique combined with PVP for the treatment of traumatic thoracolumbar VCF has been introduced.

MATERIALS AND METHODS

Study design

The present study included 62 patients with traumatic thoracolumbar VCF between T10 and L4 without neurologic impairment and admitted between January 2015 and December 2018. The average age of the patients at the time of the surgery was 43 years (range, 19–59 years). There were 27 male and 35 female patients. The patients were followed up for an average of 9.1 months. The interval between traumatic event and the surgery was less than 5 days for all the patients. The patients were divided into two groups. PPSF Group included 38 patients treated by posterior segmental instrumentation and PPSF-PVP Group included 24 patients treated by posterior segmental instrumentation with PVP.

Before the surgery, X-ray films and computed tomograms (CTs) were obtained to define acute traumatic fractures in all the patients. Sagittal index exceeding 15° or loss of anterior body height exceeding 45% was an indication for the surgery [Figure 1].

All the patients underwent PPSF. The pedicle screw was fixated above and below the fractured body. Indeed, some studies have shown that the fixation of two vertebrae above and two vertebrae below the fractured vertebra yields the best results, including adequate rigidity, and consequently, better stability.^[16,17] Pedicle screws of appropriate length were then introduced into the vertebral

body via the pedicle. Screws were connected with two rods. The rods were contoured to protect lumbar lordosis in all the patients. The rods cross-linking was done to add rigidity to the instrumentation. Posterior segmental instrumentation and fusion were performed in all the patients without any effort to directly decompress the dural sac because they all were neurologically intact. PMMA was injected unilaterally using a transpedicular trajectory under C-arm fluoroscopic guidance. PMMA was used in PPSF-PVP Group after posterior fixation. Only the fractured vertebra was augmented. The augmented pedicle was chosen randomly from the intact pedicle. The augmentation was performed as described by Jensen *et al.*^[18]

Outcome parameters

Preoperative, postoperative, and follow-up radiograms were evaluated. Plain radiograms and CTs were also examined. Anterior body height compression and local kyphosis were measured. Anterior body height compression was calculated by referring the anterior body height of the fractured vertebral body to the average anterior body height of the intact vertebral body above and below the fractured vertebral body, according to Mumford *et al.*^[19] Local kyphotic angle was measured between the superior endplate of the upper and the inferior endplate of the lower non-injured vertebrae by the Cobb method.^[20] Visual analog scale (VAS) for back pain was used to assess clinical outcomes. All cases were clinically assessed for VAS pain. Local kyphosis, anterior vertebral body height, and central vertebral body height were assessed before the surgery, 1 month, 3, 6, and 9 months after the surgery.

Statistical analysis

MedCalc 18 (MedCalc Software, Ostend, Belgium) was used for the statistical analysis. Data, including age, were compared between the two groups using the Mann–Whitney U test. Differences in male/female ratios between the two groups were compared using the *Chi*-square test. VAS, central and anterior vertebral body height, and local kyphosis between the two groups were compared using independent samples t-test. The level of significance was set at 0.05.

RESULTS

The patients' demographics are shown in Table 1.

PPSF Group included 38 patients treated by posterior segmental instrumentation without PVP, and PPSF-PVP Group included 24 patients treated by posterior segmental instrumentation with PVP. Surgical incision sites healed well. The volume of PMMA required ranged from 3 ml to 7 ml. The comparison of clinical

data between the two groups is shown in Table 1. No significant difference in age, gender, follow-up period, and fracture level was observed between the two groups. However, length of stay in the hospital was significantly different between the two groups. The

median duration of hospital stay was 5.8 days in PPSF Group and 3.2 days in PPSF-PVP Group. The duration of hospital stay significantly decreased in PPSF-PVP Group ($p < 0.001$).

No significant difference was observed between the two groups in mean central and anterior vertebral body heights, local kyphosis, and VAS scores before the surgery [Tables 2–5].

Immediately after the surgery, local kyphosis significantly decreased ($p < 0.005$) and central and anterior vertebral body heights significantly increased ($p < 0.005$) in both the groups. Moreover, between two groups, VAS assessments were significant differences ($p < 0.005$).

No significant ($P > 0.005$) difference in local kyphosis and the vertebral body height gains observed at the end of the follow-up period in PPSF-PVP Group. However, local kyphosis increased significantly ($P < 0.005$) and the central and anterior vertebral body height decreased significantly ($P < 0.005$) 9 months after the surgery as compared with the immediate postoperative period in PPSF Group [Figure 2]. The results of all the statistical tests carried out are provided in Tables 2–4.

Table 1: Comparison of the two groups

	PPSF Group	PPSF-PVP Group	P
Number of patients	38	24	
Age (years)	42.5	45.3	0.0367
Gender			
Male	16	11	0.0506
Female	22	13	
Mean follow-up period (months)	9.2	9.1	0.643
Fracture level			
T10	6	5	
T11	3	2	
T12	11	12	
L1	17	14	
L2	6	3	
L3	4	5	
L4	2	4	
Stay at hospital (days)	5.8	3.2	<0.0001

Table 2: Local kyphosis of the patients in the two groups (°)

Group	Preoperative	Postoperative	1 month	3 months	6 months	9 months
PPSF Group	35.4	12.8	12.8	13.2	13.2	13.2
PPSF-PVP Group	32.5	10.6	10.6	10.6	10.6	10.6

Table 3: Anterior vertebral body height of the patients in the two groups (%)

Group	Preoperative	Postoperative	1 month	3 months	6 months	9 months
PPSF Group	48.2	48.4	48.4	48.4	48.4	48.4
PPSF-PVP Group	47.6	50.2	50.2	50.2	50.2	50.2

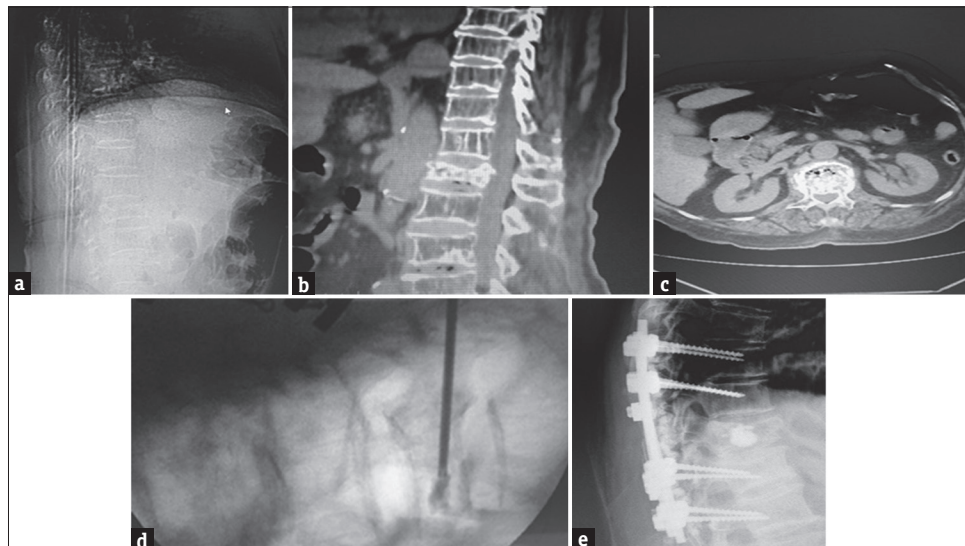


Figure 1: (a) Pre-operative lateral X-ray (b) sagittal CT (c) axial CT showed the vertebral fracture. (d) Fluoroscopic image showed the injection of bone cement after insertion of pedicle screws (e) in PPSF-PVP Group

Table 4: Central vertebral body height of the patients in the two groups (%)

Group	Preoperative	Postoperative	1 month	3 months	6 months	9 months
PPSF Group	40.6	40.7	40.7	40.7	40.7	40.7
PPSF-PVP Group	42.5	46.8	46.8	46.8	46.8	46.8

Table 5: VAS assessments of the patients in the two groups

Group	Preoperative	Postoperative	1 month	3 months	6 months	9 months
PPSF Group	9.2	3.6	2.4	2.1	1.5	1.1
PPSF-PVP Group	9.1	2.3	1.2	0.7	0.3	0.2

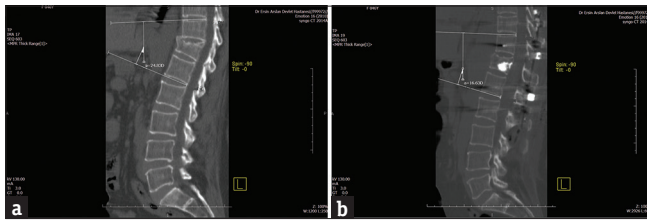


Figure 2: (a) Preoperative CT scan of a 46-year-old woman with a T12 fracture and posttraumatic T12 vertebral body wedging of 24.8°. (b) Postoperative CT scan of a patient showing the reduction of segmental kyphosis to 16.6°

VAS scores in both the groups significantly decreased after the surgery ($P < 0.005$), and mean VAS scores in PPSF-PVP Group were significantly lower than those in PPSF Group. The VAS scores in 1 month, 3, 6, and 9 months after the surgery in PPSF Group were higher than those in PPSF-PVP Group ($p < 0.005$). A significant difference was observed in local kyphosis between the two groups [Table 2].

Postoperatively, no neurological deficits were observed in any groups. All the patients had incisional pain without suffering from leg pain. There were no instances of instrumentation failure, and no patient had persistent postoperative back pain. Cement leakage was observed in eight cases (two anterior to the vertebral body and six into the disc without sequela). Postoperatively, all the patients were mobilized the day after the surgery and used braces for 3 months. During the follow-up, there was no failure of instrumentation and no patient required revision surgery.

DISCUSSION

The treatment of thoracolumbar VCF has not been standardized appropriately so far. Some patients with thoracolumbar VCF can be treated without surgery (by analgesic medication and bed rest). Surgery is the widely accepted treatment method for thoracolumbar VCF. The surgical treatment method may adjust angular deformity, reestablish vertebral body height, and allow prompt mobilization/rehabilitation.^[9] PPSF reinforced with cement is a method of posterior surgical treatment.^[10] Augmentation procedures with PMMA can

improve refractory back pain and restore the height of the compressed vertebral body height.^[21,22] However, PPSF with PVP also has limitations such as nerve injury and upper and middle thoracic fractures.

Many surgeons think that the application of PVP contraindicates the placement of transpedicular pedicle screw instrumentation. However, in the present study, a method for performing the standard pedicle screw procedure after PVP has been described. In the present study, the practicability and relative safety of this technique has been demonstrated to improve vertebral body height and reinforce the anterior column after posterior reduction and stabilization. This surgical method is a pain-relieving procedure and is effective in improving vertebral body height, kyphotic angle, and wedge angle.^[12,23] PPSF with PVP may decrease the load on the pedicle screw and reduce the risk of hardware failure and anterior column collapse.^[10] In the cadaveric biomechanical study by Mermelstein *et al.*, the findings showed that the injection of cement in a burst fracture reduced the load on the pedicle screw construct that was inserted for fracture stabilization, and vertebroplasty with cement after posterior instrumentation might reduce hardware failure and anterior column collapse.^[10] The present study confirmed that there was no hardware failure in any patient following the instrumentation and PVP during the follow-up period. Although PPSF with PVP method is widely accepted, several studies have reported that lower bone mineral density may cause screw loosening.^[24] In this patients' treatment for pain relief, PVP is a better choice.^[25]

PVP with bone cement may involve complications comprising cement leakage into the spinal canal, which may be more frequent when the posterior wall has been injured. In the present study, bone cement was injected into the vertebral body under the guidance of fluoroscopy. To prevent the incidence of neurological deficits and to guarantee the safety of this method, the injection of cement was blocked if the cement got close to the posterior part of the vertebral body or leaked into the extraosseous area. In eight cases, cement

leakage was observed; however, no patients showed any postoperative neurological complications. Moreover, none of the other systematic complications encountered, such as fat embolism, hypoxia, hypotension, myocardial infarction, and sudden death.^[26]

Fuentes *et al.* used PPSF-PVP in 18 patients of vertebral fractures. The mean vertebral height was improved by 25% and a mean improvement of 11.2° in the local kyphotic angle was obtained.^[27]

The outcomes of the present study indicated that after 9 months of follow-up, local kyphosis significantly decreased (from 35.4° before surgery to 12.8° immediately after the surgery) using posterior instrumentation in PPSF Group. In PPSF-PVP Group, local kyphosis was corrected from 32.5° before the surgery to 10.6° immediately after the surgery. Furthermore, the central and anterior vertebral height was restored significantly immediately after the surgery in both the groups. The posterior stabilization after PVP efficiently restored the structure of fractured vertebra and yielded a satisfactory result. The VAS scores and duration of hospital stay decreased significantly.

CONCLUSION

The present study showed that PVP combined with the standard pedicle screw procedure is a good choice for the treatment of traumatic thoracolumbar VCF. However, due to the lack of long-term follow-up data, concern still exists regarding the effects of pedicle screw procedure after PVP. For the evaluation of clinical and radiologic outcomes of this procedure, a longer follow-up period is needed.

Ethical approval

This study was approved by the Dr. Ersin Arslan Training and Research Hospital.

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Conflicts of interest

There are no conflicts of interest.

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