

Original Research Article

Analysis of outcome of percutaneous versus open pedicle screw fixation in the treatment of thoraco-lumbar spine fractures: a prospective comparative study

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ABSTRACT

Background: Aim of the study was to evaluate the effectiveness between percutaneous and open pedicle screw fixation in the treatment of traumatic thoracolumbar burst fractures with spinal injury.

Methods: A prospective comparative study including thirty patients with thoracolumbar burst fracture were equally divided into an open pedicle screw fixation (OPSF) group and a percutaneous pedicle screw fixation (PPSF) group. Demographic characteristics, clinical and radiological outcomes, and adverse events were assessed and compared between the 2 groups.

Results: Demographic and clinical features including age, gender, fracture level, mechanism of injury and neurological status in both groups were not significantly different (all $p > 0.05$). The PPSF group exhibits significantly lower operative time, intraoperative blood loss, and hospital stay compared with the OPSF group (all $p < 0.05$). There was no significant difference in the sagittal Cobb's angle (CA), fracture vertebral body angle (VBA), anterior vertebral body height (AVBH) on pre-operative, immediate post-operative and final follow up between the two surgical techniques (all $p > 0.05$). Visual analogue scale (VAS) remarkably decreased in both groups after surgery but difference was not statically significant ($p = 0.808$). Common postoperative complications in both groups were superficial infections, pressure ulcer and urinary tract infection (UTI) worsening. Hardware failure was seen only in one case of PPSF group.

Conclusions: Patients with thoracolumbar burst fractures can be effectively managed with PPSF/OPSF. There were no significant differences in radiological and clinical outcomes and post-op complications between 2 groups but blood loss, operative time and hospitalization stay were less in percutaneous group, which may represent a potential benefit.

Keywords: Thoraco-lumbar burst fracture, OPSF, PPSF, Prospective comparative study

INTRODUCTION

Fractures of the thoracic and lumbar vertebrae are quite common injuries among polytrauma patients, and nearly one-third of those patients have concomitant neural structure injury and variable neurologic deficit.¹ Almost 60% of spinal fractures occur within the thoracolumbar region, with 17% being burst fracture.^{2,3} These injuries are painful and may impact quality of life resulting in prolong

absence from work and chronic pain; thus, having significant socio-economic impact furthermore.⁴

These injuries are usually resulting of high energy trauma like motorized vehicle accidents or falls from height and more common in men. Elderly people also are in danger for these fractures, because of weakened bone from osteoporosis.⁵

The primary goals of treatment for such fractures include protecting the neural elements and preventing deformity and instability. The treatment depends on the individual characteristics of the fracture that range from compression fractures and burst fractures to flexion distraction injuries with fracture dislocation, which may be managed conservatively including bed rest alone, closed reduction of fractures and functional bracing, and surgical managements involving open reduction and internal fixation of the fracture. However, studies have advocated that nonoperative treatments were related to late neurologic decline in 10 to 20% of patients and were fraught with its difficulty in moving.^{4,6} Pedicle screw fixation has been widely applied in clinical practice to produce stable spinal fixation, which exerts few negative influence on the nervous system, blood vessels, and internal organs of the patients.⁷ Despite that the utilization of a standard open pedicle screw fixation (OPSF) and reduction of thoracolumbar fractures has demonstrated good radiologic and clinical outcomes, several potential disadvantages can occur from OPSF, including trauma to soft tissue, blood loss, long duration of hospital stay, high risk of postoperative complications, which can increase the suffering and economic burden of the patients especially in low-income families.^{8,9} Thus, a replacement perspective within the treatment of thoracolumbar fractures was offered with the event of percutaneous pedicle screws fixation (PPSF) procedure, which performed by sparing the paravertebral musculature and avoiding damage to the zygapophysial joint, may also reduce bleeding, postoperative pain, operative time, and also the length of hospitalization, which make rehabilitation easier and faster.^{10,11} Further, image navigation systems can facilitate insertion of pedicle screw and minimize misplacement.¹²

However, critical and substantial evaluation of percutaneous pedicle screw fixation procedures in thoracolumbar fracture is scant, and no study to our knowledge has analyzed the use of percutaneous techniques in traumatic thoracolumbar fractures compared with open techniques in our institution. Therefore, we aimed to compare the clinical and radiological outcomes of using PPSF and OPSF to treat thoracolumbar fractures.

METHODS

This prospective comparative study was conducted at a tertiary care center in Uttarakhand, India over a period of two years four months from December 2017 to March 2020. Total 30 patients meeting the inclusion criteria were studied. Patients were randomly subjected to PPSF (Figure 1) or OPSF (Figure 2) surgery, and including 15 patients in each group. Inclusion criteria included skeletally mature patients (more than 18 years) with no age restriction, no gender restriction, presence of a thoracolumbar fracture (T10-L5) with TLICS score of ≥ 4 , surgical management, and follow up of a minimum of 1 year.¹³ Patients with history of trauma more than 5 days, multilevel spinal injury, multi-organ trauma, pathologic or osteoporotic fractures, poor anesthetic patients, pregnant patient, and

patients not willing to participate were excluded from study. Study was approved by institutional ethics committee and written informed consent was obtained from all patients before surgical procedure and for participation in the study.

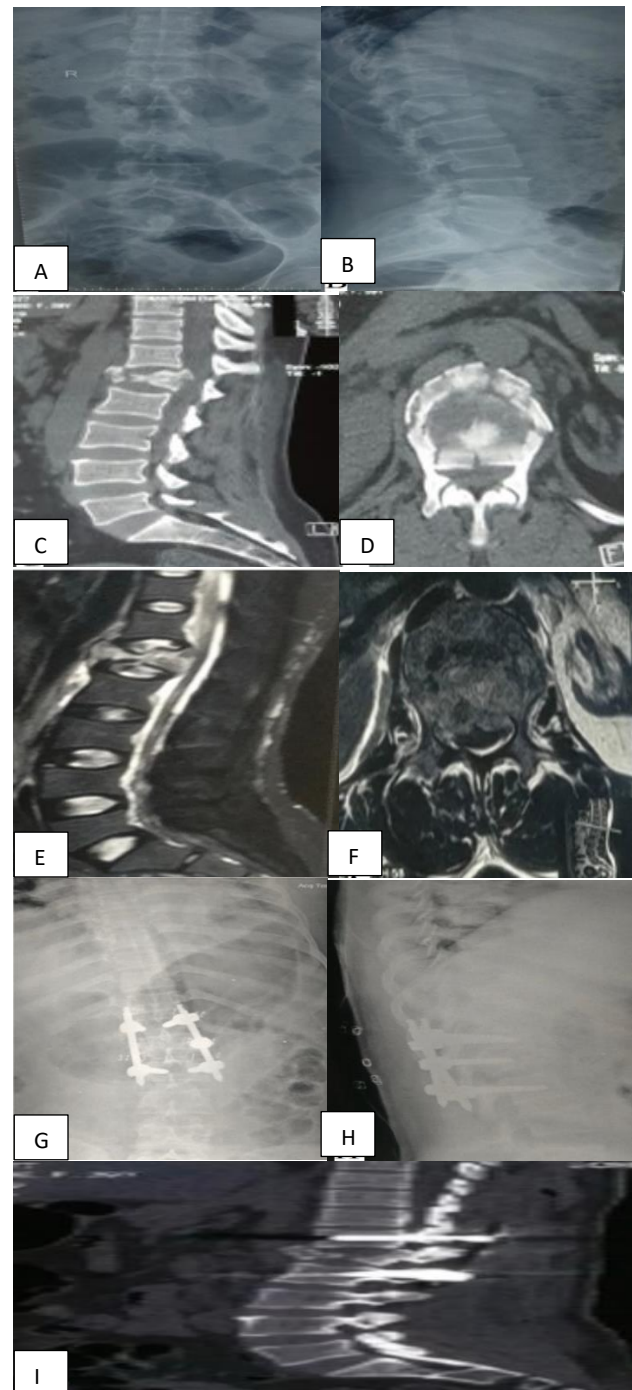


Figure 1: Radiological films of 39-year-old female with L1 burst fracture caused by fall from height and treated with PPSF. Pre-operative- (A and B) Antero-posterior and lateral radiograph; (C and D) CT scan: sagittal and axial view; (E and F) MRI film: sagittal and axial view. Post-operative- (G and H) Antero-posterior and lateral radiograph; (I) CT scan: sagittal view.

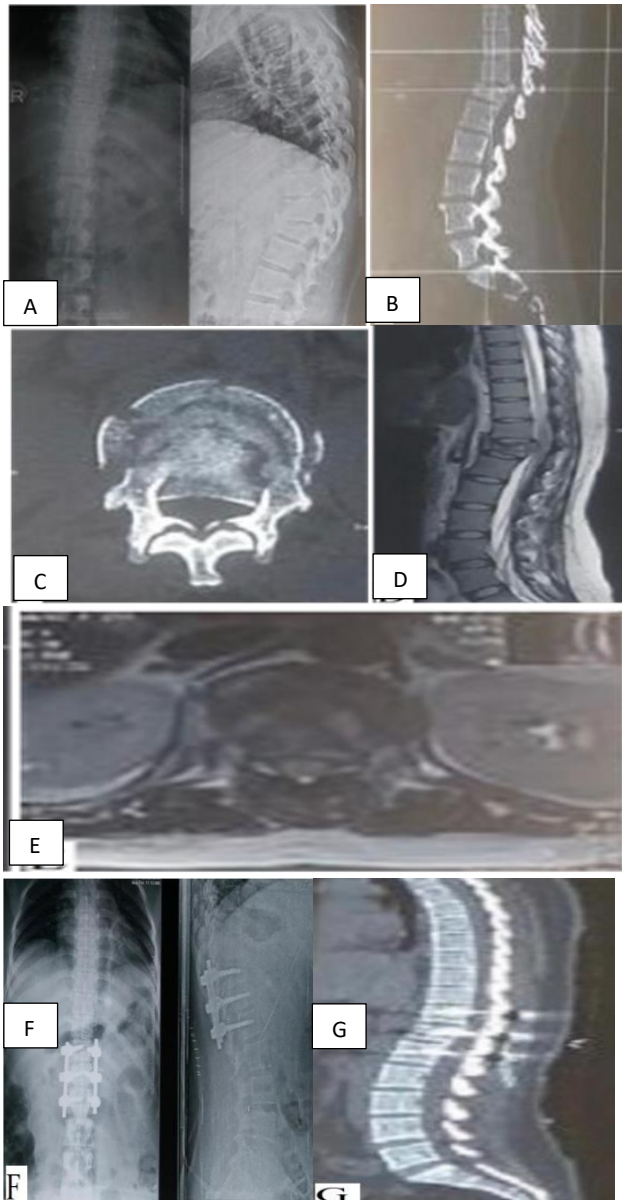


Figure 2: Films of 27-year-old male with D12 burst fracture caused by RTA and treated with OPSF. Pre-operative- (A) Antero-posterior and lateral radiograph; (B and C) CT scan: sagittal and axial view; (D and E) MRI film: sagittal and axial view. Post-operative- (F) Antero-posterior and lateral radiograph; (G) CT scan: sagittal view.

Fractures were classified according to AO spine thoracolumbar spine injury classification system.¹⁴ All patients pre-operatively underwent complete clinico-radiological (X-ray, NCCT, MRI spine) examination. Neurological deficit was graded according to American spinal injury association (ASIA) impairment scale.¹⁵

Operative techniques

PPSF group: Following induction of general anesthesia, patient was placed on a radiolucent table in a prone position with silicon pads under the iliac crests and thorax.

The kyphosis of the fractured vertebral body was corrected by hyperextension. Fluoroscopic images were obtained in the anteroposterior and lateral planes to conform that the pedicles could be adequately visualized. Landmarks for pedicle access were drawn on the skin. Entry points were chosen for the pedicles that were to be fitted with instrumentation. An approximately 15 mm incision was made at the skin entry point and extended into the underlying subcutaneous tissue. A guide wire was used to perforate the fascia, and a series of sequential dilators were used to dilate the fascia and separate the underlying paraspinal muscles right down to the spine. The dilators were removed, and a pedicle pilot hole was made under C-arm fluoroscopic guidance employing a tracked awl and a pedicle probe. A self-tapping, cannulated pedicle screw with an appropriate length and diameter was inserted into the vertebra through the guide wire under the protection of the outside catheter. All procedures were under C-arm fluoroscopic image guidance. Using the aforementioned steps, all other screws were put in sequentially and guide wire and protective catheter were removed. Two rods of appropriate lengths were inserted through the upper incision to reach the caudal pedicle screw, and rods were fixed using cranial bolt heads. The rods could also be lengthened to restore the height of the fractured vertebra, if necessary, and the cranial bolt heads were tightened subsequently. Bipolar forceps were used to control any wound hemorrhaging. The incisions were closed after irrigation, and no drainage was installed.

OPSF group: The same pre-operative procedure as utilized in the percutaneous approach was used for the OPSF group. The positions of the fractured vertebrae were determined and marked using the C-arm. After routine sterilization and placement of the drapes, midline incision of required length was made at the surgical level and then separated the subcutaneous tissue and the longissimus and multifidus muscles to expose the space around the pedicle entry point. Required number of pedicle screws were implanted sequentially by free hand, and AP and lateral fluoroscopy images were taken to make sure that the screws were placed in their ideal positions. Two rods of appropriate lengths were implanted, and the height of the vertebral body was restored by lengthening the rods appropriately. The locations of the implants were again confirmed by C-arm images. The incisions were irrigated and closed over drain placement.

Post-operatively patients were advised brace, subjected for physiotherapy and followed up of a minimum of one year. Both groups were compared in terms of patient demographics (age, gender), mechanism of injury (MOI), subjective pain perception, operation time, intraoperative blood loss, post-operative hospitalization time, complications, neurological and radiological (anterior vertebral body height, sagittal Cobb angle, vertebral body angle) improvement. The visual analog scores (VAS), anterior vertebral body height (AVBH), vertebral body angle (VBA), and Cobb's angle (CA) were evaluated at

pre-operation, the third day after surgery, and the final follow-up.

Statistical analysis

All data were entered into a Microsoft excel spreadsheet. Variables with continuous data were reported as the means and standard deviations. Independent sample t-tests were used to compare the outcomes between the two groups. These statistical tests were 2-tailed, and $p < 0.05$ was considered statistically significant. The statistical analyses were conducted using SPSS version 19 (SPSS Inc., Chicago, IL, USA).

RESULTS

Baseline characteristics of patients

The demographic and clinical characteristics of 30 patients, including 66.67% males and 33.33% females, were summarized in Table 1. There were 73.33% males and 26.67% females in the OPSF group, and 60% males and 40% females in the PPSF group. The average age of patients in the OPSF group and the PPSF group was 39.53 ± 16.93 years (ranging from 18 to 67 years old) and 38.13 ± 15.20 years (ranging from 19 to 65 years old), respectively. RTA was the most common mode of injury occurred in 11 (36.67%) patients followed by fall from

height in 10 (33.33%) patients. 46.66% of patients sustained injury at level of thoraco-lumbar junction (T12-L1 level).

The variables including mean age (year), gender, level and mechanism of injury, between OPSF group and PPSF group weren't considered the significantly different (all $p > 0.05$). All of the patients were followed up with a mean time of 19.2 ± 4.61 months (ranging from twelve to twenty-eight months).

Operation indexes

In the PPSF group, the operation time, intraoperative bleeding and postoperative hospital stay duration were significantly less than those in the open pedicle screw fixation group (all $p < 0.05$) (Table 2). The average operation duration was 115.26 ± 14.59 minutes (93-140) in the OPSF group versus 101.40 ± 12.88 minutes (80-125) in the PPSF group. The average blood loss was 444.33 ± 127.90 ml (300-700) in OPSF group versus 196.33 ± 70.11 ml (110-340) in PPSF group. None of the patients PPSF group required a blood transfusion. However, there were 2 patients who needed a blood transfusion in the OPSF group. The average post-op stay for the OPSF group was 6.6 ± 2.69 days (3-12) and for PPSF group 4.4 ± 1.76 days (3-9).

Table 1: Demographic and clinical characteristics of patients.

Variables	Total	OPSF group	PPSF group	P value
No. of patients	30	15	15	
Mean age (year)	38.83 ± 15.83	39.53 ± 16.93	38.13 ± 15.20	0.813
Gender (%)				
Male	20 (66.67)	11 (73.33)	9 (60)	0.071
Female	10 (33.33)	4 (26.67)	6 (40)	
Mechanism of injury (%)				
RTA	11 (36.67)	6 (40)	5 (33.33)	1
Fall from height	10 (33.33)	4 (26.67)	6 (40)	
Sports	6 (20)	3 (20)	3 (20)	
Others	3 (10)	2 (13.33)	1 (6.67)	
Level of injury (%)				
T10	2 (6.67)	1 (6.67)	1 (6.67)	1
T11	4 (13.33)	2 (13.33)	2 (13.33)	
T12	7 (23.33)	3 (20)	4 (26.67)	
L1	7 (23.33)	4 (26.67)	3 (20)	
L2	4 (13.33)	2 (13.33)	2 (13.33)	
L3	3 (10)	2 (13.33)	1 (6.67)	
L4	3 (10)	1 (6.67)	2 (13.33)	
L5	0	0	0	

Radiologic parameters

Statistical analysis of data (Table 3) showed no significant difference in the sagittal Cobb's angle (CA), fracture vertebral body angle (VBA), anterior vertebral body height

(AVBH) on pre-operative, immediate post-operative and final follow up of 12 months between the two surgical techniques (all $p > 0.05$). In OPSF group, the average pre-op sagittal Cobb's angle was 23.06 ± 4.58 , the immediate post-op 8.86 ± 2.87 and at final follow-up was 13.20 ± 2.85 . The average correction was 9.86 ± 4.64 . In PPSF group, the

average pre-op CA was 22.06±4.74, the immediate post-op 8.66±2.46 and at final follow-up was 13.73±2.40. The average correction was 8.33±4.11. OPSF group had better correction than PPSF group but difference was not significant (p=0.346).

Table 2: Operation indexes in two groups.

Operation indexes	OPSF group	PPSF group	P
Operation time (min)	115.26±14.59	101.4±12.88	0.01
Surgical blood loss (ml)	444.33±127.90	190.66±74.39	0.001
Post op hospital stay (days)	6.6±2.69	4.4±1.76	0.013

Table 3: Radiological parameters in two groups.

Radiological parameters	OPSF group	PPSF group	P
Sagittal Cobb's angle (°)			
Pre-operative	23.06±4.58	22.06±4.74	0.562
3-day post op	8.86±2.87	8.66±2.46	0.839
12-month post op	13.20±2.85	13.73±2.40	0.584
Vertebral body angle (°)			
Pre-operative	17.33±4.35	16.8±4.42	0.741
3-day post op	8.1±3.54	8.66±3.19	0.668
12-month post op	10.2±3.05	10.33±2.94	0.903
Anterior vertebral body height (°)			
Pre-operative	59.93±8.89	61.66±8.82	0.596
3-day post op	91.46±5.46	90.06±5.06	0.472
12-month post op	88.13±5.59	87.73±4.77	0.834

In OPSF group, the average pre-op VBA was 17.33±4.35, the immediate post-op 8.1±3.54 and at final follow-up was 10.2±3.05. Correction of 7.13±1.99 was achieved. In PPSF group, the average pre-op VBA was 16.8±4.42, the immediate post-op 8.66±3.19 and at final follow-up was 10.33±2.94. The average correction was 6.46±2.09. OPSF group had better correction than PPSF group but difference was not significant (p=0.380).

Table 5: Change in neurological status (ASIA grading system) in two groups.

Surgical technique	Pre-op status (%)	On final follow-up (%)				
	ASIA grading	A	B	C	D	E
OPSF group	Grade A-1 (6.67)		1 (6.67)			
	Grade B- 2 (13.33)			1 (6.67)	1 (6.67)	
	Grade C-7 (46.67)				3 (20)	4 (26.67)
	Grade D-5 (33.33)				1 (6.67)	4 (26.67)
	Grade E-0					
PPSF group	Grade A-1 (6.67)		1 (6.67)			
	Grade B-3 (20)			2 (13.33)	1 (6.67)	
	Grade C-5 (33.33)				2 (13.33)	3 (20)
	Grade D-6 (40)					6 (40)
	Grade E-0					

In OPSF group, average anterior vertebral body height (percentage of normal) was 59.93±8.89% before surgery and 88.13±5.59% at final follows up, yielding an average vertebral body height restoration of 28.20±8.49%, but

61.66±8.82%, 87.73±4.77% and 26.06±9.26% resp in the PPSF group. Average AVBH restoration was more in OPSF group but difference was not significant (p=0.516).

Effectiveness parameter

Before operation, VAS scores for back pain were 7.86±1.30 and 7.66±1.56 points in the OPSF group and PPSF group, respectively, and these were remarkably decreased in both groups after surgery (Table 4). However, there was no significant difference of VAS scores at the 12 months follow-up between two groups (p=0.808).

Table 4: Visual analog score in two groups.

VAS	OPSF group	PPSF group	P
Pre-op	7.86±1.30	7.66±1.54	0.7
3-day post op	3.8±0.94	3.53±0.99	0.45
12-months post op	2.13±0.99	2.06±0.79	0.84

As shown in Table 5, there was no statistical significance in preoperative neurological status (ASIA grading system) between OPSF group and PPSF (p=1). On final follow-up, 1 (6.67%) patient with grade A improved to grade B, 1 (6.67%) patient from grade B improved to grade D, 4 (26.67%) out of 7 patients improved from grade C to grade E and 4 (26.67%) out of 5 patients improved from grade D to grade E in OPSF group. Whereas, 1 (6.67%) patient with grade A improved to grade B, 1 (6.67%) patient from grade B improved to grade D, 3 (20%) out of 5 patients improved from grade C to grade E and all 6 (40%) patients improved from grade D to grade E in PPSF group. No patient in either group with grade E pre-op had any change in neurological status.

Postoperative complications

There was no significant difference in postoperative complications between PPSF group and OPSF group ($p>0.620$) (Table 6). Two patients (13.33%) in OPSF group and 1 (6.67%) in PPSF group had developed superficial infection in early post op period. All these were treated with higher antibiotics & regular dressing. None of the patients had deep infection. One patient (6.67%) had developed hardware failure (implant loosening and rod migration) after a period of 9 months in PPSF group, which was treated by implant removal and brace was advised. One (6.67%) patient in each group had developed worsening of urinary tract infection (UTI) which was managed by intermittent catheterization, bladder wash and antibiotics. Two patients (13.33%) in OPSF group and 1 (6.67%) in PPSF group had developed stage II pressure ulcer over sacrum during follow up period. All these were managed by non-operative wound care. None of the patient in either group had complications of neurological deterioration, chest infection or DVT.

Table 6: Postoperative complications in two groups.

Complication	OPSF	PPSF	P
Infection	2	1	0.62
Hardware failure	0	1	
Pressure ulcer	2	1	
UTI	1	1	

DISCUSSION

Burst fractures of the spine account for 14% of all spinal injuries.¹⁶ There has been substantial controversy regarding the operative management of such fractures. OPSF, more commonly utilized in clinical practices, has a clearer operative field and exposure to the vertebrae, it is associated with a large amount of blood loss and slow postoperative recovery. On the other side, PPSF could reduce the damage of paraspinal soft tissue and promote the recovery of scaffold structure of vertebral trabecular bone.¹⁷ In this study, we evaluated the effectiveness between OPSF and PPSF for treating thoracolumbar burst fractures with spinal injuries.

A total of 30 patients with thoracolumbar burst fracture with spinal injuries were divided into OPSF and PPSF group with 15 patients in each group. The demographic and clinical variables (Table 1) including age, gender, fracture level, mechanism of injury and ASIA grade in both the groups weren't significantly different. Type of neurological deficit (complete or incomplete) does influence the choice of surgical approach. Some surgeons are of the opinion that the efficacy of indirect decompression was greater particularly if operated within 72 hours of trauma.^{3,18} Taking this into consideration, in present study we did indirect decompression of fracture vertebra, by distracting posterior pedicle-screw construct in both groups. In PPSF group, operation time, intraoperative blood loss and postoperative hospital stay

were significantly lower than those in the OPSF group (Table 2), which is similar to previous research.¹⁹ A new meta-analysis also confirmed our study results.²⁰

For comparison of postoperative recovery of the two groups, preoperative and postoperative imaging findings were analyzed. CA, VBA and AVBH were the radiographic parameters of the normal anatomical position.²¹ In both the groups, CA and VBA were significantly decreased, whereas AVBH increased after surgery (Table 3). Despite that, they weren't significantly different. This suggested that there was no significant difference in the recovery of thoracolumbar fracture and no greater change in the thoracolumbar anatomical structure, which was beneficial to its function restoration. These finding were similar to those of Wang et al.¹⁹ However, Patil et al found significant correction of sagittal Cobb's angle in OPSF group on final follow-up.³ Fan et al found significant differences in the pre-operative and post-operative vertebral body angle and Cobb's angle, which were significantly better in the mini-open Wiltse approach with pedicle screw fixation (MWPSF) group than percutaneous pedicle screw fixation (PPSF).²²

VAS score and neurological status are also indicators of the effect of surgery. After surgery, VAS score was remarkably decreased in both groups but difference wasn't significant between two groups (Table 4). Wang et al.¹⁹ and Li K et al found significant difference of VAS score after surgery between 2 groups.²³ Decreased postoperative pain may lead to earlier mobilization, shorter recovery time, shortened hospital stay, and reduced hospital costs.

As shown in Table 5, there was no statistical significance in preoperative neurological status (ASIA grading system) between OPSF group and PPSF. However, there was rapid neurological improvement in both groups which could be achieved by means of distraction of fracture segment during surgery. The efficacy of indirect decompression could be greater as the surgery was performed within 5 days of trauma which corresponded with other study.¹⁸ Also, early mobilization in PPSF group due to reduce post-operatively pain and early initiation of aggressive and proper physiotherapy have contributed for better neurological outcome.

Common postoperative complications in both studies were superficial infections, pressure ulcer and UTI worsening (Table 6). Hardware failure was seen only in one case of PPSF group. However, there was no significant difference in postoperative complications between two groups ($p>0.620$). None of the patient in either group had complications of neurological deterioration, chest infection or DVT. Wang et al also found statically insignificant difference in postoperative complications between two groups while such complications were more common in open pedicle screw fixation with indirect decompression (OPSF) in Patil et al study.^{3,19}

Limitations of this study include (a) sample size was small with short term follow up, (b) blood loss in postoperative period in drain weren't considered, and (c) incision length in two groups weren't compared. So, there is a need for further long term, randomized and multicentric trials to verify our findings.

CONCLUSION

Patients with thoracolumbar burst fractures can be effectively managed with PPSF or OPSF. PPSF were superior in terms of blood loss, operating time and hospitalization stay, but there seems to no significant effect on radiologic outcomes and postoperative complications using percutaneous procedures compared open procedures.

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Ethical approval: The study was approved by the institutional ethics committee

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