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Comparative Study Between Short Segment Open Versus Percutaneous Pedicle Screw Fixation with Indirect Decompression in Management of Acute Burst Fracture of Thoracolumbar and Lumbar Spine with Minimal Neurological Deficit in Adults

Rahul Pramod Patil[1]*, Vinay Joshi[2], Chirayu Pamecha[3], Pavan Kumar[1], Uday Pal Bisnoi[2] and Opender Singh[2]

[1]*Department of Neurosurgery, R.N.T. Medical College, Udaipur, Rajasthan, India*
[2]*Department of Orthopaedics, R.N.T. Medical College, Udaipur, Rajasthan, India*
[3]*Shri Ram Spine Hospital, Udaipur, Rajasthan, India*

Abstract

The objective of this prospective randomized study was to compare the immediate and long-term clinico-radiological outcome of short segment open versus percutaneous pedicle screw fixation with indirect decompression achieved via distracting the posterior pedicle screw construct in management of single level acute thoracolumbar and lumbar burst fracture (TLBF) with minimal neurological deficit in adults.

All patients had burst fracture of less than 72 hours and loss of vertebral body height ≥50%, angulation ≥30^0, kyphotic deformity ≥20^0, canal compromise ≥40^0, failure of at least 2 columns, with intact pedicle and minimum neurological deficit [Grades C and D; according to American Spinal Injury Association (ASIA) grading system.

Fractures treated either via short segment open pedicle screw fixation with indirect decompression (OPSFD) or short segment percutaneous pedicle screw fixation with indirect decompression (PPSFD) techniques, were corrected using a titanium monoaxial pedicle screw construct. Post-operatively all patients were advice brace and subjected for regular physiotherapy and followed up to 1 years. Data regarding peri-operative events, clinico-radiological outcome, duration of hospital stay and period taken to return to work was collected and analysed.

Those patients treated with PPSFD techniques demonstrated superior outcomes compared to conventional OPSFD techniques, with significantly reduced operative time and blood loss during surgery, hospital stay, better neurological outcomes and early return to work. However, there was no significant difference in view of radiological improvement between the two surgical techniques.

We would recommend PPSFD techniques as the best way of treating acute single level TLBF with minimum neurological deficit in adults.

Keywords: Thoracolumbar fracture; Burst fracture; Single level fracture; Open pedicle screw fixation; Minimally invasive percutaneous pedicle screw fixation

Introduction

Five to 10% of poly-trauma patients suffer from spinal fractures, [1,2] with 70% to 80% of these occurring at the thoracolumbar and lumbar region, with 17% being burst fracture [1,3,4]. Neurological injury complicates 19% to 50% of fractures at the thoracolumbar and lumbar region in different studies [4-6].

Advancement of medical knowledge and technology has evolved the management for thoracolumbar and lumbar burst fracture (TLBF) from simple immobilization to minimally invasive surgery with better outcome over a period of time. However, the controversies surround the type optimal surgical method. Among the surgical methods pedicle screws for spinal stabilization is a fast, safe and effective procedure which is popular worldwide. Pedicle screw system engages all three columns of the spine and resists motion in all planes [7,8]. Some surgeons consider indirect decompression, by distracting a posterior pedicle-screw construct, safer than anterior decompression [9-11]. The optimum management of TLBF with minimum neurological deficit is a cause for much debate in the literature. Although minimally invasive surgery (MIS) approaches are increasingly used in the management of degenerative spinal pathology, their role in treating TLBF with minimal neurological deficit is unknown.

The aim of this study was to compare the immediate and long-term outcome of conventional short segment open pedicle screw fixation with indirect decompression (OPSFD) and short segment percutaneous pedicle screw fixation with indirect decompression (PPSFD) via distracting the posterior pedicle screw construct in management of single level acute TLBF with minimal neurological deficit in adults.

Material and Methods

The present prospective study was conducted at a tertiary care center in south Rajasthan (India) over a period of two years from October 2013 to October 2015. Adult (age 18-50 years) trauma patients, with acute single level burst fracture of thoraco-lumbar and lumbar spine with minimal neurological deficit [American Spinal Injury Association (ASIA) grades C and D and requiring surgical intervention were included in the study on the basis of thoracolumbar injury classification and severity score (TLICS) [8]. Patients with history of trauma more than 72 hours, multilevel spinal injury, fracture other

***Corresponding author:** Rahul Pramod Patil, M.S. General Surgery, Final Year Resident, M.Ch Neurosurgery, Department of Neurosurgery, R.N.T. Medical College, Udaipur, Rajasthan, India, Tel: +02942418258; Mobile: +9983833973; E-mail: dr.rahulpatil@hotmail.com

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than burst fracture, and those with neurological deficit of grades - A, B, and E (according to ASIA grading system), multi-organ trauma, vitally unstable patients and those not willing to participate were excluded from study.

Indication for surgery included loss of ≥50% vertebral body height, angulation ≥30^0, kyphotic deformity ≥20^0, canal compromise ≥40%, intact pedicle and failure of at least 2 columns. Neurological deficit was graded according to American Spinal Injury Association (ASIA) Impairment Scale. All patients pre-operatively underwent complete clinico- radiological [X-ray, NCCT spine, MRI spine] examination.

Patients were randomly subjected to OPSFD or PPSFD surgery. Titanium mono-axial pedicle screw-rod assembly was used. Decompression of the canal was achieved by distraction of the fracture vertebra. Post-operatively patients were advice brace, subjected for regular physiotherapy and followed up to 1 year. Data regarding intra-operative blood loss and duration of surgery, complications, neurological and radiological (restoration of anterior and posterior vertebral body height, change in sagittal Cobb′s angle and fracture body angle) improvement in comparison to pre-operative status at the time of last follow-up was collected and analyzed.

Results

Fifty patients (38 male, 12 female), age range 18-50 years (mean 30.36 ± 9.15 years) with TLICS score of >4 (5.2 ± 0.6) underwent posterior spinal instrumentation (Table 1). Fall from height was the most common mode of injury in 34 (68%) patients followed by road traffic accidents in 10 (20%) patients (Table 1). Seventy percent of patients sustain injury at level of thoraco-lumbar junction (T12-L1 level), and most common vertebra involved was L1 (Table 1). Statistical analysis of data showed no significant difference in the sagittal cobb′s angle, fracture vertebral body angle, anterior and posterior vertebral body height on pre-operative, immediate post-operative and final follow-up of 1 year between the two surgical techniques (Table 2). However, a statistically significant difference was observed between the two surgical techniques in corrected sagittal cobb′s angle (P-value=0.008; Table 2). On final follow-up 4 out of 10 patients improved from grade C to grade D and 14 out of 15 patients improved from grade D to grade E in OPSFL group. Whereas, 6 out of 9 patients improved from grade C to grade D and all 16 patients improved from grade D to grade E in PPSF surgical group (Table 3). There is a significant difference in average surgical time, average surgical blood loss between two surgical groups (P=value < 0.001; Table 4). There is also a significant difference in time spent in hospital and return to work between the two surgical groups, with favourable results for PPSF (P-value < 0.001, Table 5). Complication like implant failure, superficial infection, and bed sore were common in OPSFL group (1, 4 and 3 patients respectively) then PPSF group (1, 1 and zero patients respectively).

Demographics	Total	OPSFD surgery (%)	PPSFD surgery (%)
Number of patients	50	25	25
Mean age (years)	30.36 ± 36 years	29.76 ± 8.94 years	30.96 ± 5.2 years
Gender M:F	38:12	20:5	18:7
Manual labourer occupation	38 (76%)	18 (72%)	20 (80%)
Non-manual labourer occupation	12 (24%)	07 (28%)	05 (20%)
Mode of injury			
Fall from height	34 (68%)	19 (38%)	15 (30%)
RTA	10 (20%)	03 (6%)	7(14%)
others	06(12%)	03(6%)	3(6%)
Vertebral level			
T11	4 (8%)	2 (4%)	2 (4%)
T12	16 (32%)	11 (22%)	5 (10%)
L1	19 (38%)	8 (16%)	11 (22%)
L2	6 (12%)	2 (4%)	4 (8%)
L3	2 (4%)	1 (2%)	1 (2%)
L4	1 (2%)	0 (0%)	1 (2%)
L5	2 (4%)	1 (2%)	1 (2%)

Table 1: Demographics characteristics, mode of injury and distribution according to vertebral level involved for the two surgical groups.

Discussion

Burst fractures of the spine account for 14% of all spinal injuries [12]. Though common, TLBF present a number of important treatment challenges. Studies over last 3 decades have documented conservative treatment as better choice for TLBF without neurological deficit on the other hand surgery as best choice for TLBF with neurological deficit or unstable fracture [12,13].

There has been substantial controversy related to the operative management of these fractures, especially regarding the choice of the surgical approach. Also, the type of neurological deficit (complete or incomplete) does influence the decision of surgical approach. Further, new studies suggest direct decompression is not important in neurologically intact patients with different degrees of canal compromise [14-16]. Some surgeons are of the opinion that the efficacy of indirect decompression was greater particularly if operated within 72 hours of trauma [17,18]. Taking this into consideration, in present study we did indirect decompression of fracture vertebra, by distracting posterior pedicle-screw construct in open as well percutaneous surgical group.

Figure 1: Pre-operative burst fracture of L1 vertebra.

	Variables	Pre-op (mean)	Post-op (mean)	Final follow-up (mean)	Correction on final follow-up (mean)
Saggital cobb's angle (^{0})	PPSFD surgery	26.36 ± 4.29	15.12 ± 5.38	19.08 ± 5.40	7.26 ± 3.19
	OPSFD surgery	29.08 ± 8.30	15.40 ± 7.11	19.16 ± 7.86	9.96 ± 3.63
	t-value	1.45	0.157	0.042	2.769
	P-value	0.15	0.876	0.967	0.008
Fracture body angle (^{0})	PPSFD surgery	15.20 ± 4.62	25.04 ± 4.19	23.36 ± 4.04	8.28 ± 2.05
	OPSFD surgery	15.04 ± 7.11	29.08 ± 8.30	19.16 ± 7.86	9.04 ± 2.86
	t-value	1.455	0.157	0.042	0.341
	P-value	0.152	0.876	0.967	0.735
Anterior vertebral body height (cm)	PPSFD surgery	1.62 ± 0.286	2.43 ± 0.319	2.04 ± 0.359	0.412 ± 0.22
	OPSFD surgery	1.69 ± 0.311	2.57 ± 0.272	2.19 ± 0.371	0.444 ± 0.175
	t-value	0.853	1.721	1.393	0.567
	P-value	0.39	0.09	0.170	0.573
Posterior vertebral body height (cm)	PPSFD surgery	2.50 ± 0.215	2.82 ± 0.144	2.74 ± 0.153	0.24 ± 0.125
	OPSFD surgery	2.40 ± 0.252	2.80 ± 0.076	2.72 ± 0.091	0.304 ± 0.198
	t-value	-1.508	-0.612	-0.674	1.360
	P-value	0.138	0.543	0.504	0.180

Table-2: Radiological characteristic of vertebral fracture.

Surgical technique	Pre-operative status	Post-operative status					On final follow-up				
OPSFD surgery (%)	ASIA grading	A	B	C	D	E	A	B	C	D	E
	Grade A →0 (0%)	0					0				
	Grade B →0 (0%)		0					0			
	Grade C →10 (40%)			8 (32%)	2 (8%)				6 (24%)	4 (16%)	0
	Grade D →15 (60%)				3 (12%)	12 (48%)				1 (4%)	14 (56%)
	Grade E →0 (0%)					0					0
PPSFD surgery (%)	ASIA grading	A	B	C	D	E	A	B	C	D	E
	Grade A →0 (0%)	0					0				
	Grade B →0 (0%)		0					0			
	Grade C →9 (36%)			4 (16%)	5 (20%)				3 (12%)	6 (24%)	0
	Grade D →16 (64%)				1	15 (60%)				0	16 (64%)
	Grade E →0 (0%)										0

Table-3: Change in neurological status of patients as per ASIA grading system.

Variables	PPSFD surgical group	OPSFD surgical group	t-value	P-value.
Average length of incision (cm)	8.4 ± 1.321	13.96 ± 1.274	12.840	<0.001
Average surgical blood loss (ml)	85 ± 20	150 ± 35	9.201	<0.001
Average surgical time (min)	69.76 ± 11.76	103.48 ± 12.25	9.923	<0.001

Table-4: Peri-operative data.

Variables	PPSFD surgical group	OPSFD surgical group	t- value	P-value
Average post-operative stay (days)	4.08 ± 1.38	13.12 ± 2.587	15.448	<0.001
Time taken to return to work (months)	2.13 ± 1.457	4.789 ± 2.838	4.182	<0.001
No. Patients who never return to work	3 (12%)	6 (24%)	-	-

Table-5: Time spent in hospital in days, time taken to return to work.

Conventional OPSFD surgeries leads to extensive soft tissue damage, particularly by stripping the posterior paraspinal muscles away from the spine [19]. A fusion adds an additional mechanical insult by creating a permanent stiff segment with stress transfer to other levels. If no fusion is carried out, then damage to those paraspinal muscles results in functional loss as these muscle groups are required to support and move those segments [19,20]. Soft tissue damage is limited by restricting the number of segments spanned by any construct to one level above and below the fractured vertebra. Posterior short segment fixations alone have danger of loss of correction [21,22]. Hence many surgeons combined anterior fixation along with short segment posterior constructs, which provide greater structural support but carry a significant complication risk [23].

PPSFD offers the benefits of posterior correction and fixation without the damage to soft tissues and paraspinal muscles [20,24]. There was also significantly reduction in incision length (8.4 ± 0.8 cm) [25], intra-operative blood loss (75 ml) [26] and surgical duration (78 min) [26]. However, for optimal benefits PPSFD techniques must satisfy certain criteria- there must be no compromise when performing these techniques and the surgeon must be able to achieve everything that would be attained with open surgery. Fractures and deformity must be able to be reduced as well and reliably as with open techniques. Present study demonstrates that our techniques achieve this (Table 4; Figures 1-5) and that our techniques are safe, reliable and reproducible.

There was a statistically significant difference in duration of hospital stay, return to work between two surgical groups in our study (Table 5), which correlate's with the finding of Amit Kumar et al. [26].

There were no significant differences between the two approaches in regards to restoration of anterior and posterior vertebral body height, and fracture vertebral body angle (Table 2). Also on immediate post-operative period sagittal Cobb's angle showed insignificant difference between two surgical groups, however on final follow-up a significant correction of sagittal Cobb's angle was noted in OPSFD surgical group (Table 2). These results indicate that at a minimum, percutaneous

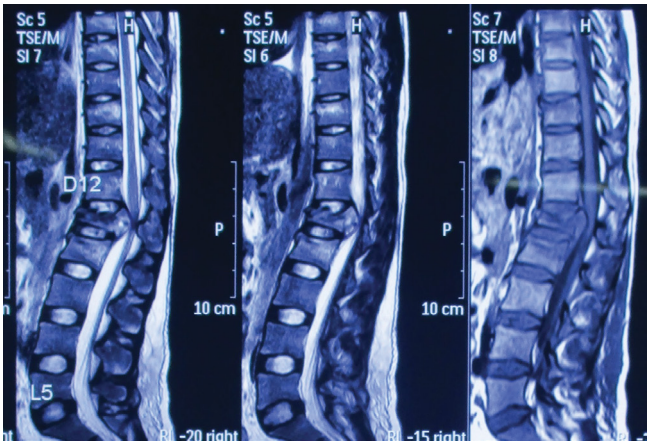

Figure 2: MRI-spine showing L1 vertebral burst fracture.

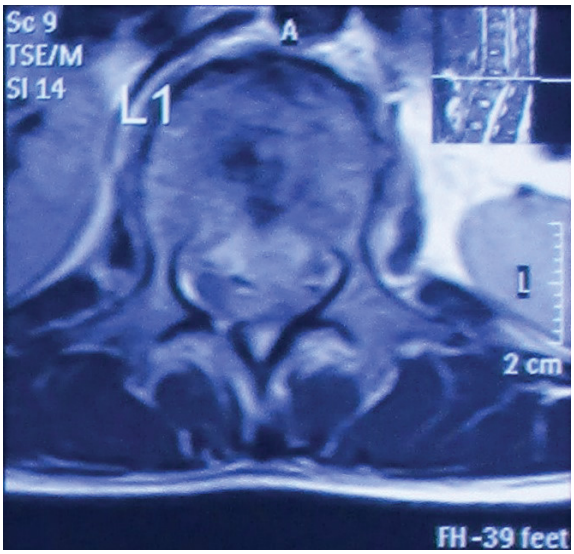

Figure 3: MRI Spine axial image showing cannal compromise.

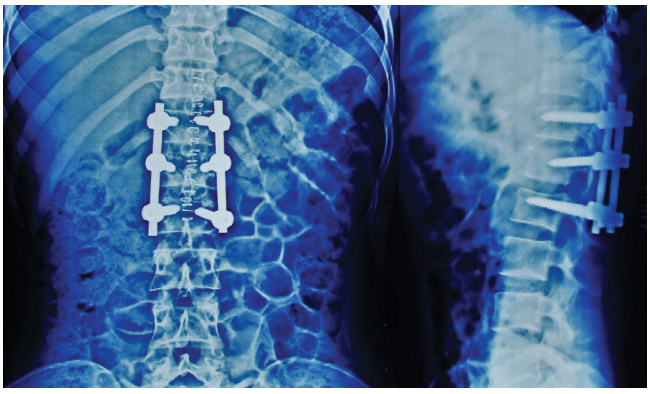

Figure 4: post-operated MRI of L1 burst fracture.

fixation of thoracolumbar fractures results in equivalent biomechanics and clinical outcomes as the open group. These finding were similar to those of Jiang et al. [27]. Dong et al. concluded that the percutaneous and open techniques did not result in significant differences in the radiologic measurement data and that both approaches achieve a good curative effect [28].

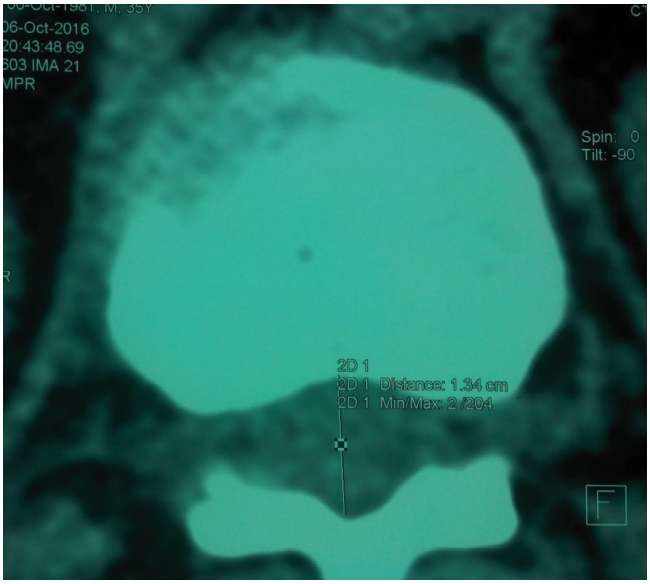

Figure 5: Post-operative Axial CT scan of L1 burst fracture.

In present study, there was rapid neurological improvement in patients belonging to PPSFD surgical group as compared to OPSFD surgical group (Table 3). This was achieved by means of distraction of fracture segment during surgeries. The efficacy of indirect decompression was greater as the surgery was performed within 3 days of trauma which corresponded with Spivak et al. study [17]. An intact anterior longitudinal ligament (ALL) prevents the occurrence of over-distraction of the fractured vertebra. A fragment bulging posteriorly with a ligamentous attachment in the spinal canal can be reduced to a certain degree by ligamentotaxis (Tables 3 and 5). Fragments bulging posteriorly near the midline are pulled back into place partly by the 0.5 to 1-cm-wide superficial fibers of the posterior longitudinal ligament (PLL) and fragments lying more laterally are reduced by their attachment to the 1-cm-wide segmental deep layer of PLL [17]. 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.

Limitations of present study include the lack of variability in patients within the cohort. We have adopted strict inclusion criteria to try and make patient groups as comparable as possible. Additionally, follow-up of longer duration data is required to assess the greater long term sequelae of such injuries and its managements.

Conclusion

Short segment PPSFD is fast, safe and effective method of treating acute single level TLBF with minimum neurological deficit.

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