

Original Article

Factors predicting long-term outcome after short-segment posterior fixation for traumatic thoracolumbar fractures

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Abstract

Background: The “gold standard” for instrumentation of unstable thoracolumbar fracture-dislocations is pedicle screw and rod fixation. Although traditional treatment supports long-segment posterior fixation (LSPF), more recent studies show short-segment posterior fixation (SSPF) may be effective, but incur higher failure rates. Here, we evaluated the effectiveness of SSPF in the management of unstable thoracolumbar injuries and analyzed the factors impacting long-term outcomes.

Methods: In this retrospective analysis of 91 patients with thoracolumbar fractures managed with SSPF alone, we assessed the clinical and radiological parameters at preoperative, postoperative, and follow-up intervals along with reasons for failures of SSPF.

Results: We analyzed 91 patients (mean age: 33.5 years; Male: Female = 50:41) with thoracolumbar fractures treated with SSPF over a median follow-up period of 30 months. SSPF failures were observed in 26 of 91 (28.6%) patients; the median time to implant failure was 17 months. On univariate analysis, statistically significant factors contributing to failure of SSPF included the presence of a burst fracture, a preoperative LSC (load-sharing classification) score >6, and translation/dislocation. With multinomial regression analysis, the only factor predictive for SSPF failure was the patients' postoperative ambulatory status.

Conclusion: Patients with thoracolumbar fracture dislocations, subjected to axial spinal loading postoperatively, should not be considered for SSPF alone. The following factors also contributed to SSPF failures: a burst fracture, a preoperative LSC score of >6, and/or presence of transverse dislocation.

Key Words: Factors affecting outcome, long-term outcome, short segment posterior fixation, spine fractures, spinal injury, spinal instrumentation, surgical treatment, thoracolumbar fractures

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INTRODUCTION

Thoracolumbar spinal trauma resulting in three-column injuries often require surgical intervention to prevent future painful deformity or worsening neurologic function.^[11] The load-sharing classification (LSC) from McCormack *et al.* and the thoracolumbar injury severity score (TLISS) classification from Vaccaro *et al.* offer detailed algorithms to assist in the nonoperative vs. operative management of thoracolumbar injuries.^[5,11] However, once the decision for operative management is made, the optimal surgical strategy remains controversial.^[1]

Recent studies document the efficacy of short-segment posterior fixation (SSPF: one level above/below) vs. long-segment posterior fixation (LSPF: two levels above/below). Nevertheless, SSPFs have been associated with a higher rate of implant failure and recurrent kyphosis.^[4,6,7] The prospective application of LSC has shown that SSPF can be used successfully in thoracolumbar spinal injuries.^[9] Here, we retrospectively analyzed patients with thoracolumbar fractures managed with SSPF alone and assessed clinical/radiological parameters at preoperative/postoperative intervals along with outcomes/failure rates.

MATERIALS AND METHODS

Study design and patient population

We retrospectively analyzed 91 patients with traumatic thoracolumbar fractures who underwent SSPF with pedicle screw/rod fixation over 20 months (2012–2013). Clinical and radiological data were obtained from the hospital medical records with prior approval from the Institutional Review Board.

Inclusion criteria

Patients with posttraumatic, single-level thoracolumbar fracture/dislocations undergoing SSPF with pedicle screws/rods with a minimum clinical/radiological follow-up of 18 months were included in the study [Table 1]. Exclusion criteria included multilevel fracture dislocations, those with long-segment posterior or anterior/posterior fixation, and follow-up of <18 postoperative months (without failure).

Preoperative data acquisition

Using the ASIA classification system, patients were divided into two groups – ASIA grades A to C (nonambulatory in the postoperative period; no axial load bearing) and ASIA grades D to E (those ambulatory without support in the postoperative period; axial load

Table 1: Clinical and radiological characteristics of the study group (91 patients)

	Thoracic #s	T-L #s	Lumbar #s	Total
No. of patients	6	27	58	91
Age (In years)				
Mean±S.D.	27.2±10.4	36.3±13.1	32.9±11.3	33.5±11.9
Range	19-48	17-71	12-60	12-71
Gender (Male: Female)	4:2	17:10	29:29	50:41
Type of Fracture (single level)				
Wedge	2	14	25	41
Burst	4	13	33	50
LSC score				
Mean LSC score	7.8±0.9	6.7±1.1	6.6±1.4	
No. of patients with LSC score ≤6	1	13	26	40
No. of patients with LSC score >6	5	14	32	51
Regional Kyphotic Angle (RKA) (Mean Angle±S.D.)				
Pre-operative	23.5±5.5	19.9±7.4	13.9±8.8	16.3±8.8
Immediate Post-operative	12.2±7.5	7. ±7.5	4.2±5.6	5.8±5.9
Change in RKA [Pre-operation to Immediate Post-operation] (%)	11.3±7.9	12.3±8.1	9.7±7.1	10.6±7.5
ASIA grade				
Self-ambulatory (D, E)	2	15	43	60
Ambulatory with support (A, B, C)	4	12	15	31
Transverse Dislocation (Translation)				
Present	5	8	13	26
Absent	1	19	45	65
Follow-up Period (In months)				
Mean±S.D	30.3±12.9	28.5±9.7	29.1±11.9	29.0±11.2
Range	11-44	10-52	9-62	9-62

#s: Fractures, T-L: thoraco-lumbar (junctional), S.D.: Standard Deviation, LSC: Load Sharing Classification, ASIA: American Spinal Injury Association

bearing present). Preoperative assessment included X-rays (anterior-posterior and lateral views), computed tomography (CT thin cuts and 2D reconstructions), and magnetic resonance imaging (MRI). Preoperative radiological parameters studied included assessment of vertebral body height at the fractured segment, regional kyphosis/angular displacement, and evaluation of translation/dislocation. The LSC score was measured for all patients.

Operative intervention

Laminectomy was performed in 43 patients to decompress the neural elements (e.g. those with severe kyphotic deformity and a compromised canal diameter). Next, all had SSPF performed, with two screws placed one level above and two screws placed one level below the fractured segment. A transverse bar connected the longitudinal rods in cases of translation/dislocation (e.g., to reduce rotational motion at the fracture site). Fracture reduction and correction of vertebral body heights was achieved utilizing the distraction/manipulation of the vertebral bodies with screws. Facets were manipulated or partially removed to correct translation/dislocation. Bone chips/dust was inserted into the drilled joint spaces or laid over decorticated joints/lamina to achieve bony fusion.

Postoperative assessment and follow-up

Patient's postoperative ASIA grade and changes in neurological status were noted. Postoperative X-rays/CT studies evaluated: anterior VBH (vertebral body height), posterior VBH, regional kyphotic angle (RKA), change in RKA, and percentage of correction of anterior VBH and posterior VBH. Only patients in whom clinical and radiological follow-up of 18 months could be assessed were included in the study.

Outcome analysis and failure definition

Assessment of outcomes included the evaluation of construct failure rates and the time to construct failure. Construct failure was defined by breakage of a rod/screw (implant failure), increase in kyphotic angle (vs. preoperative scans), decrease in VBH (collapse of vertebral body), and screw pull-out.^[8]

Statistical analysis

Data were presented as mean (\pm SD) or median [interquartile range (IQR)] in normally distributed or skewed variables, respectively. Normality of data was checked using Kolmogorov–Smirnov tests. For normally distributed data, means were compared using unpaired Student's *t*-test. For skewed data, Mann–Whitney test was applied. Logistic regression analysis described variables associated with failure of SSPF. Failure-free survivals among different categories were calculated and plotted using Kaplan–Meier curves. All statistical tests were twosided and a probability value <0.05 was considered significant.

RESULTS

Failure of short-segment posterior fixation

In our study, 91 patients with posttraumatic single-level thoracic and lumbar spine fractures underwent SSPF of the unstable spine with pedicle screw and rod fixation [Table 1]. Failure was seen in 26/91 (28.6%) patients [Figures 1-4; Table 2]. Symptomatic implant failures requiring secondary surgery/implant removal were seen in only 6 of 91 (6.6%) patients; 1/6 (16.7%) patients with thoracic, 2/27 (7.4%) patients with thoracolumbar, and 3/58 (5.2%) with lumbar level injuries.

Factors affecting failure

On univariate analysis, the factors with a statistically significant association with failure of SSPF included: the presence of a burst fracture, a preoperative LSC score >6 , and translation/dislocation. On multinomial regression analysis (taking factors with *P* value <1 on univariate analysis as covariates), the only factor which was predictive of failure in SSPF was the postoperative ambulatory status. Patients in ASIA grade D and E were likely to have failure of SSPF (*P* = 0.0060 and OR = 5.95; 95% CI: 1.69–21.03) [Table 2].

Failure of SSPF was twice as high in patients with burst-fractures compared to patients with wedge compression fractures (38% versus 17.1%; *P* = 0.047). Failure of SSPF was seen in 6/40 (15%) patients with LSC ≤ 6 , whereas it was observed in 20/51 (39.2%) patients with LSC >6 (*P* = 0.019). Failure of SSPF was higher with translation/dislocation [46.2% (12/26)] patients versus those [14/65 (21.5%)] without translation/dislocation (*P* = 0.039). Failure of SSPF did not significantly correlate with the level of injury – 2/6 (33.3%) thoracic, 8/27 (29.6%) thoracolumbar, and 16/58 (27.5%) lumbar spine injuries. Failure of SSPF was higher (approaching statistical significance) in the ambulatory group [21/60 (35%)] versus the nonambulatory group [5/31 (16.1%)] [Table 2]. Higher failure rates in those undergoing SSPF, who were ambulatory following surgery, correlated with the presence of a burst fracture, a preoperative LCS score >6 , and presence of transverse dislocation [Table 3].

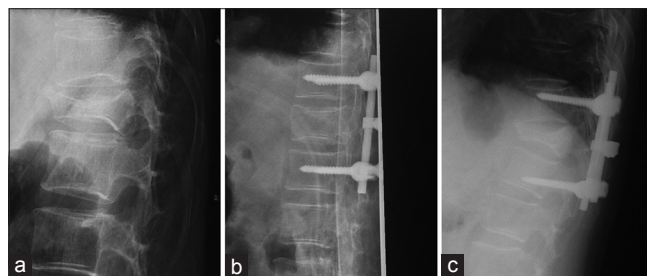


Figure 1: (a) Preoperative, (b) immediate postoperative, and (c) follow-up X-rays of a patient in our study group depicting failure of short-segment posterior fixation (SSPF) due to loss of vertebral body height

Table 2: Factors affecting outcome of Short Segment Posterior Fixation

Factors studied	Outcome of SSPF		Uni-variate Analysis		Multi-variate Analysis ^a		
	Failure	No Failure	'P' (2-tailed)	Confidence Interval (95%)	'P'	Odd's Ratio (OR)	Confidence Interval (95%)
1. Level of fracture							
Thoracic	2	4	0.946		-	-	-
T-L	8	19					
Lumbar	16	42					
2. Type of vertebral body fracture							
Burst	19	31	0.047*	1.102-8.043	0.11	2.57	0.82-8.03
Wedge	7	34					
3. Pre-operative LCS score							
>6	20	31	0.019*	1.3-10.28	0.081	2.87	0.88-9.37
≤6	6	34					
4. ASIA grade							
(D + E) Ambulatory	21	39	0.094		0.006*	5.95	1.69-21.03
(A + C) Non-ambulatory	5	26					
5. Transverse dislocation							
Present	12	14	0.039*	1.182-8.25	0.065	3.03	0.93-9.85
Absent	14	51					

*Statistically significant, ^aMultinomial regression analysis included all factors as co-variables, except 'level of fracture' (since the 'P' value in univariate analysis for this factor was >0.1). T-L: Thoraco-lumbar (junctional), LCS: Load Sharing Classification, ASIA: American Spinal Injury Association

Timing of failure and factors affecting it

The median time for failure of SSPF was 17 months (IQR: 12–28.2 months). Nearly a quarter failed within 1 year and >90% failed by 4 years after surgery. SSPF in burst fractures failed more than a year earlier than in wedge fractures (38.3 months vs 51.9 months; $P = 0.01$). Those with preoperative LCS score >6 had early failure versus those with LCS score ≤6 (38.9 months vs. 52.4 months, $P = 0.01$). Postoperative ambulatory patients (ASIA grade D-E) had early failure than nonambulatory patients (42.9 months vs 49.6 months, $P = 0.03$). The level of vertebral fracture and presence of transverse dislocation did not affect the timing of failure significantly ($P = 0.8$ and 0.06, respectively). Kaplan–Meier curves showing difference in the failure-free survivals are shown in Figure 5.

DISCUSSION

There is considerable controversy regarding the number of vertebral levels to be included in the fixation of thoracolumbar fractures. SSPF involves fixation of one level above and below the fractured vertebra, whereas LSPF involves fixation of at least two levels above and below the fractured vertebra.^[4] In recent literature, good clinical outcomes have been reported with SSPF.^[1] Nevertheless, results of SSPF are not always satisfactory and high rates of implant failure have been noted.^[1,6]

Lazaro *et al.* compared SSPF versus LPSF of the thoracic spine in an *ex-vivo* trauma model (3-column injury) and concluded that short-segment fixation provided significantly less stability than long-segment

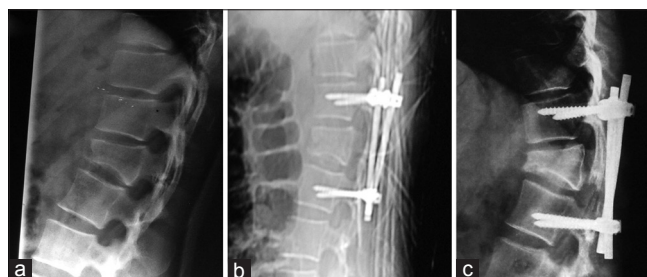


Figure 2: (a) Preoperative, (b) immediate postoperative, and (c) follow-up X-rays of a patient in our study group showing failure of short-segment posterior fixation (SSPF) due to re-kyphosis

fixation.^[4] They suggested that short-segment fixation could be an option for the treatment of less destructive lesions of the thoracic spine.^[4] However, clinical studies have found comparable outcomes between SSPF and LSPF, as assessed by pain scores and other clinical outcome measures.^[10,12]

Analysis of outcome in our study group

Construct failure after SSPF can range from 9% to 54%.^[11] Our rate of SSPF construct failure was comparable at 26/91 (28.6%) and symptomatic implant failure, requiring repeat surgery or implant removal was seen in only 6 of 91 (6.6%) patients.

Implant removal

Implant removal was recommended only if the implants were prominent and painful, had lost fixation or had broken, or if revision was indicated for progressive kyphosis.^[7] Altay *et al.*, in their series of 63 patients with thoracolumbar fractures, reported correction loss (>10%)

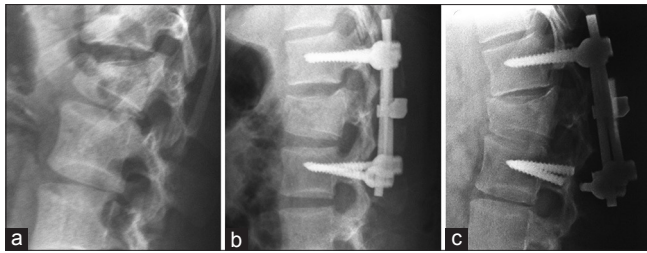


Figure 3: (a) Preoperative, (b) immediate postoperative, and (c) follow-up X-rays of a patient in our study group showing failure of short-segment posterior fixation (SSPF) due to breakage of screws (implant-failure)

Table 3: Subgroup Analysis for Ambulatory versus Non-ambulatory patients

Factors affecting outcome in PSSF	Outcome of PSSF		'P'	CI (95%)
	Failure	No failure		
Level of Spinal Injury				
Thoracic				
D + E (ambulatory)	1	1	1.000	-
A + C (non-ambulatory)	1	3		
T-L				
D + E (ambulatory)	6	9	0.372	-
A + C (non-ambulatory)	2	10		
Lumbar				
D + E (ambulatory)	14	29	0.487	-
A + C (non-ambulatory)	2	10		
Type of Vertebral body				
Fracture				
Burst				
D + E (ambulatory)	15	14	0.037*	1.228-16.88
A + C (non-ambulatory)	4	17		
Wedge				
D + E (ambulatory)	6	25	0.88	-
A + C (non-ambulatory)	1	9		
Pre-operative LCS score				
>6				
D + E (ambulatory)	17	12	0.002*	2.159-37.28
A + C (non-ambulatory)	3	19		
≤6				
D + E (ambulatory)	4	27	0.819	-
A + C (non-ambulatory)	2	7		
Translation/dislocation				
Present				
D + E (ambulatory)	9	4	0.047*	1.3-43.0
A + C (non-ambulatory)	3	10		
Absent				
D + E (ambulatory)	12	35	0.35	-
A + C (non-ambulatory)	2	16		

*Statistically significant T-L: Thoraco-lumbar (junctional), LCS: Load Sharing Classification, ASIA: American Spinal Injury Association

in 6 (19.4%) of the 32 cases of SSPF, versus only 2 (6.5%) of the 31 cases of LSPF.^[11] Alvine *et al.* reported 39% screw breakage and 23% unplanned reoperation rate

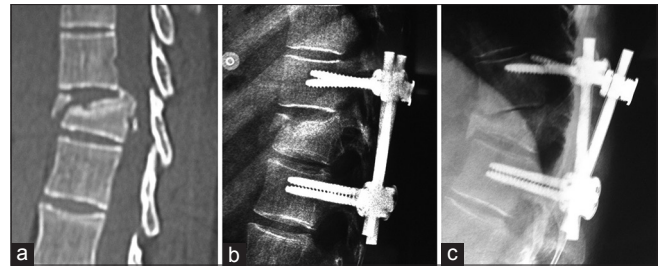


Figure 4: (a) Pre-operative CT scan (2D reconstruction), (b) immediate postoperative, and (c) follow-up X-rays of a patient in our study group showing failure of short-segment posterior fixation (SSPF) due to pull-out of screws (implant-failure)

for SSPF in their study comprising 41 patient; the authors recommend LPSF constructs, rather than SSPF constructs, for thoracolumbar fractures and suggest sequential or staged anterior corpectomy and structural grafting along with SSPF as an alternative to LPSF.^[12]

McLain *et al.* reported ten instrumentation failures with SSPF (transpedicular screws) among 19 fractures in their study.^[7] Waqar *et al.* found a trend towards poor clinical and radiological outcomes with SSPF; however, the results were not statistically significant because the study volume was small.^[12] Sapakas *et al.* noted construct failure in 7 out of 20 patients in the SSPF group. Broken and bended screws were noted within the first year and probably were caused by long-term cyclic loading.^[10]

Factors affecting failure of short-segment posterior fixation and timing of failure

The presence of burst fracture had a statistically significant association with SSPF failure and was associated with early failure after SSPF [Figure 5a]. Parker *et al.* suggested similar results, indicating that four posterior screws do not restore anterior weight-bearing capacity; hence, the implant may fail before the fracture heals. McCormack *et al.* described utilizing LCS to identify unstable thoracolumbar fractures, which were likely to have poor anterior load-bearing capabilities resulting in correction loss and implant failure.^[5] They also concluded patients with an LCS score ≤ 6 were likely to be good candidates for SSPF.^[9]

Postoperative ambulation increases short-segment posterior fixation failure

In our study, postoperative ambulatory status was predictive of failure of SSPF. Further subgroup analysis [Table 3] demonstrated deficient anterior column (burst fracture or LCS score more than 6) or high-energy impact (causing translation/dislocation) was highly predictive of failure of SSPF [Figure 5c].

Translation/Dislocation

We emphasized the role of translation/dislocation as a cause of recurrent collapse or implant failure with SSPF.

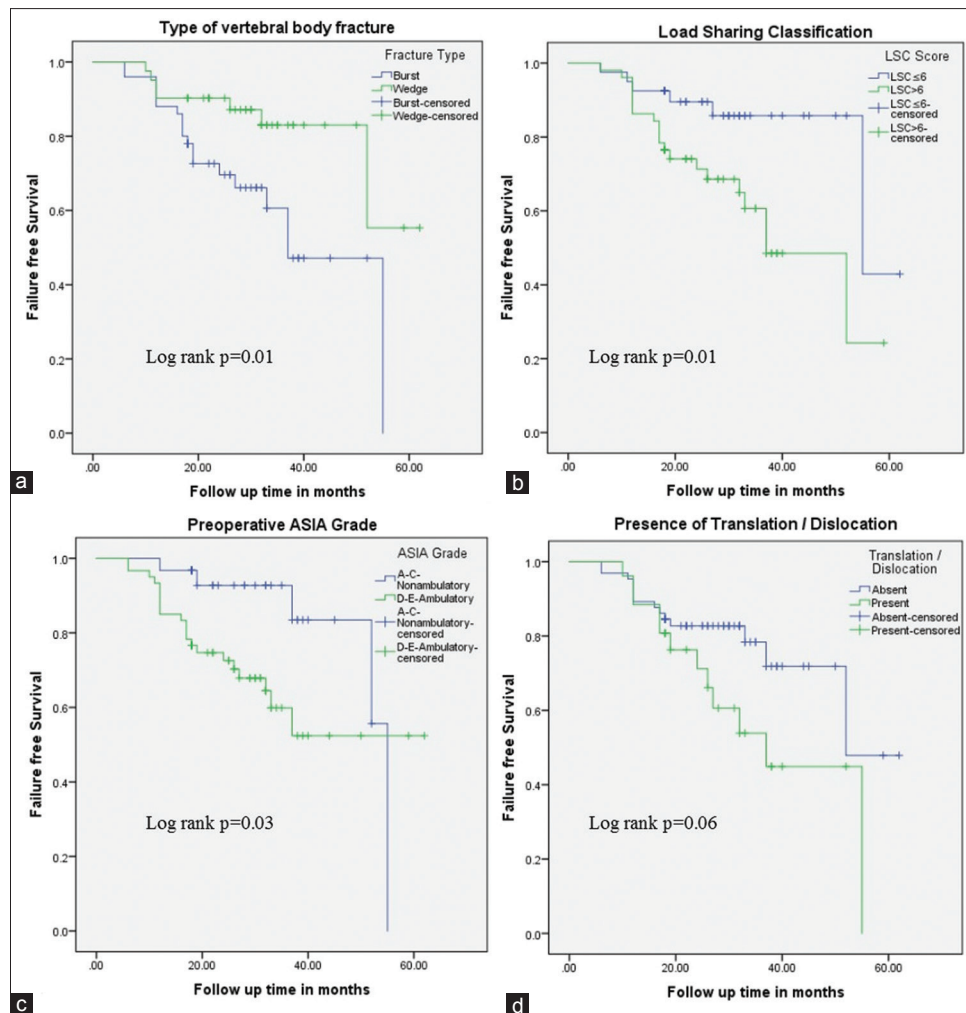


Figure 5: Kaplan–Meier curves showing difference in failure-free survivals. The presence of burst fracture (a) preoperative LSC score >6 (b) and ambulatory status (c) (ASIA grade D and E) affect the timing of failure in patients undergoing standalone SSPF. The presence of translation/dislocation (d) and the level of fracture did not significantly affect the timing of failure in the study group

This is similar to the results of Parker *et al.* where a high incidence of recurrent collapse was present in patients with translation/dislocation.^[9]

Limitations of our study

This study only reports on the long-term outcome of one surgical procedure for thoracolumbar fractures, i.e. SSPF.

CONCLUSION

Although SSPF is the most common procedure performed for thoracolumbar fracture-dislocations, is standalone SSPF adequate in treating patients with thoracolumbar fracture- dislocation? Standalone SSPF can be used in a subset of patients with thoracolumbar injuries, if carefully selected. However, those with thoracolumbar fracture-dislocations who will be ambulatory in the postoperative period (e.g., subjected to axial loading) should not be considered for SSPF alone particularly if they have accompanying burst fractures, preoperative LSC score >6, and/or translation/dislocation.

Ethical approval: Yes.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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