Short Segment Posterior Pedicle Instrumentation for Traumatic Thoracic and Lumbar Fractures: Is Bone Grafting Really Needed?

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What to Learn from this Article?

Good clinical and radiological results can be obtained by short segment posterior pedicle instrumentation without bone grafting for the treatment of traumatic thoracolumbar fractures.

Abstract

Background: The use of bone grafting in treatment of thoracic and lumbar trauma continues to be one of the controversial areas in the trauma care. The purpose of this study is to find out the outcome of pedicle instrumentation in traumatic thoracic &lumbar fractures without bone grafting in our cohort.

Methods: This study initially included 32 patients with single level traumatic thoracic &lumbar vertebral fractures with or without neurological deficit between May 2009 to December 2010. All patients underwent clinico- radiological assessment followed by short segment posterior pedicle instrumentation without bone grafting.2 patients were lost to follow up.

Results: Mean age of the patients was 31 years, withan average follow up of 45 months. Seventy percent of the patients sustained injuries at D12 and L1 vertebral level.15 patients (50%) compression fractures, 14 (46.67%) burst fractures and 1(3.33%) fracture dislocation according to Denis classification. Average operative time was 90.3 minutes and blood loss averaged 148.6 ml. 3 patients (10%) had screw loosening. Our study also showed statistically significant correction ($p < 0.01$) in all radiological parameters including sagittal index, anterior body compression, sagittal plane kyphosis, vertebral kyphosis and regional kyphosis.

Conclusion: In the management of patients of traumatic thoracic &lumbar fracture; bone grafting and fusion may not be required with short segment posterior pedicle instrumentation.

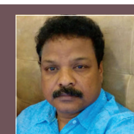
Keywords: Thoracolumbar fracture, Short segment, Pedicle instrumentation, Bone grafting

Introduction

The occurrence of thoracic and lumbar fractures (TLF) and dislocations has increased substantially due to the increase in the incidence of road traffic accidents and the greater exposure to high-energy blunt trauma [1]. Majority of these fractures occur in male patients between 15 and 29 years of age [2]. Out of the thoracolumbar injuries, approximately 50-60% affected the transitional zone (T11-L2), thoracic region involvement was around 25-40%, and 10-14% involved the lower lumbar region and sacrum [3]. In fact, the majority of thoracic and lumbar injuries occur within the region between T11 and L1, commonly referred to as the thoracolumbar junction [2]. In a Swedish study,







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the annual incidence of thoracolumbar fractures was on average 30 per 1,00,000 population. Among patients younger than 60 years, the yearly incidence was 13 per 1,00,000 and was twice in men compared to women [4]. Neurological deficit occurs in approximately 20-36% of fractures at the thoracolumbar junction in different studies [3]. Various classification systems have been proposed to describe the TLF [5, 6, 7, 8, 9].

Short-segment Posterior Pedicle Instrumentation (SSPI) has become a popular surgical treatment for TLF. Pedicle screw is placed through the pedicle into the vertebral body without breaching pedicle wall, thus providing biomechanically desirable three column fixation. Although bone grafting (autologous corticocancellous posterior iliac crest bone grafting) is often performed as an adjunct to spinal fixation, but there are many studies suggesting that bone grafting is unnecessary leading to controversy regarding its use with no universal consensus [10, 11, 12, 13, 14, 15]. The additional bone grafting for fusion is often associated with more operative time, blood loss, and graft site pain which overall increases the morbidity of the patient. Because of absence of robust evidence to support fusion with use of bone graft; this study was planned in our cohort to see the results of dorsolumbar fractures treated with SSPI without bone grafting. The treatment of thoracolumbar trauma; however, continues to be one of the most controversial areas in the spine trauma care despite the high incidence of these injuries and extensive published research.

Patients and Methods

This study initially included 32 patients with single level traumatic TLF with or without neurological deficit with age group between 15 and 60 years between duration of May 2009 and December 2010.

Mode of injury in these patients was fall from height such as fall from swing (1 patient), fall from tree (4 patients), and fall from terrace (19 patients). Other modes of injury were fall of heavy weight on back of patients (4 patients) as well as fall in ditches (4 patients).

Patients with osteoporotic or pathological thoracolumbar vertebral fractures, traumatic spondylolisthesis, uncooperative, and not willing to consent were excluded from the study. Any patient with comorbidities such as cardiac diseases (coronary artery disease), respiratory diseases (restrictive lung disease), and diabetes mellitus contraindicating surgery was also excluded from the study. Clinical history and thorough physical examination was done for each patient and details of patients including age and occupation were recorded. Appropriate radiological investigations such as anterior-posterior and lateral view radiograph of affected segment of spine in lying down position were undertaken for each patient in pre-, post-operative, follow-up period. Clinically patients were classified pre and post operatively according to American Spinal Injury Association (ASIA) scoring of neurological deficit. Benefits and risks of surgery and non-operative treatment were explained to each patient. Patients who gave informed written consent for surgery were treated with short-segment fixation of the vertebrae above and below the fracture level. The surgeries were done general anesthesia with patient in prone position. All patients had received intravenous cefazolin (1 g) and amikacin (500 mg) pre-operatively. Surgery was done through standard posterior midline approach. SSPI without bone grafting was performed in all the patients. All operations were performed with image intensification to help evaluate the accuracy of the reduction. Titanium polyaxial pedicle screws were used. Once pedicle screws were inserted, connecting rods were attached, and contoured according to dorsal kyphosis or lumbar lordosis. Decompression of canal was achieved indirectly by distraction during posterior instrumentation or directly by exploration of canal by laminectomy through posterior approach. Intraoperative blood loss and duration of surgery was recorded for each patient. Log rolling for 10 min every 2 h was allowed from immediate post-operative period. Sitting was allowed using dorsolumbar orthosis on third post-operative day. Patients were mobilized using wheelchair or patients were allowed to walk with support depending upon neurological status. The stitches were removed after an average of 12^{th} post-operative day. All patients were discharged from the hospital once stitches were removed and patients were ambulated with wheelchair or crutches. Patients were instructed to wear orthosis while in sitting or walking position for first 3 months and orthosis were gradually weaned off over next 3 months.

Clinically and radiographically patients were followed in immediate post-operative period, and then, at 6 weeks, 3 months, 6 months, 12 months, 24 months, 36 months, and up to final follow-up of maximum of 55 months. Clinically back pain and neurological status were assessed using Denis *et al* pain scale [16] and ASIA scoring, respectively.

Denis pain scale

Score pain	Scale criteria
1	No pain
2	Minimum pain, without use of medication
3	Moderate pain, with occasional use of medication
4	Moderate to severe pain, with constant use of medication
5	Severe pain, with chronic use of medication

The radiographic findings in pre-, post-operative, and follow-up period were done by anterio-posterior and lateral radiograph using following parameters.

1. Sagittal index: Local kyphotic deformity minusbaseline sagittal curve at level of fracture [17].
2. Sagittal plane kyphosis: Measured between inferior endplate of injured segment and superior end plate of upper vertebral body [17].
3. Anterior body compression: [(a+c)/2]-b/[(a+c)/2] [17, 18].

Where,
a = anterior height of superior normal vertebra
c = anterior height of inferior normal vertebra
b = anterior height of injured vertebrae.

4. Vertebral kyphosis: Measured between superior end plate and inferior end plate of injured vertebrae [17].
5. Regional kyphosis: Measured between inferior end plate of superior vertebra and superior end plate of inferior normal vertebra [17].

During follow-up period, implant was also looked for any breakage, hardware failure in the form of bending or breaking.

Statistical analysis was done using paired t-test for SI, ABC, VK, and Wilcoxon test for SPK and RK using software SPSS 17.0 Chicago, USA. The $p < 0.05$ was considered to be significant.

Results

A total of 32 patients were included in this study, out of which one patient had died 6 months after the surgery due to unrelated cause and one patient was lost to follow-up after 3 months of surgery. The results of these two patients were excluded from the study. Mean age of the patients were 31 years (range 15-45 years). 19 patients were male (67.33%) while 11 (36.67%) patients were female. The most common mode of injury was fall from height (28 patients, 93%) followed by fall of weight on the back. 70% of the patients sustained injuries at D12 and L1 vertebral level (Table 1). Out of 30 patients, one each patient had head injury, fractured ribs, pelvic fracture, and urethral injury for which they were managed conservatively.

Table 1: Fracture distribution according to level

Vertebral level	*n* (%)
D8	2 (6.67)
D9	1 (3.33)
D10	0 (0)
D11	1 (3.33)
D12	10 (33.33)
L1	11 (36.67)
L2	4 (13.33)
L3	1 (3.33)

D: Dorsal vertebrae, n: Number, L: Lumbar vertebrae

All the patients were followed up to 40-55 months with an average of 45.8 months. Patients were operated with an average of 5.96 days after injury (range 3-12 days). Average operative time was 90.3 min (range from 60 to 125 min) and blood loss averaged 148.6 ml (range from 80 to 250 ml).

Descriptive statistics summarizing radiological parameters is described in Tables 2 and 3.

An improvement in sagittal index of 3.57° ($P < 0.01$) post-operatively with loss of approximately 1.07° at final follow-up thus showing a overall 2.5° ($P < 0.01$) correction in sagittal index.

An improvement in anterior body compression of 0.137 ($P < 0.01$) post-operatively with loss of 0.01 at final follow-up thus showing overall 0.127 ($P < 0.01$) correction in anterior body correction at final follow-up.

Table 2: Summary of radiographic parameters

Radiographic parameters	Pre-operative mean±SD	Post-operative D1 mean±SD	*P* value	Final follow up mean±SD	*P* value
SI	14.8±6.272	11.23±5.315	<0.01	12.3±5.472	<0.01
ABC	0.377±0.836	0.24±0.084	<0.01	0.25±0.083	<0.01
VK	13.9±6.261	10.10±4.397	<0.01	11.43±4.876	<0.01
SPK	22.57±5.624	16.23±4.833	<0.01	17.23±5.171	<0.01
RK	15.23±9.8	10.67±10.022	<0.01	12.33±9.935	<0.01

ABC: Anterior body compression, ASIA: American spinal injury association, P-op D1: Post-operative day 1, Pre-op: Pre-operative, RK: Regional kyphosis, SD: Standard deviation, SI: Sagittal index, SPK: Sagittal plane kyphosis, VK: Vertebral kyphosis

Table 3: Mean of different radiological parameters and neurological status at pre-operative and follow-up

	Pre-operative	P-op D1	P-op 6 weeks	P-op 3 month	P-op 6 month	P-op 1 year	P-op 2 year	P-op 3 year	Final follow up	Improvement at final follow up
Radiological parameters										
SI	14.8	11.23	11.57	11.83	12.30	12.30	12.25	12.20	12.20	2.5
SPK	22.57	16.23	16.47	16.93	17.23	17.23	17.11	17.03	17.03	5.34
ABC	0.38	0.24	0.24	0.24	0.25	0.25	0.26	0.27	0.28	0.127
VK	13.90	10.10.	11.07	11.33	11.43	11.45	11.45	11.49	11.50	2.47
RK	15.23	10.67	11.90	12.33	12.33	12.35	12.37	12.40	12.40	3
ASIA frequency										
A	10	10	10	10	10	10	10	10	10	
B	10	10	5	5	5	5	4	4	4	
C	5	5	8	8	8	8	9	9	9	
D	2	2	3	3	1	1	1	1	1	
E	3	3	4	4	6	6	6	6	6	
Total	30	30	30	30	30	30	30	30	30	

ABC: Anterior body compression, ASIA: American spinal injury association, P-op: Post-operative, P-op D1: Post-operative day 1, Pre-op: Pre-operative, RK: Regional kyphosis, SI: -Sagittal index, SPK: Sagittal plane kyphosis, VK: Vertebral kyphosis

Table 4: Frequency of fractures according to Denis classification

Denis classification	*n*
Compression fracture	15
Burst fracture	
A	4
B	10
C	0
D	0
E	0
Seat belt injury	0
Fracture dislocation	1

Table 5: Denis pain scale on follow-up

Grade	P-op 6 month	P-op 1 year	P-op 2 years	P-op 3 years	Final follow-up
1	13	14	14	14	14
2	10	09	10	09	09
3	07	07	06	07	07
4	0	0	0	0	0
5	0	0	0	0	0

P-op: Post-operative

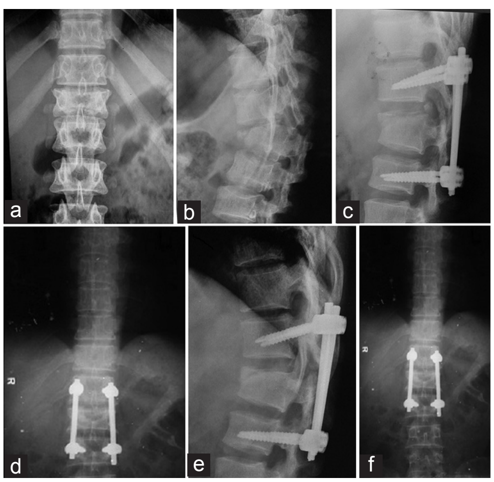

Figure 1: (a) Anterior-posterior radiograph of lumbar spine showing fracture of lumbar 1 vertebrae showing compression fracture, (b) lateral radiograph of lumbar spine showing fracture of lumbar 1 vertebrae showing compression fracture, (c) anterior-posterior radiographic view at post-operative day 1 of lumbar spine showing implant fixation in D12 and L2 vertebrae and deformity correction, (d) lateral view radiographic view at post-operative day 1 showing implant fixation in D12 and L2 vertebrae and deformity correction, (e) lateral view of same fracture at 41 months of follow-up showing fracture union, (f) anterior posterior radiographic view of same fracture at 41 months of follow-up.

An improvement in vertebral kyphosis is of 3.8° ($P < 0.01$) with loss of correction of 1.33° at final follow-up thus showing overall 2.47° ($P < 0.01$) correction in vertebral kyphosis.

An improvement in sagittal plane kyphosis is of 6.57°($P < 0.01$) with loss of correction of 1.0° at final follow-up thus showing overall 5.34° ($P < 0.01$) correction in sagittal plane kyphosis.

This study shows an improvement in regional kyphosis is of 4.56° ($P < 0.01$) post-operatively with loss of approximately 1.66° at final follow-up thus showing overall 3° ($P < 0.01$) correction in regional kyphosis.

10 patients had ASIA Grade A neurological status, who did not improve post-operatively. 10 patients having ASIA Grade B status, six patients improved and other four had same neurological status in follow-up. Four of the six patients who improved, progressed to Grade C and two to Grade E. None of the patient from Group C improved. One patients of Grade D also progressed to Grade E and the other remained same (Table 3).

There were 15 compression fractures (Table 4) and majority of patients were in grade 1 of Denis pain scale at final follow-up (Table 5). Radiographs of a patient with fracture of Lumbar 1 vertebrae after injury, after surgery, and at follow-up is shown in Fig. 1a - 1f.

There was no superficial or deep wound infection and neurological deterioration due to surgery. There was no deep vein thrombosis observed in any patient. There was no progressive kyphosis observed in any patient. Three patients had loosening of screws at around 36 months of follow-up which presented as back pain. These patients denied revision surgery and were managed conservatively till the last follow-up. There was no screw bending or breakage observed in any patient.

Discussion

The aim of management of vertebral fractures is to achieve early neurological restoration, overcome damaged spinal segments, and achieve stable fixation of spinal segments for early rehabilitation [19].

In our study, majority of the patients were young males with fall from height being the most common cause of injury. Our study showed that after an initial correction there was a gradual partial loss of correction, may due to loss of disc height, leaving an overall regional kyphosis correction of 3°. This loss of initial correction has been reported by other studies who have routinely performed in spine surgery [20, 21].

Our mean follow-up was 45 months, and it remains to be seen whether there is progression of deformity or not. Our study showed screw loosening in three patients (10%). However, pedicle screws can break even in presence of fusion. Study by Carl *et al.* showed 9 implant failure out of 38 patients (23%) and study by Esses *et al.* showed 4 implant failure out of 44 patients (9%) [21, 22]. We have removed pedicle instrumentation in two patients who had discomfort because of screw loosening. Other patients were not willing for implant removal and some did not turn up for implant removal may be because of poor socioeconomic status.

The main advantages of SSPI are that it preserves the spinal motion segments and is simple and familiar to spine surgeons with a low learning curve. Bone grafting using either anterior or posterior using autologous iliac crest, titanium mesh cages filled with cancellous bone, autologous ribs is often performed as an adjunct to spinal fixation. Here by, bone grafting we mean autologous corticocancellous posterior iliac crest bone grafting. Autologous bone grafting using iliac crest is generally considered as gold standard, and it increases the chances of spinal fusion with negligible risk of disease transmission compared to other alternatives. However, there are several advantages in not performing fusion such as reduced surgery time and blood loss often in patients who are critically injured [10]. Bone grafting is not without complications and is associated with donor site complications, such as pain related to bone harvesting and infection. Frymoyer *et al.* in a long-term study reported that 37% of the patients identified donor site pain as a problem 10 or more years after operation [11]. Another potential advantage of not performing bone grafting is that the facet joints adjacent to the fracture are less disturbed because surgical soft tissue stripping required to prepare bone graft bed is no longer needed [10]. In a recent prospective randomized study, Alanay *et al.* found no difference in the failure rates of short-segment pedicle screw constructs supplemented with transpedicular intracorporeal bone graft compared with the constructs without graft [12].

Previously posterior instrumentation with fusion versus posterior instrumentation alone was compared in three trials [13, 14, 15]. Long- and short-segment fixation was performed in these studies. All these authors found no differences between posterior instrumentation with and without bone graft in terms of function and quality of life or spinal pain. There was no decline in neurological status in any of the three studies. However, two-thirds of individuals in the fusion group of Dai *et al*. and nearly one-quarter of those in Wang *et al*. had long-term donor site pain. Based on these findings recent Cochrane review suggest in the absence of good evidence to support fusion, it is important to consider the factor of long-term donor site morbidity related to bone harvesting in deciding whether to use it or not [23].

Some authors advocate posterior decompression of vertebrae, interlaminar fusion along with posterior short-segment fixation which provides excellent reduction for segmental kyphosis, significant spinal canal clearance, and restored vertebral body height in the fracture level inpatients [24]. Lee *et al*. demonstrated that short-segment fixation without posterolateral fusion is an effective procedure for compression and burst fractures which contribute to the fractured vertebral body compression without recollapse and maintains the motion segment function [25].

This study is limited by its small sample size, mid-term follow-up, not being randomized, and without any control group (fusion group) thus being a low evidence study.

Clinical relevance

The results of this study have shown good radiological and clinical results with SSPI without bone grafting. However, a randomized study with a control group and large sample size and longer follow-up will be required to strengthen the results obtained in SSPI without bone grafting.

Clinical Message

Bone grafting and fusion may not be required with short segment posterior pedicle instrumentation.

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