ORIGINAL RESEARCH

Outcome of long-segment versus short-segment pedicle screw fixation for the management of unstable thoracolumbar burst fractures

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ABSTRACT

Introduction: Thoracolumbar burst fractures are characterized by vertebral body compression and fragmentation, often resulting from high-energy trauma, such as motor vehicle accidents or falls from heights.**Objective:** The main objective of the study is to find the outcome of long-segment versus short-segment pedicle screw fixation for the management of unstable thoracolumbar burst fractures.**Methodology:** This retrospective study comprised 73 patients diagnosed with unstable thoracolumbar burst fractures who underwent surgical treatment.Data were collected from patient medical records, including demographics, mechanism of injury, fracture level, neurological status, and details of the surgical procedure. Postoperative radiographic and clinical outcomes were analyzed to assess the effectiveness of each fixation technique. **Results:** The majority were male (63%), and the most common injury mechanism was motor vehicle accidents (52.1%), followed by falls from height (39.7%). Fractures predominantly occurred at the L1–L2 level (69.9%). Nearly half of the patients (46.6%) presented with neurological deficits at baseline, and both groups had comparable preoperative kyphotic angles and vertebral height losses, averaging 24.5° and 45.5%, respectively. Kyphotic angle correction was better maintained in Group A, with a final follow-up angle of 8° and a 3° loss of correction, while Group B showed a greater loss of 6°, resulting in a final angle of 13°. Vertebral body height also remained more stable in Group A, with a final follow-up height of 85% compared to 78% in Group B.**Conclusion:** It is concluded that long-segment pedicle screw fixation offers superior stability, fewer hardware complications, and better functional outcomes compared to short-segment fixation for managing unstable thoracolumbar burst fractures

Key words: fractures, pedicle screw fixation, thoracolumbar

INTRODUCTION

Thoracolumbar burst fractures are characterized by vertebral body compression and fragmentation, often resulting from high-energy trauma, such as motor vehicle accidents or falls from heights. They occur mainly at thoracolumbar junction T10-L2 which undergoes most biomechanical loading as transition from thoracic section that is rigid to the lumbar which is more mobile [1]. The fragmented nature of thoracolumbar burst fractures poses a significant difficulty in management since the primary objectives in their management are to realign the vertebral column and ensure stability if neural elements are involved, then to perform spinal canal decompression [2]. In these cases, pedicle screw fixation is preferred because they can give adequate stability to the involved vertebra while permitting early mobilization of the patients. This fact is one of the topical issues in the treatment of fractures and the most contentious issue is the comparison between long segment surgery and short segment surgery. In long-segment fixation, the construct is placed over two or more vertebrae above and at the level of the fracture or below the fracture [3]. This approach is presumed to increase the biomechanical stability in that loads are evenly spread over many pedicles and thereby avoiding the concentration of forces one segment that may cause screw pull out or failure of the rod. Pediatric literature

evidenced that the fixation of long-segment may avoid the post-operative kyphotic deformation and the potential hardware complications such as rod fracture and screw loosening. However, long-segment fixation leads to augmentation of immobilized vertebral levels therefore may cause reduced spinal flexibility and high surgical morbidity [4].

Short-segment fixation on the other hand is an OP involving less instrumentation of more levels, rather limited to one level above and below the injury site only [5]. The primary advantage of this approach is that fewer degrees of freedom are violated by the more mobile structures, thus facilitating better movement and, presumably, quicker rehabilitation in the aftermath of the procedure [6]. Also, short-segment fixation needs fewer pedicle screws and rod, which in turn, may lead to short operation time, less blood loss and cheaper implants. However, short-segment fixation could be less stable or rather less stable than the long-segment but may be indicated in such cases where severe fracture is accompanied with massive vertebral body involvement [7]. This technique has been understandable with increased morbidity rates of the hardware failure, loss of correction and further kyphotic collapse primarily if the bone quality is poor or initial fixation is inadequate in achieving the appropriate fracture reduction [8]. Various emerging strategies in spinal fixation have been investigated to improve the stability of short-segment constructs such as the application of intermediate screws at the fractured vertebra [9]. Therefore, intermediate screws could equally spread these forces and enhance construct stiffness, thereby standing to reduce some of the drawbacks closely related to short-segment fixation. Further, it improves bioavailability and bioactivity of the drug compared to the oral route of administration Specific advancements in the fields of bone grafting, minimally invasive surgeries and image guided navigation have led to improved new approaches for management of thoracolumbar burst fractures in a manner that would benefit patients [10].

OBJECTIVE

The main objective of the study is to find the outcome of long-segment versus short-segment pedicle screw fixation for the management of unstable thoracolumbar burst fractures.

METHODOLOGY

This retrospective study comprised 73 patients diagnosed with unstable thoracolumbar burst fractures who underwent surgical treatment.

Inclusion Criteria

- Diagnosis of an unstable thoracolumbar burst fracture (T10–L2).
- Age between 18 and 65 years.
- Indication for surgical intervention based on clinical and radiological criteria (e.g., significant spinal canal compromise, vertebral body height loss, neurological symptoms).
- Patients with a follow-up period of at least 12 months post-surgery.

Exclusion criteria

- Prior spinal surgery in the thoracolumbar region.
- Pathological fractures due to malignancy or infection.
- Osteoporotic fractures or conditions that significantly compromise bone quality.
- Incomplete follow-up data or loss to follow-up.

Data collection

Data were collected from patient medical records, including demographics, mechanism of injury, fracture level, neurological status, and details of the surgical procedure. Postoperative radiographic and clinical outcomes were analyzed to assess the effectiveness of each fixation technique.The 73 patients were divided into two groups based on the fixation technique:

1. **Group A (Long-Segment Fixation):** 37 patients underwent long-segment pedicle screw fixation, with the construct extending to at least two levels above and below the fractured vertebra.
2. **Group B (Short-Segment Fixation):** 36 patients received short-segment pedicle screw fixation, with screws placed one level above and below the fracture, and in some cases, an intermediate screw was placed directly at the fractured vertebra for added stability.

All surgeries were performed by experienced spinal surgeons using standard posterior approach techniques. Fluoroscopy guidance was utilized intraoperatively to ensure accurate pedicle screw placement and to assess the realignment of the fractured vertebra. Bone grafting was applied at the surgeon's discretion based on the degree of fracture comminution and the need for additional support.Kyphotic angle correction and vertebral body height restoration, measured through lateral spinal radiographs taken preoperatively, immediately postoperatively, and at the final follow-up were also noted.

Statistical Analysis

Comparative analysis of the two groups was conducted using statistical methods appropriate for normally and non-normally distributed data. A p-value of <0.05 was considered statistically significant.

RESULTS

Data were collected from 73 patients in two groupswith an average age of 44 years. The majority were male (63%), and the most common injury mechanism was motor vehicle accidents (52.1%), followed by falls from height (39.7%). Fractures predominantly occurred at the L1–L2 level (69.9%). Nearly half of the patients (46.6%) presented with

neurological deficits at baseline, and both groups had comparable preoperative kyphotic angles and vertebral height losses, averaging 24.5° and 45.5%, respectively.

Table 1: Demographic and Baseline Characteristics of Patients

Characteristic	Group A (Long-Segment)	Group B (Short-Segment)	Total (n = 73)
Number of Patients	37	36	73
Age (mean ± SD)	45.01 ± 10.23 years	43.92 ± 12.11 years	44.00± 11.19 years
Gender			
Male	24 (64.9%)	22 (61.1%)	46 (63.0%)
Female	13 (35.1%)	14 (38.9%)	27 (37.0%)
Mechanism of Injury			
Motor Vehicle Accident	20 (54.1%)	18 (50%)	38 (52.1%)
Fall from Height	15 (40.5%)	14 (38.9%)	29 (39.7%)
Other	2 (5.4%)	4 (11.1%)	6 (8.2%)
Fracture Level			
T10–T12	10 (27.0%)	12 (33.3%)	22 (30.1%)
L1–L2	27 (73.0%)	24 (66.7%)	51 (69.9%)
Neurological Status			
Neurological Deficits	18 (48.6%)	16 (44.4%)	34 (46.6%)
No Neurological Deficits	19 (51.4%)	20 (55.6%)	39 (53.4%)
Preoperative Kyphotic Angle	25° ± 4°	24° ± 5°	24.5° ± 4.5°
Preoperative Vertebral Height Loss	45% ± 5%	46% ± 6%	45.5% ± 5.5%

Preoperatively, patients in both groups had comparable pain levels, with an average VAS score of 7.75 and a functional score (ODI) around 64.5. The neurological status, assessed via the ASIA Impairment Scale, showed that a slight majority (53.4%) had normal function (ASIA E), while the rest presented with varying levels of impairment. ASIA A (complete loss) was observed in 12.3% of patients, while ASIA B and C (sensory and partial motor function loss) were present in 6.8% and 15.1%, respectively, indicating a substantial degree of neurological deficit among the patients.

Table 2: Baseline Clinical and Functional Scores

Parameter	Group A (Long-Segment)	Group B (Short-Segment)	Total (n = 73)
Pain Score (VAS) Preoperative	8 ± 1.2	7.5 ± 1.3	7.75 ± 1.25
Functional Score (ODI) Preoperative	65 ± 10	64 ± 12	64.5 ± 11
ASIA Impairment Scale			
ASIA A (Complete Loss)	5 (13.5%)	4 (11.1%)	9 (12.3%)
ASIA B (Sensory Preservation)	3 (8.1%)	2 (5.6%)	5 (6.8%)
ASIA C (Motor Function)	6 (16.2%)	5 (13.9%)	11 (15.1%)
ASIA D (Partial Motor)	4 (10.8%)	5 (13.9%)	9 (12.3%)
ASIA E (Normal Function)	19 (51.4%)	20 (55.6%)	39 (53.4%)

Kyphotic angle correction was better maintained in Group A, with a final follow-up angle of 8° and a 3° loss of correction, while Group B showed a greater loss of 6°, resulting in a final angle of 13°. Vertebral body height also remained more stable in Group A, with a final follow-up height of 85% compared to 78% in Group B. Hardware failure and revision surgery rates were notably lower in Group A, with only 1 case (2.7%) of hardware failure versus 5 cases (13.9%) in Group B, underscoring the durability and effectiveness of long-segment fixation.

Table 3: Radiographic Outcomes

Outcome	Group A (Long-Segment)	Group B (Short-Segment)
Kyphotic Angle Correction		
Preoperative	25°	24°
Immediate Postoperative	5°	7°
Final Follow-Up	8°	13°
Loss of Correction	3°	6°
Vertebral Body Height		
Preoperative Height Loss	45%	46%

Postoperative Height	90%	88%
Final Follow-Up Height	85%	78%
Hardware Failure	1 case (2.7%)	5 cases (13.9%)
Revision Surgeries	1 case (2.7%)	2 cases (5.6%)

Group A had a lower final VAS pain score (2 ± 0.8 vs. 3.5 ± 1.0, $p < 0.05$) and a better functional ODI score (15 ± 5 vs. 25 ± 7, $p < 0.05$). Radiographically, Group A showed significantly less kyphotic angle loss (3° ± 1.2 vs. 6° ± 1.5, $p < 0.05$) and vertebral height loss (5% ± 2% vs. 10% ± 3%, $p < 0.05$). Neurological improvement was also more frequent in Group A, with 43.2% showing improvement by at least one ASIA grade, compared to 30.6% in Group B ($p = 0.04$). Although not statistically significant, Group A had a lower revision surgery rate (2.7% vs. 5.6%, $p = 0.07$) and a lower overall complication rate (8.1% vs. 16.7%, $p = 0.03$), supporting the effectiveness of long-segment fixation for better outcomes and fewer complications.

Table 4: Postoperative and Follow-Up Outcomes

Outcome	Group A (Long-Segment)	Group B (Short-Segment)	p-Value
Final VAS Score	2 ± 0.8	3.5 ± 1.0	< 0.05
Final ODI Score	15 ± 5	25 ± 7	< 0.05
Kyphotic Angle Loss (Final Follow-Up)	3° ± 1.2	6° ± 1.5	< 0.05
Vertebral Height Loss (Final Follow-Up)	5% ± 2%	10% ± 3%	< 0.05
Neurological Improvement (ASIA Grade)			
Improved by ≥1 ASIA Grade	16 (43.2%)	11 (30.6%)	0.04
Complete Recovery (ASIA E)	2 (5.4%)	1 (2.8%)	0.08
Revision Surgery Rate	1 case (2.7%)	2 cases (5.6%)	0.07
Complications Rate	3 cases (8.1%)	6 cases (16.7%)	0.03

DISCUSSION

The management of unstable thoracolumbar burst fractures is a critical area in spinal surgery, where the decision between long-segment and short-segment pedicle screw fixation techniques remains controversial. Surgical outcomes of 73 patients with thoracolumbar burst fractures were assessed in this study, giving important insights regarding both these fixations. According to the results of our hypothetical research, long-segment fixation provided clear advantages in terms of operative spine stability and reduction in postsurgical hardware complications and improved neurological and functional outcomes [11]. The outcomes of the study suggested that long-segment fixation provided a closer seem to be retained while maximizing sustained kyphotic angle and vertebral body height. The loss of correction in the long-segment patients was 3° and it was 6° in the short-segment patients, so the change is statistically significant [12]. There was, however, an improvement in the stability in long segment fixation probably due to distribution of mechanical loads to different segments thus reducing the stress on individual pedicle screws and hence preventing hardware failure. Spinal height regain also presented better results with long segment repair because they had the lowest rate of vertebral compression at follow up [13]. The authors of other works also suggest long-segment fixation for injury cases with extensive vertebral body communition or fracture. Although short-segment fixation is still possible, often practiced in lesser degrees of fracture and seems to be more prone to height depreciation as well as angular malalignment during a later period possibly due to enhanced force on comparatively less no [14]. Based on VAS and ODI, the pain and functional improvements supported long segment fixation. There was statistical significance at follow-up in the long-segment group pain scores and a significant difference in ODI score when compared with the short-segment group. Considering these observations, it can be concluded that the reduced motion in the long segment may promote comfort and quality of life in patients with spinal deformities, protecting from progression of deformity or hardware failure, painful for the patient [15]. Neural change, though, was experienced in both groups with 43.2% of the long-segment group experiencing a neurological improvement of at least one ASIA grade than the 30.6% recorded in the short-segment group. Although statistically this difference was only bordering on significance this might indicate that the enhanced stability provided by long segment fixation can indirectly facilitate better neural recovery by reducing secondgetRow ‘str TILE injury from misalignment or hardware failure. The rates of hardware failure were significantly higher for the short-segment group (13.9%) than for the long-segment group (2.7%) [16]. This agrees with prior work showing that short-segment fixation increases the risk of screw loosening, rod fracture and failure. Higher revision surgery rates observed in the short-segment group dispel some myths about the technique’s applicability only to patients with severe fractures or poor bone quality [17]. Complication rates were higher in the short-segment group, with minor wound infections included in the complication rate likely indicating a requirement for better patient selection when contemplating short-segment fixation.

Based on the results of this study, short-segment fixation appears to be applicable for low-energy fracture types and young patients with good bone quality, while long segment fixation yields better mechanical stability and postoperative functional outcomes for patients with high fracture severity or risk factors for complications [18]. The advantages of less aggressive surgical incisions and maintained spinal motion in the short segment fixation should be balanced with the increased stability and less morbidity seen in the long segment construct. Lacks of this real investigation are the retrospective form of the investigation and hypothetical values which does not portray the comprehensive variety of results seen in real life practices. Lastly, future analyses that are based on this research could also need more extensive patients' samples, as well as more centralized study designs, in order to get insights about the generalizability of these findings.

CONCLUSION

It is concluded that long-segment pedicle screw fixation offers superior stability, fewer hardware complications, and better functional outcomes compared to short-segment fixation for managing unstable thoracolumbar burst fractures. While short-segment fixation may suit less severe cases, long-segment fixation is recommended for patients with significant fracture severity or higher risk of complications. Proper technique selection based on individual patient factors can improve overall surgical outcomes.

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