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Original Article

Short segment posterior fixation of unstable thoracolumbar vertebral fractures with fractured vertebra augmentation with intermediate pedicle screw - a clinicoradiological analysis

Sandeep Kumar Yadav, Rajesh Kumar Rajnish, Prabodh Kantiwal, Nitesh Gehlot, Abhay Elhence, Sumit Banerjee, Saurabh Gupta, Laxman Choudary, Anil Meena, Srikanth Eppakayala

Department of Orthopedics, All India Institute of Medical Sciences (AIIMS), Jodhpur, Rajasthan, India

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Abstract: Introduction: Unstable thoracolumbar burst fractures are routinely encountered in orthopedic practice. Recently, short-segment fixation with pedicle screw augmentation of the fractured vertebra for unstable thoracolumbar burst fractures has gained popularity. Nonetheless, the maintenance of the kyphotic correction during the follow-up period remains controversial. This study aimed to examine the clinical-radiological outcomes, complications, and functional outcomes of fractured vertebrae augmentation with intermediate pedicle screws in short-segment instrumentation in acute thoracolumbar spine fractures. Methods: This retrospective study was conducted in the Department of Orthopedics, All India Institute of Medical Sciences, Jodhpur, using medical records from January 2021 to October 2022. Parameters such as local kyphosis correction, loss of kyphotic correction at final follow-up, anterior body height correction (%), and loss of correction (%) at final follow-up were measured as primary outcomes. Various other parameters such as operative time, blood loss, length of hospital stay, and visual analog scale were measured as secondary outcomes. Results: The mean correction obtained via surgery in the immediate postoperative period was 13.7±2.3 degrees. The mean loss of correction at the final follow-up was 4.1±2.0 degrees, and the mean final local kyphotic angle was 7.2±2.4 degrees ($P<0.05$). The mean correction obtained via surgery in the immediate postoperative period was 37.2%±9.0%. The mean loss of correction at the final follow-up was 10.5%±5.3%, and the mean final anterior vertebral body height maintained was 72%±11.0% ($P<0.05$). Conclusion: Short-segment posterior fixation with pedicle screw augmentation achieves good correction of local kyphotic angle and anterior vertebral height in the immediate postoperative period, but some loss of correction at final follow-up is common. In our study, the loss of correction corresponded directly to the load-sharing score.

Keywords: Spine fractures, fall from height, vertebral fractures, intermediate screw, kyphotic angle, pedicle screw augmentation

Introduction

One of the most prevalent and troubling issues in orthopedic practice is spinal trauma. Of all spinal injuries, 67%-80% are thoracolumbar fractures [1]. Owing to variations in mobility between the thoracic and lumbar spine regions, the transitional zone between them suffers huge biomechanical pressures after traumatic occurrences, rendering it vulnerable to fractures.

A typical thoracolumbar fracture type is the burst fracture. It happens when the axial force causes the anterior and middle columns to fail. All unstable burst fractures require surgical stabilization. In terms of biomechanics, an unstable burst fracture is one in which the anterior vertebral body height has decreased by >50%, the kyphotic angle has increased by >20%, or the canal has been compromised by >50% [2].

The posterior approach to the spine is preferred by surgeons as the anterior approach is associated with high morbidity, invasiveness, and several technical variations. Better correction rates and less loss of correction post-surgery have

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been observed in long-segment posterior fixation. However, this method has its disadvantages, including increased surgical time, higher blood loss, and loss of more motion segments [3]. The conventional four-screw short-segment posterior instrumentation involves the instrumentation of both pedicles immediately proximal and distal vertebrae adjacent to the fractured vertebra. This technique has gained popularity over the past three decades; however, Mclain et al. and a few other researchers have reported a significant rate of early implant failure and loss of correction [4-6]. Short-segment fixation with pedicle screw augmentation of the fractured vertebra has gained acclaim as this technique has reduced the operative time and blood loss, and achieved local kyphotic angle correction, and its outcomes are comparable to that of transpedicular grafting [7].

However, certain studies have reported that short-segment posterior fixation with pedicle screw augmentation achieved good correction of the local kyphotic angle in the immediate postoperative period but the correction was not maintained in the long-term. Other studies have documented that the local kyphotic angle correction was not significantly lost [8-12]. There exists a controversy in the current literature regarding the maintenance of kyphosis correction in the follow-up period.

Therefore, this study aimed to examine the clinical-radiological outcomes, complications, and functional outcomes of fractured vertebrae augmentation with intermediate pedicle screws in short-segment instrumentation in acute thoracolumbar spine fractures.

Materials and methods

This retrospective study was conducted in the Department of Orthopedics, All India Institute of Medical Sciences, Jodhpur, using medical records from January 2021 to October 2022 after obtaining institutional ethics committee approval (AIIMS/IEC/2023/4798). Cases meeting the inclusion criteria and with a follow-up period of at least 1 year were included in this study. All patients were evaluated with radiographs, computed tomography (CT), and magnetic resonance imaging (MRI) after admission. AO spine injury classification system was used to classify the type of fracture and load sharing classification by Mc Cormack et al. was used to calculate Load sharing score [13, 14].

Of the total 74 patients operated on for thoracolumbar burst fractures in the institute, 30 patients met our inclusion criteria. Inclusion criteria: (a) patients with single-level type-A3 and A4 burst fractures according to the AO spine injury classification system; (b) patients with fractures involving the level between T11 and L3; (c) patients who had undergone the procedure in the form of short-segment posterior fixation with pedicle screw augmentation; (d) patients who had at least 1 year of follow-up with radiographic evaluation. Exclusion criteria: Patient with (a) pre-op or post-op infection; (b) degenerative disc disease; (c) fractures in both pedicles; (d) loss of follow-up.

Surgical technique

All procedures were performed by two senior surgeons. A standard posterior midline approach was used. One vertebra above and one below the fractured vertebra were exposed to the transverse process on either side. Pedicle screws were inserted into the vertebrae proximal and distal to the fractured vertebra, and the intermediate pedicle screw was inserted into the pedicles of the fractured vertebra using a free-hand technique. However, if one of the pedicles was broken, only one screw was placed in the other intact pedicle. Reduction of kyphosis was achieved or vertebral height was reduced using a rod over contouring or distraction. In the case of fractures with neurologic deficits, a decompressive laminectomy was performed. The degree of kyphosis correction and the positions of the screws were assessed using postoperative radiographs. All patients were periodically followed up with clinical and radiological evaluations. Radiographs were acquired at 3, 6, 9, and 12 months after the surgery.

Postoperative assessment

At each follow-up, various parameters such as local kyphosis correction, loss of kyphotic correction at final follow-up, anterior body height correction (%), and loss of correction (%) at final follow-up were measured as primary outcomes. Local kyphotic angle was measured using Cobb's method i.e., tangential lines drawn from the superior endplate of the cephalic intact vertebra to the inferior endplate of the caudal intact vertebra (**Figure 1**). The percentage of the anterior body height of the fractured verte-

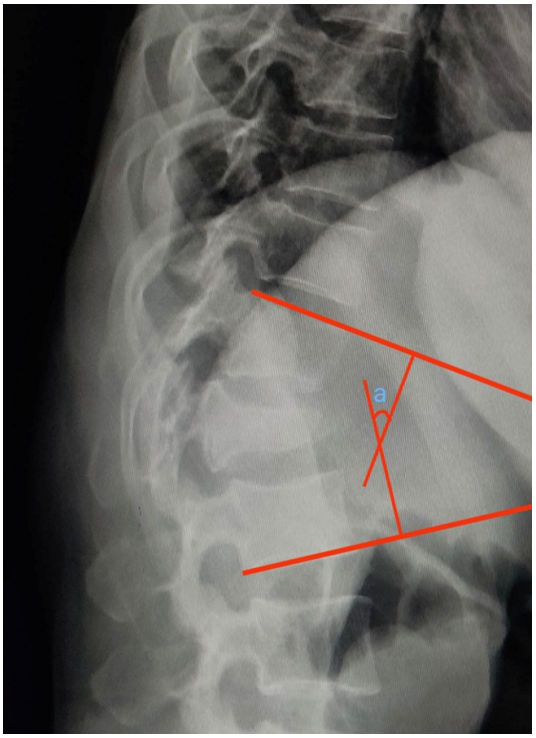

Figure 1. The Cobb's method of kyphotic angle measurement.

bra was calculated as the anterior vertebral body height of the fractured vertebra divided by the average of the anterior vertebral body heights of vertebrae immediately above and below it. Various other parameters such as operative time, blood loss, length of hospital stay, and visual analog scale (VAS) for pain were measured as secondary outcomes.

Data analysis

Data were processed and analyzed using statistical software SPSS version (v 28.0.1.1) IBM Inc., with a *p*-value of <0.05 set to be significant. Continuous variables were reported as mean ± standard deviation and compared using the student's 't' test or Wilcoxon signed rank test based on the type of data obtained.

Results

Demographic details

The mean age of the patients was 37.1 years (range: 15-70 years); 21 (70%) were men, and (30%) were women. The average follow-up period was 17.5±5.2 months. Fall from height was the most common cause of injury, and the L1 vertebra was the most commonly involved level. On the preoperative assessment of neurological status using the American Spinal Injury Association Impairment Scale (ASIA scale), 17 patients were ASIA E, 12 patients were ASIA D, and 1 patient was ASIA B. Pelvic fracture followed by calcaneal fracture was the most associated injury in our series. The mean load-sharing classification score was 5.58, the average duration of surgery was 95±21 min, the average blood loss was 136±18 mL, and the average hospital stay was 10.3±3 days. Demographic details of the patients are provided in **Table 1**.

Table 1. Demographic details of the patients

Age	37.1±15.4 years
Gender	Males-21, females-9
Fracture level	
T11	3
T12	7
L1	13
L2	7
L3	0
Load sharing score	
≤6	21
≥7	9
Follow up	17.56±5.2 months
Mechanism of injury	
FFH*	17
RTA**	13
Average hospital stays	10.3±3.15 Days

*FFH-Fall from height; **RTA-Road traffic accident.

Radiographic parameters

The mean preoperative kyphotic angle was 17.0±2.7 degrees, which improved significantly to 3.43±1.1 in the immediate postoperative period (P<0.05). The mean correction obtained via surgery in the immediate postoperative period was 13.7±2.3 degrees. The mean loss of correction at the final follow-up was 4.1±2.0 degrees, and the mean final local kyphotic angle was 7.2±2.4 degrees (P<0.05). The mean preoperative anterior vertebral body height was 47.7%±9.3%, which improved significantly to 82.4%±8.8% in the immediate postoperative period (P<0.05). The mean correction obtained via surgery in the immediate postoperative period was 37.2%±9.0%. The mean loss of correction at the final follow-up was 10.5%±5.3%,

Table 2. Radiological and clinical outcomes

Preoperative kyphotic angle (degrees)	17.0±2.7
Immediate postoperative kyphotic angle (degrees)	3.43±1.1
Final kyphotic angle (degrees)	7.2±2.4
Loss of correction (degrees)	4.1±2.0
Preoperative anterior vertebral body height (percentage)	47.7±9.3
Immediate postoperative anterior vertebral body height (percentage)	82.4±8.8
Final anterior vertebral body height (percentage)	72±11.0
Loss of correction (percentage)	10.5±5.3
VAS score at admission	7.23
VAS score at final follow-up	1.7

and the mean final anterior vertebral body height maintained was 72%±11.0% (P<0.05).

Load sharing classification

In our study, the average kyphotic correction loss was 3.1 degrees in patients with a load-sharing score of ≤6 and 6.2 degrees in those with a score of ≥7, making the difference statistically significant. Similarly, the average correction loss in anterior vertebral body height in patients with a load-sharing score of ≤6 was 7.8%, whereas it was 16.6% in those with a score of ≥7, which was also statistically significant.

Visual analog score

The mean VAS score at admission was 7.2, and at the final follow-up, it was reduced to 1.7. Radiographic parameters and VAS scores are shown in **Table 2**.

Discussion

Long-segment fixation for unstable thoracolumbar burst fractures is an established and preferred method in terms of achieving good kyphotic correction and maintenance of correction, but the construct involves more levels of mobile lumbar vertebra, making it a stiff construct [4, 15]. Conventional four-screw short-segment posterior instrumentation has gained popularity over the past three decades; however, this procedure is associated with a significant rate of early implant failure and loss of correction [4-6]. Mahar et al., in their cadaver-based biomechanical study, proposed instrumenting pedicle screws in the fractured vertebra in short-segment fixation, which permits a three-point reduction of the fractured vertebra and enhances the biomechanical stability of the construct [16]. Multiple clinical studies on short-segment fixation of thoracolumbar burst fractures with pedicle screws in the fractured vertebra have reported clinical outcomes comparable to those of long-segment fixation [10, 11, 17].

In our study, although a significant improvement was observed in the kyphotic angle in the immediate postoperative period, the obtained correction was not maintained at the final follow-up. A significant loss of correction was noted at the final follow-up (P<0.05). Similarly, significant improvement was seen in the anterior vertebral body height during the immediate postoperative period but was not maintained at the final follow-up (P<0.05). These results agree with the findings of Vu et al. [9]. They attributed this loss of correction at the final follow-up to the large bone defect caused by the compression of the cancellous bone in the vertebral body. A similar study published previously by Eno et al. also reported a significant loss of kyphotic correction at the final follow-up, but the absolute loss of correction was relatively small despite being statistically significant and did not affect the clinical outcomes [8]. In another recent retrospective study by Rispoli et al., long-segment posterior fixation and short-segment with intermediate screw fixation for thoracolumbar burst fractures were compared. The study concluded that long-segment fixation has a better ability to maintain the achieved kyphotic correction than short-segment with an intermediate screw at 1-year follow-up [18]. The present study also found that the maintenance of correction depends largely on the degree of comminution at the time of the injury. Furthermore, with pedicle screw instrumenta-

tion, the instantaneous axis of rotation is in the posterior region of the spine. During anterior-posterior bending of the spine, a high load might be applied to the front of the vertebra and the intervertebral disc, thereby leading to the loss of kyphotic correction obtained with ligamentotaxis [19]. However, the results of our study differ from those of El Behairy et al. and Khanna et al., who documented the absence of significant loss of kyphosis or anterior vertebral body height restoration at the 2-year follow-up [12, 21]. In both studies, there was a loss of kyphotic angle correction of approximately 2.4 degrees at the final follow-up.

Interestingly, Xiong et al. introduced the technique of intermediate inclined angle polyaxial pedicle screws in the fractured vertebra in short-segment internal fixation of thoracolumbar burst fractures and compared it with short-segment internal fixation with intermediate straight-forward monoaxial screws and long-segment internal fixation. No significant differences were noted in terms of loss of correction of the kyphotic angle among all three groups, but the loss of correction in anterior vertebral body height was significant in the group of short-segment internal fixation with intermediate straight-forward monoaxial screws compared with the other two groups. The study concluded that short-segment internal fixation with intermediate inclined angle polyaxial pedicle screws in the fractured vertebra could exert greater interface strength on the fractured vertebra and effectively maintain the height of the fractured vertebra compared with short-segment internal fixation with intermediate straight-forward monoaxial screws [20].

McCormack et al. developed the load-sharing classification (LSC) to identify thoracolumbar fractures that require supplemental anterior reconstruction to avoid failure. According to this classification system, anterior vertebral reconstruction is essential in patients with an LSC score of ≥7 to prevent loss of correction or implant failure [14]. In our study, the load-sharing score was correlated with the loss of correction at the final follow-up. This finding agrees with the studies of Atlay et al. and Vu et al., which showed that patients with a higher load-sharing score were more susceptible to loss of correction and late kyphotic deformity [4, 9]. However, our results contrast with the studies of Khanna et al. and El Behairy et al., which concluded that there was no significant loss of kyphotic angle correction or anterior vertebral body height restoration at the 2-year follow-up [12, 21]. The average VAS score at the final follow-up was 1.7 in our study, which is comparable to the study of Khanna et al. in which the average VAS score at the final follow-up was 1.6. Several studies have previously reported that loss of kyphosis correction does not have a significant effect on clinical symptoms [5, 6, 20, 22].

The limitations of this study are the small sample size, lack of a control group, short follow-up period, and its retrospective nature. A prospective study may be planned to identify the maintenance of kyphosis after short-segment posterior fixation of unstable thoracolumbar burst fractures.

Conclusion

Short-segment posterior fixation with pedicle screw augmentation achieves good correction of local kyphotic angle and anterior vertebral height in the immediate postoperative period; however, some loss of correction at final follow-up is common. In our study, the loss of correction corresponded directly to the load-sharing score.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Srikanth Eppakayala, Department of Orthopedics, All India Institute of Medical Sciences (AIIMS), Basni Industrial Area, 2nd Phase, Jodhpur 342005, Rajasthan, India. Tel: +91-7416771640; ORCID: 0000-0002-6159-0732; E-mail: srikanth.e138@gmail.com

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