Original Research Article

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Radiological Comparison of Short-Segment Fixation with Index Vertebra Instrumentation Versus Long-Segment Fixation in Thoracolumbar Burst Fractures

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Abstract

Background: Thoracolumbar burst fractures are an important aspect of spinal injuries, which can be treated by surgery to stabilize and restore neurological function. Whether to use short-segment or long-segment posterior pedicle screw fixation is a controversial issue. This study aimed to compare radiological outcomes of short-segment fixation instrumentation versus long-segment fixation of thoracolumbar burst fractures.

Methods: This study was conducted at Department of Orthopaedic Surgery, National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh from July 2024 to June 2025, involving the recruitment of 91 consecutive patients who sustained a thoracolumbar burst fracture and were treated with posterior pedicle screw fixation. The patients were separated into two groups: short-segment fixation (n = 46) and long-segment fixation (n = 45). The neurological status was assessed on the basis of the ASIA Impairment Scale. Data were entered and analyzed using SPSS version 26.

Results: The two groups had a significant within-group radiological improvement. Fixation with short-segments had a mean Cobb angle correction of 9.31° and kyphotic angle correction of 13.24°. The long-segment fixation attained a correction of 8.31° and 11.20°, respectively. There was no significant difference in Cobb angle correction between groups (P = 0.187), but there was significantly greater kyphotic correction with short-segment fixation (P = 0.022). Nevertheless, the correction loss was much higher in short-segment fixation (6.02° vs 4.69°, P = 0.005). Both groups improved neurologically on the ASIA Impairment Scale.

Conclusion: The two techniques of surgery provide a great radiological outcome in thoracolumbar burst fractures. Short segment Fixation with the index vertebra provides similar Cobb angle correction and better kyphotic reduction, but with higher correction loss. The fixation in the long segment offers superior long-term maintenance of correction.

Keywords: Thoracolumbar burst fracture, pedicle screw fixation, kyphotic angle, cobb angle, short-segment fixation

Introduction

Thoracolumbar burst fractures, which are mostly at the thoracolumbar junction (T11–L2), are one of the most frequent yet one of the most difficult to treat spinal injuries that cover about 10–20% of all spinal fractures.[1] The high-energy trauma on thoracolumbar junction can occur because of the fact that the rigid thoracic spine is replaced by the more mobile lumbar spine, which makes this region biomechanically vulnerable.[2] The objectives of surgery are mainly decompression of the neural components, restoration of the spinal position, and the development of sufficient mechanical stability that will allow early movement and rehabilitation.[3] The posterior pedicle screw fixation has become the most used mode of operative treatment in unstable thoracolumbar burst fractures because of technical reliability and ability to control three columns, and good biomechanical characteristics.[4] The short segment fixation versus long segment fixation (SSF vs. LSF) is a controversy that has persisted in relation to the management of the thoracolumbar burst fractures. Instrumentation above and below the fracture, known as long-segment fixation, spreads mechanical forces more widely and has been traditionally linked to excellent maintenance of correction.[5] It, however, compromises on other motion segments, duration of operation, blood loss, and chances of neighbor degeneration.[6] Short-segment fixation, on the other hand, which entails a one-level superior and one-level inferior to the fracture, conserves the motion segments and decreases surgical morbidity. Interest in SSF as a possible alternative has resurged with the inclusion of transpedicular screws at the index (fractured) level of the vertebra (a modification that improves cantilever biomechanics and prevents kyphotic deformity).[7] Studies have also found that SSF using index vertebra instrumentation offers anterior column support due to the action of ligamentotaxis and bone grafting, which lowers the rate of implant failure and loss of correction.[8] The measure of radiological evaluation of correction with the Cobb angle and regional kyphotic angle is the common parameter by which the effectiveness of surgery is measured, and the progression of deformities after surgery is monitored. Several prospective studies have indicated that progressive kyphosis after fixation of a burst fracture is linked to chronic back pain and poor functional outcomes.[9,10] Although the evidence is increasing, there is still a scarcity of prospective data comparing SSF to index-vertebra instrumentation to LSF in the same group of patients.[11] Therefore, this study aimed to compare short-segment fixation with index vertebra instrumentation versus long-segment fixation in patients having thoracolumbar burst fractures.

Methods

The study was a prospective observational study carried out at the Department of Orthopaedic Surgery, National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh from July 2024 to June 2025. 91 patients were involved and assigned to 2 distinct groups regarding the method of operation: short-segment ($n=46$), and long-segment ($n=45$), where the instrumentation was administered to one level above and one level below the fracture, including index vertebra fixation, and to two levels above and below, respectively, without index vertebra fixation. The inclusion criterion was patients with thoracolumbar burst fractures (T10L2) confirmed with plain radiograph, computed tomography (CT), and magnetic resonance imaging (MRI), and treated with the posterior pedicle screw fixation method. Inclusion criteria were acute thoracolumbar burst fracture, neurological deficits of ASIA Grade B-D or mechanically unstable fracture, and at least 12 months of follow-up. The exclusion criteria were pathological fractures, osteoporosis (T-score less than –2.5), prior spinal surgery on the same level, polytrauma limiting to surgery in the early stages, and missing follow-up information. Such variables as demographic (age, sex), duration of operation, pre- and post-operative Cobb angle, and regional kyphotic angle determined by the Cobb method on the

lateral radiographs, correction loss at 12 months, and neurological status were evaluated with the help of the American Spinal Injury Association (ASIA) Impairment Scale. The outcome based on clinical evaluation at the end of final follow-up was checked on the basis of the Modified McNab criteria. IBM SPSS Statistics version 26 was used to enter and analyze the data. Mean ± standard deviation was used to report continuous variables, and the independent samples t-test was used to compare the results. The chi-square test was used to compare categorical variables. A *P*-value < 0.05 was considered significant for the analysis.

Results

Table 1 represents the baseline demographics of both groups of surgeries. The short-segment group had a mean age of 31.59 ± 9.98, and 36 men and 10 women, with an average duration of operation between 120 and 150 minutes. The long-segment ($n = 45$) had a mean age of 30.73 ± 8.56 years, comprising 38 males and 7 females, and the operating time was between 150 and 180 minutes [Table 1].

Table 2 shows the results of the ASIA Impairment Scale of the neurological status of the short-segment group at pre- and post-operative time points. In the pre-operative status, there were 6 Grade B, 18 Grade C, and 22 Grade D. In the post-operative status, there was significant improvement in the neurological status, where 32 people were Grade E and only 1 stayed at Grade C. None of the patients worsened to Grade A, indicating positive neurological results of short-segment fixation using the index vertebrae [Table 2].

The results of the long-segment group in the ASIA Impairment Scale are shown in Table 3. At pre-operative, Grades B, C, and D were 11, 15, and 19, respectively, and 29, 3, and 13 at post-operative, respectively. As with the short-segment group, there were no participants who stayed at Grade A nor any of those who degenerated [Table 3].

Table 4 summarizes the radiological improvement of both surgical groups. Both the Cobb angle mean change (9.31, $P < 0.001$) and kyphotic angle mean change (13.24, $P < 0.001$) were statistically significant in the short-segment group. Equally, the long-segment group showed a high level of improvement in mean Cobb angle change (8.31, $P < 0.001$) and mean kyphotic angle change (11.20, $P < 0.001$). These findings support the claim that

Table 1: Demographic characteristics of the study population ($N = 91$)

Variable	Short segment fixation ($n = 46$)	Long segment fixation ($n = 45$)
Age (years)	31.59 ± 9.98	30.73 ± 8.56
Sex	–	
Male	36	38
Female	10	7
Average operation time (minutes)	120–150	150–180

Table 2: ASIA impairment scale in short segment group ($n = 46$)

ASIA impairment scale	Pre-operative	Post-operative
Grade A	0	0
Grade B	6	0
Grade C	18	1
Grade D	22	13
Grade E	0	32

Table 3: ASIA impairment scale in long segment group ($n = 45$)

ASIA impairment scale	Pre-operative	Post-operative
Grade A	0	0
Grade B	11	0
Grade C	15	3
Grade D	19	13
Grade E	0	29

both methods are effective in restoring the spinal alignment during the first few stages of post-operative practice [Table 4].

Table 5 provides between-group radiological comparisons. There was no big difference in terms of Cobb angle correction between groups (9.31° vs 8.31°; $P = 0.187$). Nonetheless, the short-segment group had shown a much better correction in the kyphotic angle (13.24° vs 11.20°; $P = 0.022$). At 12 months, the amount of correction loss was also significantly higher in the short-segment group (6.02° vs 4.69°; $P = 0.005$), indicating long-segment fixation has better maintenance of radiological correction with time [Table 5].

Discussion

This was a prospective comparative study involving short-segment fixation (SSF) using instrumentation of the index vertebra in comparison with long-segment fixation (LSF) in 91 patients with thoracolumbar burst fractures in 12 months of follow-up. The results indicate that both methods can result in a great and clinically meaningful radiological improvement with different biomechanical trade-offs. The short-segment group also recorded a significant mean correction of the kyphotic angle of 13.24°, which was statistically higher than the mean of 11.20° of the long-segment group ($P = 0.022$). The biomechanical explanation of this observation is that transpedicular screw fixation of the index level offers a superior cantilever construct, which facilitates greater correction of kyphotic deformity of the fracture site.[12] The same results have been obtained by Spiegl et al., who found that SSF using index vertebra screws was much better in terms of changing regional kyphosis than conventional SSF without index instrumentation.[13] The Cobb angle correction, however, was not significantly different among groups ($P = 0.187$), indicating that the two methods are similar in terms of being effective in restoring global spinal alignment. This is consistent with the results of Alpantaki et al., who reported similar Cobb angle correction between SSF and LSF in a multicenter cohort, and that the clinical relevance of kyphotic angle correction could be of more functional importance.[14] The critical result of this study is that correction loss is much greater in the SSF group (6.02 vs 4.69, $P = 0.005$) after 12 months. This is explained by the fact that the long lever arm of the short-segment construct exposes

Table 4: Within-group radiological improvement

Parameter	Pre-op Mean ± SD	Post-op Mean ± SD	Mean change	*t*-value	*P*-value
Short segment ($n = 46$)					
Cobb angle (°)	22.09 ± 3.62	12.78 ± 2.32	9.31	14.82	< 0.001
Kyphotic angle (°)	24.24 ± 3.71	11.00 ± 2.03	13.24	18.94	< 0.001
Long segment ($n = 45$)					
Cobb angle (°)	21.29 ± 8.20	12.98 ± 4.69	8.31	6.72	< 0.001
Kyphotic angle (°)	21.96 ± 6.03	10.76 ± 2.13	11.20	9.85	< 0.001

Table 5: Between-group comparison of radiological correction

Variable	Short segment ($n = 46$) Mean ± SD	Long segment ($n = 45$) Mean ± SD	Mean difference	*t*-value	*P*-value
Cobb correction (°)	9.31 ± 3.10	8.31 ± 4.20	1.00	1.33	0.187
Kyphotic correction (°)	13.24 ± 3.40	11.20 ± 4.60	2.04	2.33	0.022
Correction loss (°)	6.02 ± 2.02	4.69 ± 2.30	1.33	2.88	0.005

individual implants to increased cyclic loads that predispose screw backout and progressive kyphosis. Loss of correction has been recognized as the main limitation of SSF, as described by Farrokhi et al., and the rates of the same are inversely correlated with anterior column support.[15] This is to some degree addressed by index vertebra instrumentation, which changes the construct into a five-screw structure, which disperses loads more uniformly, but not with the capability to create biomechanical rigidity of LSF.[16] Neurological outcome was outstanding in both groups, as most of the patients obtained Grade E at the end of follow-up, as shown by the ASIA Impairment Scale. This indicates the effectiveness of the indirect decompression by means of ligamentotaxis and fracture decrease by means of posterior instrumentation regardless of fixation duration. These outcomes are in agreement with Vaccaro et al., who have emphasized that neurological recovery largely depends on the sufficiency of the initial decompression and reduction as opposed to the length of fixation itself.[17] As to the operative efficiency, LSF was related to the increased operative time (150–180 min vs 120–150 min), which has implications on anesthetic risk, the intraoperative blood loss, and the use of resources in a resource-limited setting. Also, LSF loses even more motion segments, which create additional biomechanical load on neighboring levels and lead to the possibility of the development of adjacent segment disease in the long run.[18] On the other hand, SSF using index vertebra instrumentation maintains motion segments and yet offers enough early correction, which makes it an attractive choice, especially in younger and active patients who are more prone to the long-term effects of higher spinal fusion length.[19,20] The internal validity of the study is reinforced by the fact that the demographics of both groups are similar in terms of mean age and sex distribution. The risk of measurement bias is also further reduced by the prospective design and the standardization of the radiological measurement protocol. SSF index vertebra instrumentation has a good balance of effective kyphotic correction and motion segment maintenance whereas LSF has better maintenance of correction over time. The decision between the two techniques must be customized according to the fracture morphology, bone quality, age of the patient, and experience of the surgeon.[21,22]

Limitations of the Study

This study has weaknesses of a single-centered design and moderate sample size, which can impair external validity of the results; furthermore, there is a lack of patient-reported functional outcome measures, which can restrict the ability to view the clinical recovery as a whole.

Conclusion

Short-segment fixation using index vertebra instrumentation and long-segment fixation are both viable surgical techniques that are used to treat thoracolumbar burst fractures, and each presents strong radiological outcomes in terms of spinal alignment. Short-segment fixation is better in the case of kyphotic angle correction and preservation of additional motion segments; hence it can be used in younger and active patients. Nevertheless, the long-segment fixation allows the maintenance of the correction better with time, and the correction loss is much lower after 12 months. In both groups, neurological outcome was positive, with the majority of patients being assessed as ASIA Grade E. The nature of the fixation strategy must be personal and must consider the fracture nature, patient demographics, bone quality, and the experience of the surgeon to give the best long-term functional and radiological results.

Recommendations

Multicenter randomized controlled trials that employ longer follow-up time and use of validated patient-reported outcomes, bone

mineral density measurements, and sophisticated imaging technology are encouraged in the future to better define the indications of the best fixation method.

Ethical Approval

The study was approved by the Institutional Ethics Committee.

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