COMPARISON BETWEEN SHORT AND LONG SEGMENT TRANSPEDICULAR FIXATION OF THORACOLUMBAR BURST FRACTURES

Makkena Ravikanth[1], Tummala Venkata Suresh Babu[2], Annamalai Chandrasekaran[3]

[1]Associate Professor, Department of Orthopaedics, ASRAM Medical College, Eluru.
[2]Associate Professor, Department of Orthopaedics, Dr. PSIMS & RF, Gannavaram, Vijayawada.
[3]Professor, Department of Orthopaedics, SRMC & RI, Chennai.

ABSTRACT

BACKGROUND

Transpedicular instrumentation systems have distinct advantages such as rigid segmental fixation, stabilization of the three columns, least failure at bone metal interface, early post-operative mobilization with efficient nursing care and least complications in the management of thoracolumbar burst fractures. The aim of this study was to analyze and compare the clinical and radiological outcome of thoracolumbar burst fractures treated by short segment and long segment transpedicular instrumentation.

METHODS

34 patients who underwent posterior spinal stabilization with transpedicular instrumentation and posterolateral fusion for unstable thoracolumbar burst fractures with or without neurological deficit were included in the study. Load sharing classification (Gaines scoring) was used retrospectively to correlate fracture comminution and displacement with progression of the deformity and implant failure. Neurological evaluation was done and patients were graded according to ASIA (American Spinal Cord Injury Association) impairment scale as a part of physical examination.

RESULTS

The mean intra-operative correction in the short segment group was 14.4° and the loss of correction observed at the last follow-up evaluation was 7.48° with a final gain of 6.92°. The mean intra-operative correction in the long segment group was 19.77° and the loss of correction observed at the last follow-up evaluation was 6.61°. Final gain was 13.16°. On radiological evaluation, mean correction loss of 7.48 degrees and 3.4% implant failure was noted in the short segment group while the long segment group had 6.61 degrees of mean correction loss and no implant failure. There was no positive correlation found between Gaines score with progression of deformity.

CONCLUSION

Transpedicular fixation is a stable, reliable and less surgically extensive construct for addressing thoracolumbar burst fractures. About 6-8° loss of correction was observed with both short and long segment stabilizations in our study. Long segment has better results in terms of maintenance of reduction and final gain.

KEYWORDS

Thoracolumbar burst fractures, short segment posterior fixation, spine.

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INTRODUCTION: Thoracolumbar burst fractures are usually a result of substantial axial loading force that results in compression failure of anterior and middle spinal columns. Majority of these injuries occur as a result of fall from height and motor vehicle accidents. Burst fractures have a predilection for thoracolumbar spinal segments. The sudden application of supraphysiological load results in vertebral end-plate failure as adjacent disc tissue is driven into the vertebral body.

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Corresponding Author:
Dr. Ravikanth Makkena,
D. No. 29-6-6/1, Nakkal Road, Suryaraopeta,
Vijayawada, Andhra Pradesh.
E-mail: ravikanthmakkena@gmail.com
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These fractures are associated with some degree of canal compromise, typically as a result of retropulsion of an osseous fragment or fragments from the superior endplate.[1,2]

Prevention and limitation of neurological injury as well as restoration of spinal stability are the primary goals of management in such fractures. Secondary issues of concern include deformity correction, minimizing motion loss, and facilitating rapid rehabilitation. The treatment option chosen should also provide a biological and biomechanical environment conductive to osseous and soft tissue healing, in order to recreate a stable pain free spinal column.

Stabilization has evolved greatly during the years. Initially, fixation devices including Harrington rods, hooks and sub laminar wires were used. However, these were associated with issues such as loss of number of motion segments, lack of correction in the sagittal plane, and increase in neurological deficit after a few years.[3,4]

The introduction of transpedicular instrumentation systems were considered highly beneficial because of its distinct advantages such as rigid segmental fixation, stabilization of the three columns, least failure at bone metal interface, early post-operative mobilization with efficient nursing care and least complications. Additionally, pedicle screw fixation does not require the presence of intact lamina, facet joints or spinous processes.[5,6]

The pedicle withstands all of the transmitted stresses of rotation, side bending, and extension of the spine. Thus, the pedicle has been labelled by Steffee as the "force nucleus" of the vertebral body.[7] It is an ideal structure to lock into and control with posterior instrumentation when spinal fixation is needed.

Short segment instrumentation (pedicle screw fixation one level above and below the injured vertebra) was introduced with an aim to preserve the number of motion segments along with an attempt to improve fusion rates, ability to obtain reduction, and maintain sagittal contour which would eventually lead to a lower incidence of residual back pain.[8,9]

Although there are several studies which have evaluated the benefits and drawbacks of transpedicular instrumentation, there is a lack of studies which have made a direct comparison between the short and long segment methods. Hence, the aim of this study was to analyze and compare the clinical and radiological outcome of thoracolumbar burst fractures treated by short segment and long segment transpedicular instrumentation.

MATERIALS AND METHODS: This study was conducted in the department of orthopaedics, SRMC & RI, From April 2002 to October 2004. 34 patients who underwent posterior spinal stabilization with transpedicular instrumentation and posterolateral fusion for unstable thoracolumbar burst fractures with or without neurological deficit were included in the study.

All patients who had sustained unstable thoracolumbar burst fractures with or without neurological deficit were included.

The criteria for instability were:

- Kyphosis angle >11 degrees.
- Loss of anterior vertebral body height by at least 30%.
- 2 or 3 column involvement.
- Presence of neurological deficit.

Exclusion criteria for this study were as follows:

- All pathological fractures.
- Patients who underwent global fusion (anterior and posterior).
- Patients who underwent anterior-only surgery.

A detailed history was obtained from the patient and/or the relatives. The history included details of date and time of Injury, mode of injury, bowel and bladder details, co morbid factors like systemic disorders and the type of treatment given earlier. Physical examination along with plain AP and lateral radiographs, CT scans and / or MRI scans were carried out in all patients.

Following primary survey attention was paid to the examination of injuries in relation to spine. Any abrasions/ lacerations, swelling, deformity, tenderness, step off, gaps/ mal-alignment were looked for by log rolling the patient. Neurological evaluation was done and patients were graded according to ASIA (American Spinal Cord Injury Association) impairment scale as a part of physical examination.

A=Complete: No motor or sensory function is preserved in the sacral segments S4-S5.
B=Incomplete: Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5.
C=Incomplete: Motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade less than 3.
D=Incomplete: Motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade of 3 or more.
E=Normal: Motor and sensory function is normal.

Neurological assessment also included the extent of motor and sensory deficit by using ASIA motor and sensory score for a total of 50 and 56 points respectively.

AP and Lateral views of the dorsolumbar spine were obtained. Additionally, trauma series X rays were done to assess for any associated injuries of the skeletal system. Initial radiographic assessment included interpedicular distance on an AP view, loss of vertebral body height (anterior and posterior), Kyphus angle and wedge angle on a lateral view.

Kyphus angle was measured from superior end plate of the intact vertebra just above to the inferior end plate of intact vertebra just below the fracture. Wedge angle was measured from the superior end plate to the inferior end plate of the fractured vertebral body. CT imaging was done to demonstrate the amount of comminution, apposition of fragments and retropulsion of fragments in to the canal. MRI is recommended for patients with a neurological deficit to identity possible spinal cord or cauda equina injury, haemorrhage, or epidural haematoma.

Both CT and MRI were done where ever possible.

Load sharing classification (Gaines scoring) was used retrospectively to correlate fracture comminution and displacement with progression of the deformity and implant failure.

Operative Procedure: Surgery was performed as an elective procedure at the earliest after assessing fitness for surgery. Prophylactic antibiotics were administered prior to induction. A self-retaining Foley's catheter was maintained during and after surgery. Adequate amount of blood was kept available.

Under general anaesthesia, patients were positioned in a prone position over Hall-Retlon frame. Fracture site anatomy was checked using c-arm image intensifier and incision line was marked.

Exposure of the spinous processes was carried out two levels above and below the fractured site through a standard posterior midline approach for a short segment fixation, while 3 levels above and below were exposed for long segment fixation. Sub periosteal erasure of Para spinal muscles was done up to the facets of the respective segments. Capsulotomy of the facets with dissection up to the tips of the transverse processes was done bilaterally.

Under image intensifier control, levels were confirmed and pedicle screws were inserted bilaterally. This procedure was repeated as necessary depending on short segment or long segment construct. Laminectomy was done at the fracture level to achieve posterior decompression wherever necessary. Decortication of the spinous process, transverse processes, and lamina was done along with facetectomy.

Adequate quantity of corticocancellous bone graft harvested from iliac crest was used to augment fusion. Care was taken to ensure that all the slots of the screws were aligned. The rod was contoured depending on the sagittal contour of the zone of fixation and was loaded into the universal top loading connecting post of the screws. Rod pusher was used when required to facilitate correct seating, secured in that position by tightening inner and outer nuts. Rods were inserted bilaterally over the screws. Connecting blocks were placed over the rods.

Connecting rod was used to augment torsional rigidity and prestressing was done to prevent the parallelogram effect. Wherever posterior longitudinal ligament was intact on MRI, indirect reduction technique by distraction was done. Haemostasis was achieved, and the wound was closed in layers with a suction drain in situ.

The implants used were: Transpedicular screw fixation with rod-screw system (Moss Miami). Size of the pedicle screws most commonly used were 4.5 and 5.5 mm.

Postoperative Protocol and Rehabilitation: Postoperatively antibiotics and analgesics were administered as per schedule. Suction drain was removed usually after 48 hrs. Vital signs input and output, abdominal charts were maintained in the immediate postoperative period as a routine.

Patients were log rolled in the bed for the first 2 days along with passive stretching exercises of both lower limbs and active exercises of both upper limbs.

Neurological assessment was done when pain had subsided and patient was able to move the lower limbs without distress. If bladder sensation was regained, hourly clamping was done. Otherwise patient was taught to clean self-catheterization intermittently. Suppository was needed for bowel clearance. Otherwise digital evacuation was done and taught to the attendant.

Sutures were removed on 12th post-operative day. Patients were kept in the hospital considering their response to the treatment instituted, progress in rehabilitation programme, complications if any, socioeconomic conditions and were discharged when considered fit enough to sustain himself independently at least at house environment. Patients were mobilized postoperatively with supporting brace (TLSO brace) from the time patient was pain free and this was continued for 6 months. Rehabilitation training continued for other normal daily activities.

Standard AP and lateral films were taken to assess position of the implant, degree of correction achieved in the early post-operative period. Later follow-ups included assessment of progression of deformity, loss of correction, final gain and implant failure.

Four radiological parameters were assessed; Anterior and posterior vertebral body heights in mm and Cobb's & wedge angles in degrees. These parameters were assessed in terms of:

- Intraoperative gain (difference between pre and post-operative values),
- Reduction loss (difference between post-operative value and the value at last follow up), and,
- Final gain (difference between intra operative gain and reduction loss).

Progression of the deformity was measured as a change in the sagittal alignment of the spine from the initial post-operative radiographs, to the most recent follow up radiographs. Progression was considered to be absent, minor, or major. Absent progression was defined as Kyphosis measuring 0–4 degrees, while minor progression was defined as kyphosis measuring 5 to 9 degrees and major progression was defined as increase of 10 degrees or more. Neurological assessment was done at each follow up and the most recent follow-up using ASIA impairment scale. Patients were followed up at 3 weeks, 6 weeks, 3 months, 6 months, 1 year and then every 6 months. Each patient was assessed clinically and radiologically at each follow-up.

RESULTS: Among 34 patients who were included in the study, 5 patients were lost for follow-up.

Among the 29 patients evaluated, 22 were male (76%) and 7 were female (24%). The mean age was 28.5 years for short segment and 28 years for long segment. 16 of the 29 patients underwent short segment stabilization (56%) while the rest 13 of them underwent long segment stabilization (44%).

The injured levels were D11 in 4 patients (13.8%), D12 in 5 patients (17.2%), L1 in19 patients (65.5%), and L2 in 1 patient (3.4%). The vertebral level most commonly involved was D12-L1 (82.7%). Calcaneal fracture (22.2%) was the most commonly associated skeletal injury.

All the patients underwent surgery on an elective basis within 1-27 days following the injury (average being 7 days). After surgery, patients were mobilized in a semi rigid brace which was worn for a period of six months post operatively. The average length of hospital stay for these patients was 28.6 days (range, 12 to 58 days). Average follow-up period was 13.81 months and 18.15 months for short and long segments, respectively.

Radiological Outcome: Combined Outcome: The mean average pre-operative K angle was 19.89°. The mean intra-operative correction was 16.82°. Mean correction loss was 7.1° with a mean final gain of 9.72°.

Combined:

	Pre	Post	Gain	LFU	RL	FG
AVBH	15	22.65	7.65	21.10	1.55	6.1
PVBH	29.12	29.51	0.39	29.41	0.10	0.29
K-angle	19.89	3.07	16.82	10.17	7.1	9.72
Wedge	22.34	8.31	14.03	11.06	2.75	11.3

Table 1: Combined radiological outcome

Average pre-operative wedge angle was 22.34° which was corrected intra operatively by 14.03°. Mean loss of correction was 2.75° with a final gain of 11.3°.

Average pre-operative anterior vertebral body height was 15 mm; intra-operative correction was 7.65 mm. Average correction loss in 1.55 mm with a final gain of 6.1 mm.

Outcome in Short Segment Group: The mean average pre-operative K angle deformity was 16.6°. The mean intra-operative correction was 14.4° and the loss of correction observed at the last follow-up evaluation was 7.48° with a final gain of 6.92°.

Short Segment:

	Pre	Post	Gain	LFU	RL	FG
AVBH	16.25	23.25	7	21.87	1.38	5.62
PVBH	29.37	29.87	0.50	29.87	0.0	0.50
K-angle	16.6	2.2	14.4	9.68	7.48	6.92
Wedge	20.12	7.69	12.43	11.56	3.87	8.56

Table 2: Radiological outcome in the short segment group

Average pre-operative wedge angle was 20.12° which was corrected intra operatively by 12.43°. Loss of correction was 3.87° with a final gain of 8.56°.

Average pre-operative anterior vertebral body height was 16.25 mm, and the intra-operative correction was 7 mm. Correction loss was 1.38 mm with a final gain of 5.62 mm.

Outcome in Long Segment Group: The mean average pre-operative K angle deformity was 23.92°. The mean intra-operative correction was 19.77° and the loss of correction observed at the last follow-up evaluation was 6.61°. Final gain was 13.16°.

Long Segment:

	Pre	Post	Gain	LFU	RL	FG
AVBH	13.30	21.92	8.62	20.15	1.77	6.85
PVBH	29.61	28.92	0.31	28.69	0.23	0.08
K-angle	23.92	4.15	19.77	10.76	6.61	13.16
Wedge	25.07	9.07	16	10.46	1.39	14.61

Table 3: Radiological outcome in the long segment group

Average pre-operative wedge angle was 25.07° which was corrected intra operatively by 16°. Loss of correction was 1.39° with a final gain of 14.61°.

Average pre-operative anterior vertebral body height was 13.30 mm; intra-operative correction was 8.62 mm. Correction loss is 1.77 mm with a final gain of 6.85 mm.

Radiological Comparison: In short segment group, mean correction loss of 7.48 degrees and 3.4% implant failure was noted. In contrast, long segment group had 6.61 degrees of mean correction loss and no implant failure.

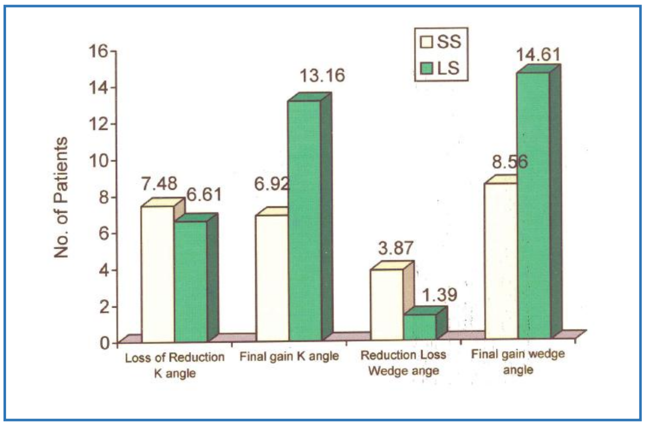

Fig. 1: Comparison of the radiological outcomes between the groups

Gaines Score: There was no positive correlation found between Gaines score with progression of deformity.

	Short Segment			Long Segment		
Load Sharing Score	5	6	7	5	6	7
No.of Patients	2	13	1	1	11	1

Table 4: Gaines score in both groups

Progression of Deformity (degrees)	Short Segment	Long Segment
Absent (0-5)	7	8
Minor (5-9)	8	5
Major (> 10)	1	0

Table 5: Comparison of progression of deformity across both groups

One intraoperative complication was noted while there were 6 complications during early postoperative period and 7 during the late post-operative period. The types of complications noted have been listed below.

Intra operative: Faulty screw placement 1.

Early post-op:

Bed sore 3.
Chest infection 1.
Superficial infection 1.
Wound dehiscence 1.

Late Post-op:

Deep infection 1.
UTI 4.
Implant failure 1.
Loss of correction >10 degrees 1.

DISCUSSION: The mean average age of the patients in our study was 27.9 years with a male to female ratio of 3:1.

In our study 82.7% of the injuries were around D12-L1 junction. This is the commonest site of injury as this area represents the transition from the normal thoracic kyphosis to lumbar lordosis and therefore maximum stress concentration occurs here on weight bearing.

In the treatment of patients with thoracolumbar burst fractures the absolute goal must be to stabilize an unstable injury. A relative goal of treatment is to decompress a compromised spinal canal and correct the deformity.[10]

It has been well shown that essential key to the reduction of intracanal fragment in burst fractures is distraction.[11] Gertzbein has shown that fragments of bone can resorb over a period of 1 to 2 years.[12]

The mean average preoperative K angle was 16.6° in the short segment and 23.92° in the long segment. Preoperative K angle was more in the long segment. The intraoperative gain in the K angle was 14.4° in the short segment and 19.77° in long segment. The mean average K angle at the last follow up was 9.68° and 10.76° in the short and long segment, respectively.

The mean average loss of correction K angle by the last follow-up was 7.48° in the short segment and 6.16° in the long segment; whereas in Mirjanli et al study, the values were 16.2° and 5.7°, respectively.[13] In Louis et al study, loss of correction was 9.3° and 10.5°.[14] In our study, loss of correction was observed to have occurred more in the early post-operative period (3 months) than in the late post-operative period.

The mean final gain of K angle in our study was 6.92° and 13.16° in the short and long segments, respectively. These values in Louis et al study were as low as -02° and 2.9°, respectively.[14]

Long segment had better results in terms of prevention of loss of correction and final gain in spite of extensive collapse. The mean average preoperative wedge angle was 20.12° in the short segment and 25.07° in the long segment. The mean average intraoperative gain was 12.43° in short segment and 16° in long segment.

The loss of correction of wedge angle was 3.87° and 1.39°, in short segment and long segments, respectively. In Louis et al study there was not much of a difference in the loss of correction with the mean values of 4.8° and 4.84°, in the short and long segments respectively.[13]

The final gain of wedge angle was 4.5° and 5.36° in short and long segments, respectively, in Louis et al study.[13] While the corresponding values in our study were 8.56° and 14.16°.

The mean final gain in anterior vertebral body height was 5.62 mm in short segment versus 6.85 mm in long segment. There was no significant difference between the two groups in achieving reduction or maintenance of reduction of posterior vertebral body height.

Parker et al[14] in their review of 46 patients with a mean follow-up period of 66 months concluded that load sharing classification is a straight forward way to describe the amount of bony communition in a spinal fracture and can help the surgeon to decide on short segment pedicle screw based fixation for less comminuted injuries. They also concluded that a low load sharing score of 6 or less indicates adequate sharing of load through the injured vertebral body when instrumented posteriorly and a score of 7 points or more indicates poor transport of load and points to the necessity for anterior instrumentation and strut grafting.[14]

In our study there were 2 patients with a load sharing score of 7, one in short segment and one long segment. There was major progression of the deformity in one patient treated with short segment due to faulty screw placement and implant failure later. 1 patient in long segment with load sharing score of 7 had minor progression.

There were 15 patients and 12 patients in short and long segments, respectively, with a load sharing score of 6 or less. Of the 15 patients in the short segment, 2 patients had a load sharing score of 5, and 13 patients had a load sharing score of 6. There was absent progression in 7 patients (46.7%) and minor progression in 8 patients (53.3%).

Of the 12 patients in the long segment, 1 patient had a load sharing score of 5 and 11 patients had a load sharing score of 6. There was absent progression in 8 patients (66.7%) and minor progression in 4 patients (33.3%).

There was no positive correlation between Gaines score and progression of deformity, although long segment was better in preventing progression of deformity.

We had 1 patient with implant failure (3.4%) in short segment which was due to faulty screw placement intraoperatively leading to screw pullout and major progression of deformity (>10°). There was 1 patient in the long segment with screw bending, but no implant failure.

However, a higher incidence of implant failure was reported in earlier studies. Danniaux et al reported 19% incidence of implant failure following transpedicular instrumentation,[15] while in Mirjanli et al study, mean implant failure of 22.3% and 3.6% was reported in short segment and long segment groups, respectively.[12]

CONCLUSION: Based on the outcomes noted in our study, it was clear that transpedicular fixation is a stable, reliable and less surgically extensive construct for addressing thoracolumbar burst fractures. However, such procedures require a thorough understanding of fracture pattern, pedicle morphometry and proper intraoperative technique. In general, 6-8° loss of correction was observed with both short and long segment stabilizations in our study. Nevertheless, long segment has better results in terms of maintenance of reduction and final gain.

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