Posterior fixation including the fractured vertebra in short segment fixation of unstable thoracolumbar junction burst fractures

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Abstract

The aim of this study was to observe the efficacy of inclusion of the fractured vertebra in short segment fixation in terms of clinical and the radiological outcomes in unstable thoracolumbar junction burst fractures at a minimum of 1 year follow-up. Records of 52 patients (age: 21-50 years) with thoracolumbar burst fracture (T10–L2) in Magerl Type A fractures underwent posterior pedicle screw fixation including the fractured vertebra. Clinical parameters were back pain using Visual Analogue Score (VAS) and disability using Oswestry disability index (ODI), neurological deficit (using ASIA grade) and radiologic parameters (Cobb angle, the kyphotic deformation and vertebral height) were measured before surgery and at 3, 6 and 12 months post-operatively. The presence of screw pullout, screw breakage, rod breakage and peri-implant loosening were evaluated as implant failure. The majority of fractures resulted due to falls (31 cases), and the remaining cases resulted from car accidents (21 cases). The fractured vertebral body level was L1, T12, L2, T11, and T10 in 23, 17, 6, 4 and 2 cases and achieved satisfactory clinical outcomes according to the modified Mcnab criteria 18, 25, 6 and 3 cases were considered to have excellent, good, fair, and poor outcome. The mean kyphotic angle at pre-, post-operative and final follow-up was 13.5 ± 6.3, 13.4 ± 4.3, 8.5 ± 6 degrees respectively. The average loss of kyphosis correction was 6.4 ± 5.2° at the final follow-up. The pre- and post-operative kyphotic deformation of vertebral body was 5.1 ± 3.2, 4.8 ± 2.3 and at final follow-up was 4.5 ± 4.0 ($p>0.05$). The anterior and posterior vertebral height showed significant improvements post-operatively, which were maintained at the final follow-up. The mean ODI and VAS scores at the end of 1 year were 17.4%, 1.7 respectively. There was no case of major complication after surgery and during the follow-up period. In conclusion, reduction of unstable thoracolumbar junction burst fracture can be achieved and maintained using short-segment pedicle screw fixation including the fractured vertebra, avoiding the need for anterior reconstruction.

Introduction

Traumatic thoracolumbar junction (T10-L2) injuries are the second most frequent site of vertebral column injury in adults.[1] In this region, the rigid, kyphotic thoracic spine joints the more mobile, lordotic lumbar spine which make it particularly susceptible to injury.[2] An unstable fracture of spine is one in which the anterior and middle columns fails in compression and the posterior osteoligamentous column is significantly disrupted.[2] The treatment of unstable fracture and fracture dislocation of thoracolumbar spine is still confusing.[3] Surgical treatment is needed, the choice for operative approaches remains controversial.[4,5] Absolute indication for early surgery is progressive neurological deterioration.[6] Other indications for surgical intervention are incomplete neurological deficit, >25-30° angle of kyphotic deformity, >50% loss of vertebral body height, and > 40 to 50% of canal narrowing.[7]

The goal of the treatment of unstable thoracolumbar burst fractures is optimizing neural decompression while providing stable internal fixation over the least number of spinal segments.[8] Anterior, posterior or both approaches can be used to achieve fusion but the efficacy of each approach is same.[9-11] However, the posterior approach is less extensive.[12]

Short-segment posterior fixation is the most common and simple treatment. It offers the advantage of incorporating fewer motion segments in the fusion.[4,13] Short-segment posterior fixation alone may led to implant failure and re-kyphosis (9-54%) in the long-term, and moderate-to-severe pain (50%).[4,5,14] To prevent this, several techniques have been developed to augment the anterior column in burst fractures, such as placement of body augmente,[15] polymethylmethacrylate injection,[16,17] transpedicular bone grafting,[4,13,18] anterior instrumentation and strut grafting[19,20] or long-segment posterior fixation (LSPF).[21] There are few controlled studies explaining the reasons for implant failure and re-kyphosis for thoracolumbar fractures.[4,22]

There are biomechanical advantages of posterior fixation including the fractured vertebra (PFFV) over conventional short-segment fixation. It will be biomechanically stronger by inserting screws at the fracture level[23] which in turn may omit the need for further anterior reconstruction. Studies have shown the inclusion of the fracture level in short segment fixation.[23,24] In this study, we tried to evaluate the efficacy of inclusion of the fractured vertebra in short segment fixation in terms of clinical and the radiological outcomes in unstable thoracolumbar junction burst fractures.

Materials and Methods

Records of 52 patients (age range 21-50, mean 33.4 ± 8.4 years) with thoracolumbar burst fracture (T10–L2) in Magerl Type A fractures underwent posterior pedicle screw fixation including the fractured vertebra (PFFV) from January 2008 to December 2015, studied retrospectively in our hospital (BSMMU) and private settings through investigating the medical records, radiological data and interview at outpatient clinic. Inclusions criteria were: a) single-level burst fracture in Magerl Type A fracture; b) neurologic function limited to ASIA Grades C, D or E; c) limited involvement of T10–L2; d) <3 weeks from the time of injury, e) computed tomography (CT) scan revealing a burst type fracture with more than 25% retropulsion into the canal; and f) sagittal index of more than 15^0. Exclusion criteria were: a) severe neurological problem (ASIA Grades A and B) treated with anterior or combined surgery; b) Magerl Type B, and C fractures. All the operations were performed by the same surgeon. Patients were placed in a prone position under general anesthesia with modified kneeling with two sand bags under each side of trunk which allowed the abdomen to hang free, minimizing epidural venous dilation and bleeding. Pedicle screw fixation and reduction were perform-ed under C-arm guidance. Laminectomy to decompress spinal cord was carried out at the involved level and bone was saved to be used as bone graft. Universal spinal instrumentation systems (India) were used in all patients. Screws were 40 or 45 mm long, depending on the level and size of the vertebra. At the 10th and 11th thoracic levels, 5.5 or 6.5-mm-diameter multiaxial screws and at the 12th thoracic level and caudally 6.5-mm-diameter multiaxial screws were used. The instrumentation was applied bilaterally and cross-links were used to augment torsional rigidity. Reduction of the fracture and indirect decompression of the spinal canal were accomplished by the rod contouring and extension and compression-distraction forces before tightening the screws. Posterolateral short level fusion (only fractured vertebra included the fusion area) with autogenous bone graft taken from the spinous process and lamina was performed in all patients and applied thoraco-lumbosacral orthosis (Taylor brace) post-operatively for 3 months.

Clinical and radiological examinations were done on admission. CT scans and MRI were taken pre-operatively to classify the fracture type, to assess chief complaints, cord compression and to see whether the pedicles of the neighboring vertebrae were intact and able to take the screws. Sagittal index was measured as described by Farcy et al.[25] The following baseline estimates for the intact sagittal curve: 5° in the thoracic spine, 0° in the thoracolumbar junction, and 10° in the lumbar spine.[23] Segmental kyphosis at the fracture level was defined as a positive value. Subtracting the baseline values from the segmental kyphosis was used to derive the sagittal index (Figure 1A and 1B). Local kyphosis angle of the vertebral body (Cobb angle) was measured as the angle formed between a line drawn parallel to the superior endplate of 1 vertebra above the fracture and a line drawn parallel to the inferior endplate of the vertebra 1 level below the fracture (Figure 1C). Segmental kyphosis was measured as the angle between the inferior endplate of the superior adjacent vertebral endplate and the superior endplate of the inferior adjacent vertebra (Figure 1D). This method of measurements incorporates both discs in the instrumented spine section. Overall disc height was defined as the average of anterior and posterior disc height (Beck index). Follow-up measurements were expressed in relation to disk height immediately after the operation. The percentage of spinal CC was calculated with the formula[26]:

$$a = (1 - X|Y)\ 100$$

where a= percentage of canal compromise, X= mid sagittal diameter of the spinal canal at the level of injury, Y=mean of the mid sagittal diameters of the spinal canal one segment above and below the level of injury

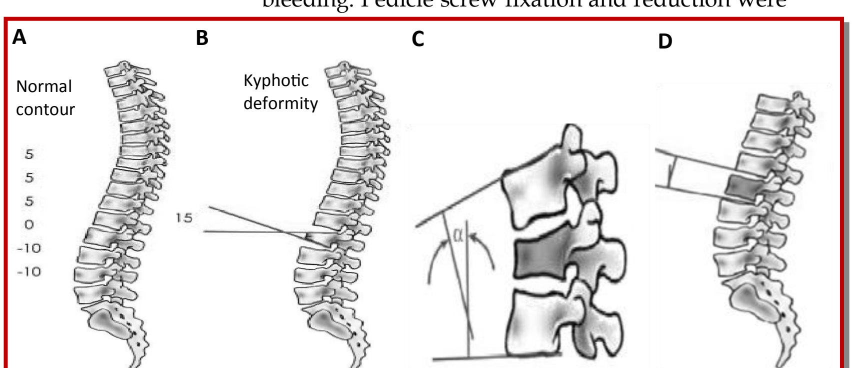

Figure 1: Segmental kyphosis at the fracture level

A fracture severity score was constructed using the LSC (load shearing classification) described by McCormack et al.[27] to compare fracture severity. The fractures were classified according to the system developed by Magerl et al.[28]

Clinical and radiographic follow-up were done immediately after the operation and at 3, 6, and 12 months and every year thereafter. Data were collected concerning the age, sex, localization, type of injury, presence of neurological deficits, pain, work status, complications and radiologic parameters (Cobb angle, kyphotic deformation of vertebral body, vertebral height and posterolateral fusion).

Correction loss was defined as progressive loss of Cobb angle more than 10^0 (an increase of more than 10^0 in sagittal index) in the latest follow-up radiographs compared with the measurement on the initial post-operative radiographs. Loss of kyphosis correction was calculated by subtracting the local kyphosis angle at the time of the latest follow-up from the local kyphosis angle after kyphosis correction. The fusion status of the patients was determined primarily with use of plain radiographs according to the classification system of Christensen et al.[29] by two independent observers. Clinical parameters: back pain using Visual Analogue Score (VAS), disability using Oswestry disability index (ODI), neurological deficit (using ASIA grade) and radiologic parameters (Cobb angle, the kyphotic deformation and vertebral height) were measured before surgery and at 3, 6 and 12 months post-operatively. The presence of screw breakage, screw pullout, peri-implant loosening, and rod breakage were considered as criteria for implant failure. Overall outcomes were evaluated using the modified Mcnab criteria at the last follow-up.[30] Chi-squared test and paired-t test were used for statistical analysis using SPSS version 13.0 software. A p value of <0.05 was considered to be significant. All patients provided informed consent.

Results

There were 33 men and 19 women with male to female ratio were 1:0.73. Most of the patients were over 31 years old. Mean age was 33.4 (± 8.4) within the range of 21–50 years. Maximum 32 patients were manual worker and rest 20 patients were sedentary worker and associated with co-morbidities e.g. diabetes mellitus (n=5), hypertension (n=4), ischemic heart disease (n=2) and chronic kidney disease (n=2) (Table I).

The majority of fractures were due to falls (31 cases). The remaining cases were due to car accidents (21 cases). The fractured vertebra body level was L1, T12, L2, T11, and T10 in 23, 17, 6, 4 and 2 cases. All the patients were decompressed posteriorly and short segment stabilization including fracture vertebrae was performed in each case by titanium pedicle screws and rods which is showed in Figure 2D and 2E. Post-operative X-ray showed good hardware position in all patients. One example is showed in Figure 2E and 2F. During the follow-up (average 2.2 years; range, 1–8 years), no hardware failure was detected. Adequate decompression was achieved in all the cases. No significant loss of correction was observed.

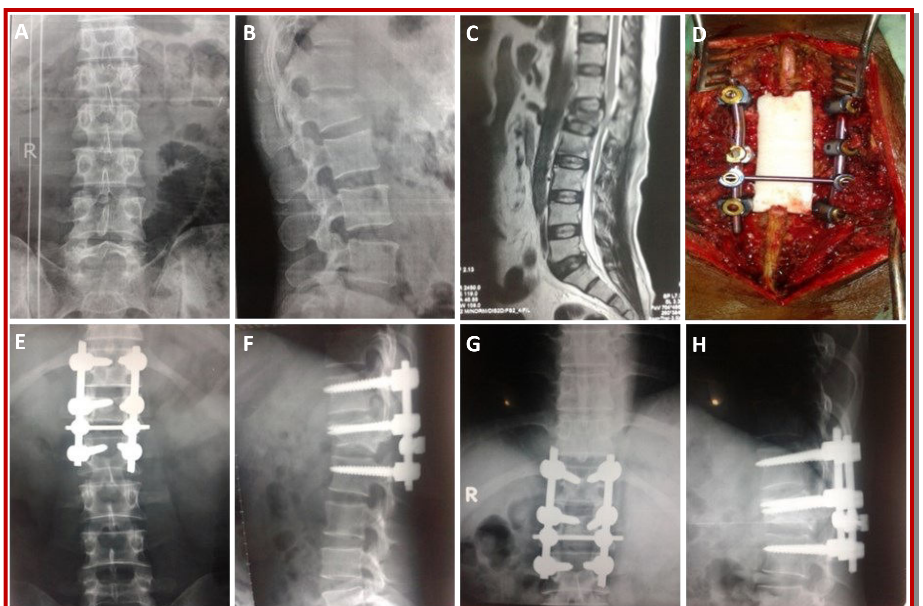

Figure 2: Pre-operative X-ray: A) Anterior posterior view, B) Lateral view, C) MRI saggital section T2 weighted image, D) Per-operatve image of short segment pedicle screw fixation. Early post-operative X-ray image: E) Anterior posterior view, F) Lateral view, One year post-operative X-ray image, G) Anterior posterior view, H) Lateral view

The mean duration of surgery was 152 min whereas the mean blood loss was 220 mL. The mean post-operative hospital stay was 8.6 days (range 7-15 days) and all the patients were mobilized in the 1st or 2nd post-operative day and achieved satisfactory clinical outcomes according to the modified Mcnab criteria 18 (34.6%), 25 (48.1%), 6 (11.5%), and 3 (5.8%) cases were considered to have excellent, good, fair, and poor outcome. The mean kyphotic angle at pre-, post-operative and final follow-up was 13.5 ± 6.3°, 13.4 ± 4.3°, 8.5 ± 6°. The average loss of kyphosis correction was 6.4 ± 5.2° at the final follow-up. The mean pre- and post- operative kyphotic deformation of vertebral body was 5.1 ± 3.2, 4.8 ± 2.3 and at final follow-up was 4.5 ± 4.0 (p>0.05). The mean pre- and post-operative anterior and posterior vertebral height was 0.6 ± 0.1, 0.9 ± 0.2 and at final follow-up was 0.9 ± 0.2, which showed

Table I

Demographic features of the patients

	n
Sex	
Male	33
Female	19
Age	
21-30	6
31-40	30
41-50	16
Co-morbidity	
Diabetes	5
Hypertension	4
Ischemic heart disease	2
Chronic kidney disease	2
Fracture location	
L1	23
T12	17
L2	6
T11	4
T10	2
Magerl classification	
A3.1	30
A3.2	8
A3.3	14
Cause of injury	
Motor vehicle accident	18
Fall from roof of building	12
Fall from tree	19
Fall of heavy object over back	3
ASIA scale (at present)	
C	6
D	22
E	24
ASIA scale (last follow-up)	
C	0
D	1
E	51
Superficial wound infection	3
Per-operative complication	0

significant improvements post-operatively and were maintained at the final follow-up.

The mean pre-operative VAS and ODI scores were 5.2 ± 01.1 (range, 6–9), 54.8 ± 7.7 (35-70) and at the end of 1 year were 1.7 ± 0.5 (range, 0–3), 17.4 ± 12.4 (10-42) respectively (Table II).

There was no case of major complication after surgery and during the follow -up period except three cases where superficial wound infections occurred and that was managed conservatively and cured. All patients with incomplete neurologic injuries improved one ASIA scale. At presentation 6 patients (11.5%) was ASIA scale C, 22 patients (42.3%) was ASIA scale D and 24 (46.2%) was E. In the last follow-up visit, among 52 patients, 51 patients (98.1%) in ASIA scale E and one patient (1.9%) was ASIA scale D. Associated injuries were found in 4 patients having calcaneal fracture, 3 with stable pelvic fracture and 1 talar dome fracture which was managed non -surgically.

Discussion

The thoracolumbar junction is a common site of spinal injury occurring in an estimated 6% of patients experiencing blunt trauma.[31] In more than 50% of the cases, spinal fractures affect the thoracolumbar junction.[32] The burst fracture was first described by Sir Frank Holdsworth.[33] The existence of the unstable burst fracture, with complete disruption of the posterior elements and increased potential for neural injury was described by White-sides.[34] It is estimated that approximately 75% of patients with thoracolumbar injuries sustain some degree of neurological deficit.[35] These types of injuries are best treated by vertebral column decompression and stabilization.[36] The management plans differ among many of the researchers regarding operative[37,38] and non-operative[39,40] approaches.

Disadvantages of conservative treatment are deterioration in neurological status (17%),[41] progressive kyphotic deformity (20%),[42] persistent backaches,[43] decubitus ulcer and deep venous thrombosis.[44] These complications can be avoided by early mobilization and decreased hospital stay by early surgery.

Majority of patients in this study were young. The mean age was around 33.4 (± 8.4) years (age range 21-50). It is clear from many studies that young people suffer spinal injuries more often than any other age group. Out of 52 cases, 33 (63.5%) were male and 19 (36.5%) were females. Raja[36] showed 86% male patients in his series of 50 patients, similarly in other studies males are supposed to be more exposed to trauma than females.[45,46] Fall was the most common cause of injury in 31 (59.6%) cases which has also been observed in Raja study[36] but other study[47] showed road traffic accident is the common cause of injury.

Hyperflexion and axial loading was the common mode of injury observed. Most common level of involved was L1 (44.2%) followed by T12 (32.7%) in our study but Raja[36] showed 46% involvement of L1 and 12% involvement of D12, coinciding almost with our results. Other studies, Shah et al[48] and Hitchon et al,[49] also showed the common level of injury is D12–L1. Most common ASIA scale found in these types of fractures was ASIA scale E. It was also noted that more severe the canal compromise, worse the neurological deficit. Gerzbein[46] and Hitchon[49] also showed the similar scenario.

The thoracolumbar junction constitutes the transition zone between the rigid thoracic and the mobile lumbar spine. Vertebral fractures in this area are usually extremely unstable and kyphotic deformity is often of significant degree.[45] Therefore, inserting the screws only one level above and below the fractured segment might not have provided adequate stability. Gurr et al.[50] found that two levels above and below the injured level in an unstable calf spine model provided more stiffness than the intact spine. Katonis et al.[51] found that two levels above and one level below the fracture at the thoracolumbar junction and SSPF in the lumbar area provided stability and formed a rigid construct with no correction loss.

SSPF is frequently regarded as the procedure of choice because it offers advantages such as incorporating fewer motion segments in the fusion, shorter operative time and fewer blood transfusions. But without body reconstruction, SSPF has a 9–54% incidence of implant failure and re-kyphosis or the loss of reduction 50% to 90%.[14,45] To prevent this, several techniques have been developed to augment the anterior column in burst fractures. According to McCormack et al.[27] load sharing classification (LSC) in order to predict the prognosis of short segment fixation using posterior approach. They divided spine fractures into 3 categories according to the amount of damaged vertebral body, the spread of the fragments in the fracture site and the amount of corrected traumatic kyphosis; then, each category was scored from 1 to 3 according to the degree. When the total score is more than 6 points, they insisted that the long segment fixation, which fixes

Table II

Demographic features of the patients

	Pre-operative	Follow-up (after 1 year)
Visual analogue score	5.2 ± 1.1	1.7 ± 0.5
Oswestry disability index	54.8 ± 7.7	17.4 ± 12.4
Cobb angle	13.4 ± 6.3	8.5 ± 6.0
Kyphotic deformation of Vertebral body	5.1 ± 3.2	4.5 ± 4.0
Vertebral height (Beek Index)	0.6 ± 0.1	0.9 ± 0.2

the anterior approach are required.

Kana et al[52] reported that reduction of unstable thoracolumbar injuries can be achieved and maintained with the use of short-segment pedicle screw fixation including the fractured vertebra, avoiding the need for anterior reconstruction. Another two studies[23,24] have shown that by inserting screws at the fracture level, the construct will be biomechanically stronger; which in turn may omit the need for further anterior reconstruction, which has also been observed in our study. Farrokhi et al[53] showed similar clinical outcome in their study one level above and one level below excluding the fracture level (bridging group), or including the fracture level (including group) but high rate of instrumentation failure in the ''bridging'' group. The ''bridging'' group showed a mean worsening (29%) in kyphosis, whereas the ''including'' group improved significantly by a mean of 6%. The significant effect of the ''including'' technique on the reduction of kyphotic deformity was most prominent in Type C fractures. The fixation of burst fractures by posterior approach is generally conducted with posterolateral fusion or posterior fusion. However, Dai et al[32] and Ni et al[54] reported good results by using open or percutaneous pedicle screw fixation only without fusion in patients who have the thoracolumbar burst fractures with LSC scoring equal to or less than 6 points.

In our study all the post-operative follow-up X-ray has been evaluated by qualified radiologists with an interpretation of good alignment repositioning and restoration of the spinal column and post-operative correction of kyphotic deformity. We have shown that posterior decompression with posterior fixation including the fractured vertebra (PFFV) in short segment fixation of unstable thoracolumbar junction burst fractures good restoration of the sagittal curve is possible without loss of correction during the healing of the fracture. The mean kyphotic angle at pre-operative was 13.5 ± 6.3° and at 1 year final follow-up was 8.5 ± 6°. The average loss of kyphosis correction was 6.4° ± 5.2° at the final follow-up and we did not observe any significant loss of correction in this period, moreover no correlation was found between the final amount of kyphosis and the degree of pain reported. Jin-Woo Hur[7] showed 7.5 ± 4.4° correction loss which is comparable to our result. Another study showed loss of mean kyphosis angle was 11.6 ± 6.3° at the final follow-up.[52] In other study also demonstrated the successful repositioning, kyphosis correction, reliable fracture consolidation and neural decompression as well as good neurological recovery achieved via the dorsal approach,[55] although Verlan et al[56] concluded that no treatment is able to restore the morphology of the vertebral segment to normal physiological levels for thoracolumbar spine fractures. In our study the mean pre- and post-operative kyphotic deformation of vertebral body was 5.1 ± 3.2, 4.8 ± 2.3 and at final follow-up was 4.5 ± 4.0 (p>0.05). Kanna et al showed the mean pre-operative wedge angle was 23.0 ± 8.1°. This was corrected to 9.7 ± 6.2° (p=0.000) and there was a loss of kyphosis (mean 1.2°) in the follow-up period. The mean anterior and posterior vertebral height also showed significant improvements post-operatively, which were maintained at the final follow-up. The mean ODI and VAS scores at the end of 2 years were 17.5% and 1.6, respectively, which has also been observed in our study. Furthermore, according to the modified Mcnab criteria, we achieved satisfactory clinical outcomes (82.7%). Many surgeons believe that kyphotic deformity of the thoracolumbar spine precipitates poor clinical outcomes, but the relationship between these two factors is unclear. Some authors advocate that there is no proven association between kyphosis and back pain or functional impairment.[39,40]

There are some limitations of our study as the study population is small and we could not determine whether posterior decompression clears the canal adequately as the computed tomography scans were not performed post-operatively. Moreover, a long-term follow-up is required to assess any sort of loss of correction of kyphosis. Only the functional improvement and radiological alignment were considered and no co-morbid factors were evaluated regarding the outcome of the surgery.

Conclusion

Short-segment pedicle screw fixation including the fractured vertebral body has offered a better kyphosis correction, fewer instrument failures, without additional complications and improved biomechanical stability by providing additional fixation points which may aid in fracture reduction and kyphosis correction.

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