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

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Abstract
The objective of this study was to observe the outcome of short segment fixation of the unstable burst fracture in the thoracolumbar region. The study was conducted on 30 patients (age: 21-50 years) from February 2019 to August 2020 with thoracolumbar burst fracture (T10–L2). In Magerl Type A fractures, all underwent posterior pedicle screw fixation, including the fractured vertebra. The functional evaluation was done by Visual Analogue Score (VAS), Oswestry disability index (ODI), ASIA grade and radiologic parameters (Cobb angle, the kyphotic deformation and vertebral height) were recorded immediately preoperatively and at 3, 6 and 12 months then yearly. The presence of screw pullout, screw breakage, rod breakage and peri-implant loosening were evaluated as implant failure. Most of the fractures resulted from falls (21 cases), and the remaining from the road traffic accidents (9 cases). The fractured level was L1 in 13 patients, T12 in 9 patients, L2 in 6 patients and T11 and T10 in 2 patients. The modified McNab criteria were excellent in 18 cases, good in 11 cases and poor in 1. All patients showed improvement in mean kyphotic angle. Their pre-operative, post-operative and final follow-up mean kyphotic angle were 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 deformity of the vertebral body were 5.1±3.2, 4.8±2.3 and at final follow-up was 4.5±4.0 (p>0.05). Both posterior and anterior vertebral height improved significantly post-operatively with no significant loss of height at final follow-up. Functional outcomes mean ODI was 17.4% and VAS score was 1.7 at the end of one year. No complications were seen postoperatively and at final follow-up. In conclusion, short-segment pedicle screw fixation, including fractured vertebra was capable of reducing and maintain the reduction of unstable burst fractures of the thoracolumbar region.

Keywords: Short segment fixation, fractured vertebra, unstable burst fractures, thoracolumbar

Introduction
Thoracolumbar burst fractures are a common spinal injury where at least the anterior and middle columns of the spine are involved, caused by a vertical load, with or without flexion [1, 2]. These injuries are the second most frequent site of vertebral column injury in adults [3]. In this region, the rigid, kyphotic thoracic spine joints the more mobile, lordotic lumbar spine, which makes it particularly susceptible to injury [4]. An unstable fracture of the spine is one in which the anterior and middle columns fails in compression and the posterior osteoligamentous column is significantly disrupted [4]. The absolute indication for early surgery is progressive neurological deterioration [5]. 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 [6]. However, the treatment of thoracolumbar burst fractures is controversial where it ranges from bed rest alone, closed reduction and bracing, and open reduction with fixation. There is no consensus regarding the selection of treatment methods of fractures of varying severity [7-12]. The goal of the surgical management of unstable thoracolumbar burst fractures is to optimize 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 the same [9-11]. However, the posterior approach is less extensive [12]. Short-segment posterior fixation is the most common and simple treatment with the advantage of incorporation of fewer motion segments [4, 13]. Short-segment posterior fixation alone may lead 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 augmented [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 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 the 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
Thirty patients were included in this retrospectively study from BP K.I.H.S University in Nepal. The age range 21-50 years with thoracolumbar burst fracture (T10–L2) in Magerl Type A fractures underwent posterior pedicle screw fixation, including the fractured vertebra (PFFV) from February, 2019 to august, 2020 through all investigations and radiological data and interview at an 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°. 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.

Surgical Technique
Patients were placed in a prone position under general anesthesia with modified kneeling with two sandbags under each side of the trunk, which allowed the abdomen to hang free, minimizing epidural venous dilation and bleeding. Pedicle screw fixation and reduction were performed under C-arm guidance. Laminectomy to decompress the spinal cord was carried out at the involved level and ne was saved from being used as a bone graft. 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 was accomplished by the rod contouring and extension and compression-distraction forces before tightening the screws. Postero-lateral 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 thoracolumbosacral orthosis, post-operatively for 3 months. Clinical and radiological examinations were done on admission. X-ray 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. Clinical and radiographic follow-ups were done immediately after the operation and at 3, 6, and 12 months and every year after that. 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 postero-lateral fusion). Clinical parameters: back pain using Visual Analogue Score, disability using Oswestry disability index, 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 was considered as criteria for implant failure. Overall outcomes were evaluated using the modified Mcnab criteria at the last follow-up [19]. A p value of <0.05 was considered to be significant. All patients have given informed written consent.

Results
There were 23 males and 7 females with a male to female ratio were 3.29:1. Most of the patients were over 31 years old. The mean age was 33.4 (±8.4) within the range of 21–50 years. A maximum of 23 patients were manual workers and the rest of 7 patients were sedentary work.

The majority of fractures were due to falls (23 cases). The remaining cases were due to car accidents (7 cases). The fractured vertebra body level was L1, T12, L2, T11, and T10 in 13, 9, 6, 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. Post-operative X-ray showed good hardware position in all patients. No hardware failure was detected. Adequate decompression was achieved in all the cases. No significant loss of correction was observed.

The mean duration of surgery was 2 hours, whereas the mean blood loss was 300 mL. The mean post-operative hospital stay was 8.6 days (range 7-15 days) and all the patients were mobilized on the 1st or 2nd post-operative day and achieved satisfactory clinical outcomes according to the modified Mcnab criteria 18 (60%), 11 (36.6%), 1(3.33%), and cases were considered to have excellent, good, f, 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 the 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 significant improvements post-operatively and were maintained at the final follow-up.

The mean pre-operative VAS and ODI scores were 5.2±0.1 (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.

There was no case of major complication after surgery and during the follow-up period except in three cases where superficial wound infections occurred and that were managed conservatively and cured. All patients with incomplete neurologic injuries improved one ASIA scale. At
presentation, 6 patients (20%) were ASIA scale C, 11 patients (36.6%) were ASIA scale D and 13 (32.5%) were E. In the last follow-up visit, among 30 patients,

**Pre-operative X-ray**

![Pre-operative X-ray](image1)

![Pre-operative X-ray](image2)

![Pre-operative X-ray](image3)

![Pre-operative X-ray](image4)

**Post-operative x-rays (Immediate and after one year)**

![Post-operative x-rays](image5)

![Post-operative x-rays](image6)

![Post-operative x-rays](image7)

**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 [53]. The existence of the unstable burst fracture, with complete disruption of the posterior elements and increased potential for neural injury, was described by Whitesides [44]. It is estimated that approximately 75% of patients with thoracolumbar injuries sustain some degree of neurological deficit [30]. These types of injuries are best treated by vertebral column decompression and stabilization [50]. 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.

The majority of patients in this study were young. The age is between 21-50 years. It is clear from many studies that young people suffer spinal injuries more often than any other age group. Out of 30 cases, 23 (76.6%) were male and 7 (23.3%) 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 the Raja study [36] but another study [47] showed road traffic accident is the most common cause of injury.

Hyperflexion and axial loading was the common mode of injury observed. The most common level of involvement was L1 (43.3%), followed by T12 (30%) in our study but Raja [36] showed 46% involvement of L1 and 12% involvement of D12, coinciding almost with our results. In other studies, Shah et al. [48] and Hitchon et al., [49] also showed the common level of injury is D12–L1. The most common ASIA scale found in these types of fractures was ASIA scale E. It was also noted that the more severe the canal compromise, the worse the neurological deficit. Gerzbein [46] and Hitchon [49] also showed a 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 a 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 kyphosis or the loss of reduction of 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 a 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 at least more than two segments of above and below the fracture site, or the anterior reconstruction with the anterior approach are required.

Kana et al. [52] reported that the 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, 54] 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 outcomes in their study one level above and one level below, excluding the fracture level (bridging group), or including the fracture level (including group) but a 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 reducing 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 the 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 Hur7 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. In another 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 the 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 1 year which has also been observed in our study. Furthermore, according to
the modified Menab 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. 

There are some limitations of our study as the study population is small and we could not determine whether posterior decompensation 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 short of loss of correction of kyphosis. Only the functional improvement and radiological alignment were considered. And evaluated regarding the outcome of the surgery.

**Conclusion**

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

**References**