Anterior decompression with single segmental spinal interbody fusion for Denis type B thoracolumbar burst fracture: a midterm follow-up study

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Abstract

Purpose Our goal was to observe the midterm results of a case series of Denis type B thoracolumbar burst fracture treated with anterior decompression with single segmental spinal Interbody fusion.

Methods Twenty patients with Denis type B thoracolumbar burst fractures underwent anterior decompression with single segmental spinal Interbody fusion. They underwent clinical and radiologic follow-up for at least three years after the surgery.

Results The mean follow-up period lasted 57 months. To the last follow-up, there were no cases of internal fixation loosening, failure and other complications. Titanium mesh or interbody bone grafts were in good position. Spinal kyphosis was not observed. Interbody fusion was achieved for all cases. The average fusion time was 4.5 months. Based on visual analogue scale (VAS) pain scores, percentage of vertebral body height loss and Cobb angle, the difference was statistically significant between the preoperative period and postoperative one year or final follow-up ($P < 0.05$). Results at postoperative one year and final follow-up were better than the preoperative period. However, the difference was not significant between postoperative one year and final follow-up ($P > 0.05$).

Conclusions Good midterm results on clinical and radiologic evaluation of anterior decompression with single segmental spinal Interbody fusion for suitable patients with Denis type B thoracolumbar burst fracture can be achieved. The incident rate of relative complications is low.

Keywords Thoracolumbar spine · Burst fracture · Denis type B · Anterior decompression · Single segmental fusion · Midterm result

Introduction

Anterior decompression with stabilisation is one of the established methods for treating patients with thoracolumbar burst fractures [1, 2]. This method allows complete decompression under direct visualisation without manipulation of the dural tube. However, patients with Denis type B in which the superior endplate is mainly involved can tolerate one-segment fixation to preserve the disc below [3, 4], because the lower half of the injured vertebral body sometimes escapes injury. The total flexibility of the lumbar spine is lower than normal after single-level fusion and is decreased even further after two-level fusion. Clinical or biomedical studies of the anterior decompression with single segmental spinal Interbody fusion in Denis type B thoracolumbar burst fractures have shown encouraging results [3–6]. However, midterm and long-term clinical results on this technique are few. The purpose of our study was to assess midterm results of a case series of Denis B thoracolumbar burst fracture treated with anterior decompression with single segmental spinal Interbody fusion.

Materials and methods

Patients

From 2004 to 2009, 20 patients with Denis type B thoracolumbar burst fractures underwent surgery at the authors' institution in which anterior decompression with single segmental spinal Interbody fusion was performed. The fractures were classified according to Denis [7] and are shown in Table 1.

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Table 1 Denis classification

Classification type	Description
Type A	<ol style="list-style-type: none"> 1. Fracture of both end plates without kyphosis 2. Mechanism of injury: pure axial load 3. Predilection site: low lumbar region
Type B	<ol style="list-style-type: none"> 1. Fracture of the superior end plate [computed tomography (CT) may also demonstrate a sagittal split of the lower end plate] 2. Most frequent type of burst fracture 3. Mechanism of injury: axial load and flexion 4. Predilection site: thoracolumbar junction
Type C	<ol style="list-style-type: none"> 1. Fracture of the inferior end plate 2. Rare 3. Mechanism of injury: probably axial load and flexion 4. No particular site pattern identified
Type D	<ol style="list-style-type: none"> 1. Burst rotation fracture 2. Burst fracture with comminution of the vertebral body, large central defect on CT, loss of posterior height, increase of the interpediculate distance, vertical fracture of lamina, bone retropulsed into the spinal canal 3. Mechanism of injury: axial load and rotation 4. Predilection site: midlumbar region
Type E	<ol style="list-style-type: none"> 1. Burst lateral flexion fracture 2. Fractured posterior wall of the vertebral body with fragment extrusion towards the side of the flexion 3. Mechanism of injury: axial load and lateral flexion

The experimental group comprised 12 men and eight women. Mean age at the time of surgery was 41.5 (range, 28–55) years. Of these patients, 12 sustained their injuries in a fall and eight in traffic accidents. The fractured site was at T12 in five patients, L1 in 11 and L2 in four. Fifteen patients underwent surgery within one month after injury; initially, five patients were treated conservatively in another hospital and underwent surgery between one and two months after injury in our hospital.

All patients were examined radiologically before surgery based on computed tomographic (CT) scans and sagittal tomograms or plain radiographs. For all patients, canal compromise was >50 %; there were no osteoporotic spines (T score on bone mineral densitometry >1.0). There were no intervertebral narrowings, osteophytes or other degenerative manifestations in the above or below adjacent segments. Neurologically, five patients had Frankel grade B [8], six Frankel grade C and nine Frankel grade D before surgery. The spinal canal of all patients was decompressed by discectomy and semivertebrectomy in the upper half of the vertebral body. The single level was fused, because there was neither a crush fracture nor a wide cleavage fracture >2-mm wide in the lower half of the vertebral body. All patients were followed up for at least three years.

Surgical technique

All procedures were performed by the same senior surgeon using a left extrapleural–retroperitoneal approach with the patient in the lateral position. The involved vertebral body and the upper adjacent vertebral body were exposed. The disc above the injured vertebra and the upper half of the crushed vertebral body were removed, but the posterior longitudinal ligament was preserved. Reconstruction of the ventral column was performed with an adjusted autologous tricortical iliac crest bone graft or titanium mesh cage packed with local autograft, and the use of titanium screws and rods. Screws for the damaged vertebra were inserted as adjacent as possible to the end plate. If screws for the inferior half of the involved vertebral body could not be fixed solidly, single segmental fusion was abandoned, and the crushed vertebral body was excised totally and stabilised with the vertebra below, changing to the two segmental fusion. The conventional technique for correction of the kyphotic deformity was applied, with a spreader between the upper and lower screw heads. To prevent loosening of the lower screws, correction was performed with the spreader applied to the anterior intervertebral space. The two rods were applied with considerable compression force. On postoperative day three, after removal of the suction drain, patients were allowed to ambulate in a thoracolumbosacral orthosis (TLSO) brace, which was used for three months after operation.

Assessment methods

Follow-up examinations were performed at three, six and 12 months and yearly thereafter. The kyphosis angle was the percentage of vertebral body height loss measured on lateral radiographs with the patient in the neutral position before and one year after surgery and at the time of the final follow-up examination. The kyphosis angle (Cobb angle [9]) was measured from the superior end plate of the vertebral body just above the fracture to the inferior end plate of the fractured vertebral body. The percentage of vertebral body height loss was reported as fractions of anterior height between fractured vertebra and normal height of the adjacent vertebra below the fractured vertebra [10]. Other parameters of interest were the visual analogue scale (VAS) pain score [11], Frankel grade and adjacent segment degeneration (University of California at Los Angeles Grading Scale [12]), which were also evaluated at final follow-up.

Statistical analysis

Statistical analysis, including mean values and standard deviations (SD), was performed using SPSS software (SPSS, Chicago, IL, USA). Comparison between preoperative and postoperative data was done using the paired *t* test. The size of test took bilateral $\alpha=0.05$.

Results

Perioperative data

Average operative time was 139 min (range 120–158 min). Average intra-operative blood loss was 650 ml (350–950 ml). Pedicle screws were accurately placed in all cases. There were no intra-operative complications of neurovascular injury and no significant complications or neurological deterioration after screw insertion. All incisions healed by first intention.

Radiological outcome

All patients were followed up for a mean of 57 (range, 36–78) months. Bone grafts in all patients thoroughly fused, with a fusion time ranging from three to six (mean 4.5) months; no nonunion, pseudarthrosis, internal fixation loosening or rupturing were found through the final follow-up (Fig. 1).

Posterior–anterior (Fig. 1a) and lateral (Fig. 1b) radiographs in this patient were obtained before surgery. CT, scan sagittal view (Fig. 1c), before surgery shows canal compromise before surgery was >50 %. Magnetic resonance imaging (MRI), sagittal view, before surgery shows lumbar intervertebral disc injury between L1 and L2 and significant compression of dural sac and spinal cord as a result of posterolateral fracture fragments. The patient underwent an anterior approach and single segmental

spinal Interbody fusion. Twenty patients initially received the single-level fusion. However, this was converted to the double-level fusion in two patients. Anteroposterior (Fig. 1e) and lateral (Fig. 1f) radiographic views at one year after surgery revealed that the height of the injured segment was restored. Anteroposterior (Fig. 1g) and lateral (Fig. 1h) radiographic view at final follow-up (three years after surgery) revealed that the reconstructed height of the injured segment was maintained.

Based on Cobb angle and percentage of vertebral body height loss (Table 2), the difference was statistically significant between the preoperative period and postoperative one year or final follow-up ($P < 0.05$). Cobb angle and percentage of vertebral body height loss at the last follow-up increased slightly but not significantly compared with the postoperative one year follow-up ($P > 0.05$). According to University of California at Los Angeles Grading Scale criteria, at final follow-up, adjacent segment degeneration was not observed.

Clinical outcome

VAS pain scores demonstrated a significant variation between pre- and one year postoperative or final follow-up ($P < 0.05$), but significant differences were not found between results at one year postoperatively and final follow-up ($P > 0.05$) (Table 2). Neurologically, Frankel grades 1 or 2 improved in all cases after surgery (Table 3).

Fig. 1 A 49-year-old patient with L2 burst fracture treated with anterior approach and single segmental spinal Interbody fusion without a cage. **a** Posterior–anterior radiograph obtained before surgery. **b** Lateral radiograph obtained before surgery. **c** Computed tomography (CT) scan, sagittal view, before surgery. **d** Magnetic resonance imaging (MRI), sagittal view, before surgery. **e** Anteroposterior radiographic view one year after surgery; lateral view one year after surgery. **f** Anteroposterior radiographic view at final follow-up; lateral view at final follow-up

Table 2 Cobb angle, percentage of vertebral body height loss and visual analogue scale (VAS) pain scores ($n=20$)

	Preoperative period	Postoperative 1 year	Final follow-up
Percentage of vertebral body height loss (%)	46.3±3.5	17.4±2.8*	19.1±3.0*
Cobb angle (°)	35.8±5.9	9.08±4.8	11.8±5.1
VAS pain scores (points)	8.5±1.8	2.3±1.2*	2.2±1.3*

* Compared with preoperative period, $P<0.05$

Discussion

Denis [7] classified spinal fractures according to a three-column model and defined burst fractures as being when both the anterior and middle columns were involved. The type B fracture is the one of the most common type of burst fractures. The question as to how these fractures should be approached and stabilised (anteriorly or posteriorly) has been the subject of debate. Some authors have confirmed that direct decompression of the middle column can be done through the posterior approach [13]. However, It is generally believed that canal decompression is limited by and often incomplete with the posterior approach when treating thoracolumbar fractures associated with neurologic deficit. Decompression followed by placement of a structural bone graft and anterior instrumentation have allowed direct reconstruction of the weight-bearing column and fusion of the column. Neurologic deficit was caused by impact and compression to the ventral surface of the spinal cord in most patients with thoracolumbar fractures, and the anterior approach provided optimal direct exposure for visualisation of the ventral aspect of the dura mater during surgical decompression [1, 14]. Such a procedure would offer patients with neurologic deficit a better chance of improving than when using other procedures, even though this technique is surgically more challenging and has a greater potential for complications [13].

In addition to approach, the number of fusion segments is also in dispute for single thoracolumbar fractures. Superior and inferior adjacent segmental spinal Interbody fusion have been widely applied in clinical practice. Because fusion segments

using this technique were longer, patients suffered from many complications in the long term, such as intractable low back pain, limitation of lumbar mobility and degenerative disease of adjacent vertebrae. Some authors believe that patients with Denis type B fracture could undergo one-segment fixation to preserve the inferior intervertebral disc [15, 16]. However, lumbar motion in patients with single-segment fusion will be lower than normal but higher than with a two-segment fusion [15]. Furthermore, the pressure of lumbar intervertebral discs at adjacent levels in single segmental fusion was significantly lower than with two-segment fusion [16].

Theoretically, there are advantages to performing decompression of the spinal canal directly and an arthrodesis of only one vertebral level cephalad to the fracture, as well as providing immediate internal fixation. Wei et al. [17] reported single-level pedicle instrumentation can provide parallel instant stability as well as two-level instrumentation in the reconstruction of unstable spine models. Moreover, Ou et al. [3] found that as long as indication is correctly chosen, anterior finite decompression with adjacent vertebral segment internal fixation and intervertebral body fusion can attain strong bony fusion and satisfactory reduction, and obviously reduce the incidence rate of refractory low back pain and of adjacent intervertebral disc degeneration. Results of the study reported here, although conducted on only a few patients, indicate that anterior decompression with single segmental spinal interbody fusion for Denis type B lumbar burst fracture does not result in degeneration of the adjacent disc. Therefore, we believe there must be many patients who should undergo single segmental interbody fusion to preserve a mobile segment.

Many studies have reported the indications for this technique [3–5]. From results of related studies [3–5], we believe that patients with type B thoracolumbar burst fractures can receive a single-segment fixation if the following states were encountered:

1. Degree of compression in the anterior half of the injured level is half or less
2. Canal compromise before surgery from fracture fragments of the superior endplate is >50 %
3. Preoperative CT examination reveals normal bone structure in the lower parts of the injured vertebral body, with no obvious splitting
4. Patients do not have an osteoporotic spine so that screw fixation strength is not impacted

Studies reporting early results of single segmental interbody fusion show this technique can effectively decompress the vertebral canal and maintain spinal stability when treating Denis type B fractures [3–5]. However, few studies report mid- and long-term clinical effects of this technique. In this study, we observed midterm effects of single segmental interbody fusion in treating Denis type B thoracolumbar burst fracture. We demonstrate that patients had completed bone

Table 3 Neurological function outcomes (Frankel grade)

Preoperative period	Final follow-up				
	A	B	C	D	E
A	–	–	–	–	–
B	–	–	1	3	1
C	–	–	–	4	2
D	–	–	–	–	9

union within six months after surgery, low pain score, reconstructed height of the injured segment and no failure of internal fixation on radiographs through an average follow-up of 57 months. Our results suggest that Denis type B thoracolumbar burst fractures were treated successfully with anterior decompression using single segmental spinal Interbody fusion, achieving excellent or good midterm results.

In terms of the limitations of this study, all surgeries were carried out by a single surgeon, which may lead to biased interpretations of data. Also, the study group was small, limiting statistical power. Timing of surgery was not uniform between patients. Many fractures were chronic by the time some patients received surgery. Furthermore, this study lacks randomisation, leading to an inhomogeneous distribution of fracture patterns and individual treatment strategy. The differences in clinical effects between single and long segmental spinal Interbody fusion in patients with Denis type B thoracolumbar burst fractures require further studies.

In conclusion, good midterm clinical and radiologic evaluation results of anterior decompression with single segmental spinal Interbody fusion for suitable patients with Denis type B thoracolumbar burst fracture can be achieved. The incident rate of relative complications from this technique is low.

Conflict of interest None.

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References

1. Zahra B, Jodoin A, Maurais G, Parent S, Mac-Thiong JM (2012) Treatment of thoracolumbar burst fractures by means of anterior fusion and cage. *J Spinal Disord Tech* 25:30–37. doi:10.1097/BSD.0b013e31820bb0a9
2. Kang CN, Cho JL, Suh SP, Choi YH, Kang JS, Kim YS (2013) Anterior Operation for Unstable Thoracolumbar and Lumbar Burst Fractures: Tricortical Autogenous Iliac Bone Versus Titanium Mesh-Cage. *J Spinal Disord Tech* Epub ahead of print. doi:10.1097/BSD.0b013e3182867489
3. Tosounidis T, Kanakaris N, Nikolaou V, Tan B, Giannoudis PV (2012) Assessment of lateral compression type 1 pelvic ring injuries by intraoperative manipulation: which fracture pattern is unstable? *Int Orthop* 36:2553–2558. doi:10.1007/s00264-012-1685-4
4. Spiegl U, Hauck S, Merkel P, Bühren V, Gonschorek O (2013) Six-year outcome of thoracoscopic ventral spondylodesis after incomplete cranial burst fractures of the thoracolumbar junction: ventral versus dorso-ventral strategy. *Int Orthop* 37:1113–1120. doi:10.1007/s00264-013-1879-4
5. Chen Y, He Z, Yang H, Wang X, Chen D (2013) Clinical and radiological results of total disc replacement in the cervical spine with preoperative reducible kyphosis. *Int Orthop* 37:463–468. doi:10.1007/s00264-012-1754-8
6. Pu X, Zhou Q, He Q, Dai F, Xu J, Zhang Z, Branko K (2012) A posterior versus anterior surgical approach in combination with debridement, interbody autografting and instrumentation for thoracic and lumbar tuberculosis. *Int Orthop* 36:307–313. doi:10.1007/s00264-011-1329-0
7. Denis F (1976) The three column spine and its significance in the classification of acute thoracolumbar spinal injuries. *Spine* 8:817–831
8. Frankel HL, Hancock DO, Hyslop G, Melzak J, Michaelis LS, Ungar GH, Vernon JD, Walsh JJ (1969) The value of postural reduction in the initial management of closed injuries of the spine with paraplegia and tetraplegia. I. Paraplegia 7:179–192. doi:10.1038/sc.1969.30
9. Okuyama K, Abe E, Chiba M, Ishikawa N, Sato K (1996) Outcome of anterior decompression and stabilization for thoracolumbar unstable burst fractures in the absence of neurologic deficits. *Spine* 21:620–625
10. Kim HY, Kim HS, Kim SW, Ju CI, Lee SM, Park HJ (2012) Short Segment Screw Fixation without Fusion for Unstable Thoracolumbar and Lumbar Burst Fracture : A Prospective Study on Selective Consecutive Patients. *J Korean Neurosurg S* 51:203–207. doi:10.3340/jkns.2012.51.4.203
11. Wood KB, Bohn D, Mehbod A (2005) Anterior versus posterior treatment of stable thoracolumbar burst fractures without neurologic deficit: a prospective, randomized study. *J Spinal Disord Tech* 18:S15–23
12. Madadi F, Yazdanzhenas H, Madadi F, Bazargan-Hejazi S (2013) Double acetabular wall-a misleading point for hip arthroplasty: an anatomical, radiological, clinical study. *Int Orthop* 37:1007–1011. doi:10.1007/s00264-013-1780-1
13. Suzuki T, Abe E, Miyakoshi N, Murai H, Kobayashi T, Abe T, Kikuchi K, Shimada Y (2012) Anterior Decompression and Shortening Reconstruction with a Titanium Mesh Cage through a Posterior Approach Alone for the Treatment of Lumbar Burst Fractures. *Asian spine journal* 6:123–130. doi:10.4184/asj.2012.6.2.123
14. Yan D, Wang Z, Lv Y, Baiyila B, Li J (2012) Anterior versus posterior surgical treatment of unstable thoracolumbar burst fracture. *Eur J Orthop Surg Tr* 22:103–109
15. Luk KD, Chow DH, Evans JH, Leong JC (1995) Lumbar spinal mobility after short anterior interbody fusion. *Spine* 20:813–818
16. Denozieri G, Ku DN (2006) Biomechanical comparison between fusion of two vertebrae and implantation of an artificial intervertebral disc. *Journal of biomechanics* 39:766–775. doi:10.1016/j.jbiomech.2004.07.039
17. Wei F, Liu S, Liang C, Zhao W, Chen B (2008) Biomechanical evaluation of single-level pedicle instrumentation in management of thoracolumbar fracture. *Biom Eng Clin Med* 12:85–89