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Case Report

Modified surgical treatment of thoracolumbar burst fractures with neurological deficit: subtotal corpectomy with single-segment titanium mesh fusion and internal fixation through posterior approach

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Abstract: Inferior endplate of injured vertebrae are found almost intact in large amount of thoracolumbar burst fractures with neurological deficit. For this type of fractures, we designed a modified surgical treatment, which is a subtotal corpectomy via foramen-pedicle for single-segment titanium mesh fusion and internal fixation through posterior approach. Forty-five patients were treated in this study. The measurements of sagittal cobb angle, percentage loss of the vertebral body height and percentage of the spinal canal compromise preoperatively and postoperatively were compared. The outcome assessment were evaluated with Frankel grade and Asia motor score. Minimum follow-up was 12 months. The loss rates of vertebral body heights, cobb angles and the spinal canal obstruction were restored significantly at postoperative period. The mean cobb angle was (5.71±2.04) and the mean percentage of the spinal canal obstruction was (10.80±3.63)% in the latest follow-up and the mean Asia motor score before and after the operation was 39.8, 79.4, which all showed obvious significance ($P<0.05$). Almost all patients had obvious recovery according to the Frankel rating, Except for one patient with serious canal compression and severe spinal cord injury observing by CT and MRI. No implant sinkage, breaking or loosening of screw occurred in the latest follow-up. This surgical technique is an ideal and reliable treatment for most thoracolumbar burst fractures with neurological deficit which has intact inferior endplate.

Keywords: Thoracolumbar burst fractures, orthopedic procedures, spinal fusion

Introduction

Thoracolumbar burst fractures are the most common injuries of the spine, which could lead to vertebral collapse, neurological deficit and kyphotic deformity. Patients suffering from these fractures often require surgical treatment to alleviate serious symptoms and improve the quality of life. The aims of surgical treatment are to obtain spinal canal decompression, restore body height and alignment/stabilize the column of the spine.

There are three approaches to treat these types of fractures: anterior, posterior and combined anterior-posterior approach [1-3]. The anterior approach and combined anterior-posterior approach provide excellent anterior fusion and sufficient decompression of spinal canal but with more blood loss and surgical time. The posterior approach has been developing in recent years. Traditional treatment using posterior pedicle screw fixation could offer the protection against spinal malalignment without neurological deficit. Moreover, this operation has a higher incidence in the failure of early internal fixation, progressive deformity and screw breakage [4, 5]. The main reason, according to Denis' three-column theory, is possibly correlated with imbalance in load-sharing of the three spinal columns [6]. To prevent this failure, some authors considered other methods, such as pedicle screw fixation plus augmentation vertebroplasty, transpedicular placement of distractable cage with screw instrumentation through posterior approach and so

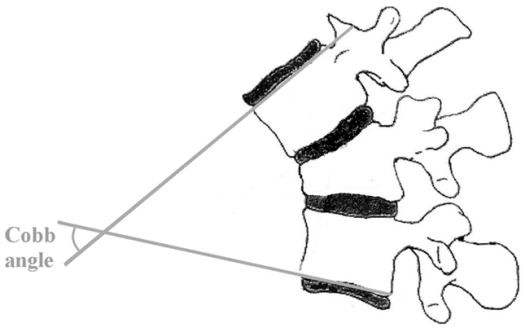

Figure 1. Cobb angle: The sagittal cobb angle was measured by the superior endplate of the vertebral body above the fractured vertebrae and the inferior endplate of the vertebral body below the fractured.

on [4, 7, 8]. Although many literatures give some procedures for the surgical treatment, there are still no clear literatures available for surgeons to choose an optimal technique for thoracolumbar burst fractures [9].

Referring to a large number of literatures [6, 10], inferior endplate of injured vertebra is found almost intact in large amount of burst fractures. Therefore, we design a modified surgical procedure: subtotal corpectomy via foramen-pedicle for single-segment titanium mesh fusion and internal fixation through posterior approach. The purpose of this article is to investigate the efficacy of our method for some types of thoracolumbar burst fracture with neurological deficit.

Material and methods

Ethics statement

This study was approved by the Ethics Committee of Hospital. Informed consent was obtained from all subjects recruited for this study prior to participation.

Patients and methods

From November 2009 to December 2014, 45 patients suffered from thoracolumbar burst fractures with neurological deficit were identified and included in this study. The mean follow-up time was 38 months (range, 12-81 months). The study includes 32 male and 13 female. Mean age was 46 years (range, 17-74 years). The mechanism of this injury was motor vehicle accidents in 11 cases, falls from heights in 23 and crush-related injuries in 11. The fractures happened at L3 in 2 cases, at L2 in 11, at L1 in 22, at T12 in 7 and at T11 in 3. According to the AO classification [11], 35 patients belonged to type A (subtype A3.1 in 28 patients, subtype A3.2 in 7 patients), 10 patients belonged to type B (subtype B1.2.1 in 10 patients). By the Frankel system for neurological function, there were 3 cases of grade A, 11 cases of grade B, 17 cases of grade C and 14 cases of grade D. The mean time between injury and operation was 2.6 days (range, 1-7 days). All the patients were treated by antibiotics, neurotrophic drugs and hormones postoperatively. They were managed with bed rest for 5 or 7 days. 31 cases were receiving hyperbaric oxygen treatments in about a week after operation. The decannulation time was within 3 days. Sutures were removed at 12-14 days. All patients used hyperextension braces for 3 months and were required to take the suitable waist musculi dorsi function exercise.

The preoperative, postoperative, and follow-up radiographs were evaluated. The analysis included measurements of the sagittal cobb angle, the percentage loss of the vertebral body height and the percentage of the spinal canal compromise. The percentage of the spinal canal compromise was estimated on the preoperative computed tomography (CT) scan by measuring the available sagittal diameter of the spinal canal of the fractured vertebrae and the average of the diameter of the canal space above and below the injured level. The sagittal cobb angle was measured by the superior endplate of the vertebral body above the fractured vertebra and the inferior endplate of the vertebral body below the fractured (**Figure 1**). The percentage loss of the vertebral body height was figured out by dividing the height of the fractured corpus by the average height of the vertebrae above and below fractured and then minus this number from 100%.

Surgical technique

The patients were placed on the operating table in prone position, with procedures performed under general anesthesia with endotracheal intubation. A posterior longitudinal midline incision centered on the affected level is made to expose the lamina and articular process of the vertebrae, including the fractured

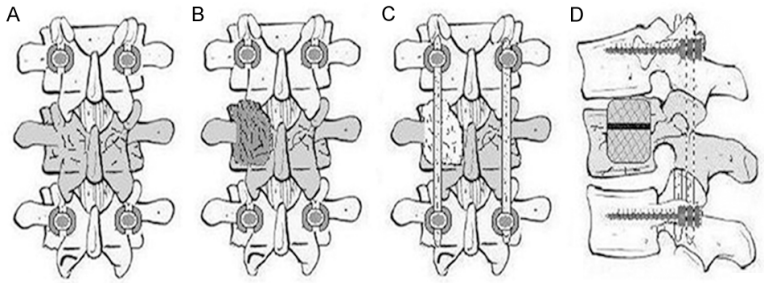

Figure 2. Diagram illustrating the procedure. A: 4 pedicular screws were placed bilaterally in the vertebrae above and below the fractured. B: Facetectomy was performed at the superior facet joints of the fractured vertebrae and interior facet joints of the upper adjacent vertebrae. The lamina and the pedicle of the damaged vertebra were completely removed. C: The posterior lateral two thirds of the fractured corpus was totally evacuated. The inferior endplate and parts of the cancellous bone of the fractured corpus were remained. Discectomies were performed at the upper disc space of the fractured vertebrae. Partial restoration of vertebral body height was obtained by the posterior stabilization system. D: Cage fixed in the fractured vertebrae by the posterior stabilization system.

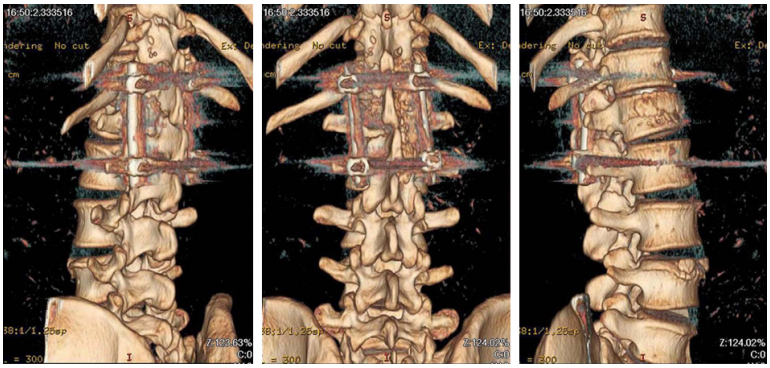

Figure 3. Postoperative neuroimaging of a 44-year-old man was done in CT three-dimensional reconstruction.

vertebra, the vertebrae above and below the fractured. Four pedicular screws were placed bilaterally in the vertebrae above and below the fractured (**Figure 2A**). According to the transverse section of CT scans, one side of the transverse processes of the fractured vertebra, which had serious vertebral canal compression, was dissected off of the pedicle, but not removed. On this side, facetectomy and lamnectomy was performed with care taken to decompress vertebral canal by a standard posterior subperiosteal dissection. After exposing the lateral portion of the thecal sac, the pedicle of the fractured vertebra was also removed (**Figure 2B**). Through the foramen-pedicle gaps formed after pedicles resection, the posterior two thirds of the vertebral body were partly evacuated. Direct remodeling of spinal canal initially was performed by tapping the retropulsed fracture fragment into the vertebral body through a posterior approach carefully. The fractured vertebra was hollowed out and the inferior endplate and parts of the cancellous bone of the fractured corpus were remained. The resection should be enough to place the titanium mesh. Discectomies were performed at the upper disc space of the fractured vertebra. The cartilage endplate of the upper neighboring vertebral body was shaved, but the bone endplate was retained. Then, the restoration of vertebral body height was obtained by distraction of the pedicle screws on the rods (**Figure 2C**). With the thecal sac and nerve root carefully protected, the appropriate titanium mesh with the autogenous bone fragments was inserted into the space of the fractured vertebra. The surgeon ensured the cage correctly inserting into the hemivertebrectomy cavity under intraoperative fluoroscopic guidance. The cage was fixed between the inferior endplate of the upper vertebral body and the inferior endplate of the fractured vertebra (**Figure 2D**). Finally, the pedicle screw-rod system was fixed firmly. The redundant cancellous bone was implanted around the titanium mesh and pedicle screw-rod for surrounded three-dimensional fusion. The wound was cleaned up completely, a drain was placed and then the muscle, fascia and skin were sutured in standard operations (**Figure 3**).

Statistical analysis

Data was analyzed by SPSS version 18.0 (SPSS Inc., USA). All measurement data are presented as the mean ± SD (standard deviation). Statistical analysis was performed with paired t test for changes of each radiographic parame-

Table 1. The loss rates of vertebral body heights, Cobb angles and Canal compromise preoperatively, postoperatively and at the latest follow-up (measured as mean ± SD)

Item	Preoperative	Postoperative	Latest follow-up
Loss of anterior column height (%)	40.62±13.42	5.25±2.76*	8.90±2.87*
Loss of middle column height (%)	24.67±6.63	3.63±2.15*	6.69±2.50*
Loss of posterior column height (%)	3.71±1.27	1.79±0.72	2.38±0.86
Cobb angle (°)	18.38±5.96	3.16±1.74	5.71±2.04*
Canal compromise (%)	68.67±10.28	10.80±3.63	

*, P<0.05, versus the preoperative group.

Table 2. Neurologic function of Frankel grade for 45 patients

	Preoperative neurologic status (no. of patient)				
Postoperative neurologic status	E	D	C	B	A
E		14	12		1
D			5	7	1
C				3	1
B				1	
A					

ter and correlation coefficient (R) for comparison between changes of different parameters. The *p*-value <0.05 were considered significant.

Results

All patients were transferred to the ward safely after surgery. The mean operative time was 129 minutes (range, 100 to 210 minutes). The mean blood loss was 829 mL (range, 400 to 1600 mL).

The loss rates of vertebral body heights and Cobb angles before and after surgery compared with the latest follow-up showed obvious significance (**Table 1**). The level of significance was set at P<0.05. The mean percentage of the spinal canal obstruction was (68.67±10.28)% (range, 45%-90%) preoperatively. The mean percentage of the spinal canal obstruction was (10.80±3.63)% (range, 5%-19%) postoperatively. Neurological function improved by at least one Frankel grade in all patients except one who still remained at Frankel grade B (**Table 2**). The mean AMS before and after the operation was 39.8, 79.4, also showed obvious significance. There is no screw breakage, no internal fixation looseness and no implant sinkage occurred among any of the patients at the time of the latest follow-up (**Figures 4**, **5**).

Discussion

According to the Denis three-column theory, we predict an ideal therapeutic program that should take into account the stress balance of anterior-middle-posterior spinal column, restore the height of vertebral body and three dimensional sequences. Simple posterior pedicle instrumentation after spinal decompression has a high prevalence of secondary deformity or internal fixation failure [12]. The reason is that most of the anterior vertebral load stress is concentrated on the pedicle screw, which could induce the early failure of internal fixation, secondary deformity and long-term nerve damage [13]. Accordingly, some scholars advocate anterior or combined anterior and posterior approach operation for vertebral resection decompression and reconstruction of vertebral height, however, it has a higher traumatic risk, more blood loss and greater influence on abdominal organs [7, 14].

In recent years, posterior pedicle fixation combined with vertebroplasty or corpectomy/mesh fusion for treatment of unstable thoracolumbar burst fractures continue to be reported [15-17]. These methods could not only achieve the spinal canal decompression and correction of kyphosis, but enhance the long-term stability of anterior column. Compared the above operations, only unilateral vertebral facet and pedicle are resected in our method. The anterior longitudinal ligament remains intact and part of the posterior longitudinal ligament was preserved, which is less damage for the middle-posterior column structure and posterior ligamentous complex. With titanium mesh replacing the fractured corpus, it shares the load over the posterior system [18]. Three-column stabilization was obtained. In addition, compared to the two-segment fusion adopted by the above methods, our technique is a single-segment interbody fusion, which retains normal intervertebral disc between the fracture vertebra and

Figure 4. A 44-year-old male who had a burst fracture at the first lumbar vertebra, with a neurological loss of Frankel grade C on admission. A: Preoperative lateral radiograph. Cobb angle was 25°. B: This patient underwent surgery 4 days after admission. This lateral radiograph was taken 3 days after the operation. Cobb angle was corrected to 4°. C: Standing lateral radiograph taken 18 months after the operation showing re-establishment of sagittal alignment. Cobb angle was corrected to 9°. D: Standing lateral radiograph taken 2 years after surgery showing maintenance of sagittal alignment. Cobb angle had slightly deteriorated to 11°. This patient had recovery of neurological loss of Frankel grade from C to E.

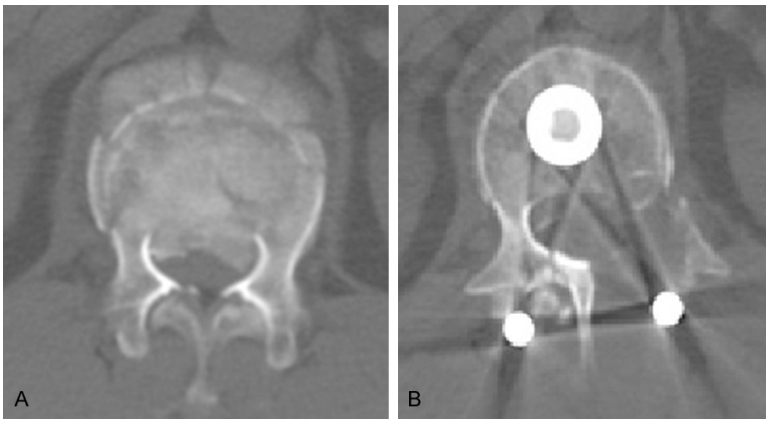

Figure 5. A 44-year-old male who had a burst fracture at the first lumbar vertebra, with a neurological loss of Frankel grade C on admission. A: Preoperative CT scan demonstrated a spinal canal narrowing of 67%. B: Postoperative CT scan demonstrated a spinal canal narrowing of 12% after surgery.

inferior adjacent vertebra. Multi-segment fusion or intervertebral disc resection would accelerate the degeneration of adjacent intervertebral disc [19]. Related research also reported that the removal of pedicle screws after one-segment fusion could increase spinal motion, reduce the stress of the adjacent intervertebral discs and delay disc degeneration [20]. It was obvious that our surgical technique provides effective decompression, restores vertebral body height and alignment, stabilizes the column of the spine and meets the standards of microtrauma operation.

In this study, there was a significant correction of vertebral height and Cobb angle after surgery. More importantly, there were no obvious differences about the loss rate of vertebral height and Cobb angle in the follow-up period. Our technique provides anterior and posterior spinal stabilization, decreases the risk of screw breakage, decreases the loss of the vertebral body height and Cobb angle, and prevents progressive deformity. Moreover, it provides less operative time, blood loss and complications.

Based on our experience, there are also some risks and requirements for surgeons in this surgical procedure. The attention in this operation is as follows: (A) The posterior subtotal corpectomy is performed via unilateral foraminal-pedicle channel; there-

fore, it is worth noting that the upper/lower adjacent nerve root and dural sac is assured. (B) When the transverse process and vertebral body is resected, pay special attention to protecting the abdominal aorta-vein and segmental vessels. (C) The pedicular screw fixation system is used for temporary distraction in order to facilitate allocation of titanium mesh. Once proper placement is confirmed, the pedicular screw fixation system is given appropriate compression fixation to prevent the titanium mesh movement. (D) Make sure the lower endplate structure of injured vertebra is integrated, to support the titanium mesh for bony fusion. In addition, our research found that this operation may be adapted to type A3.1, A3.2 and part of type B1.2 fractures according to AO classification.

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Disclosure of conflict of interest

None.

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