Thoracolumbar burst fractures with a neurological deficit treated with posterior decompression and interlaminar fusion

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Abstract

Introduction To our knowledge, thoracolumbar burst fractures with a neurological deficit treated with posterior decompression and interlaminar fusion have never been reported. Our study was to assess the outcome of posterior decompression and interlaminar fusion in treating thoracolumbar burst fractures with a neurological deficit.

Materials and methods Forty-one patients suffering from thoracolumbar burst fractures with a neurological deficit were included this study. All patients were treated with posterior decompression, interlaminar fusion and short-segment fixation of the vertebrae above and below the fracture level and the fractured vertebrae.

Results All patients were followed up for at least 24 months after surgery. Operative time and blood loss averaged 72 min and 325 ml, respectively. Thirty-eight patients with incomplete neurological lesions improved, by at least one American Spine Injury Association grade, whereas no neurological deterioration was observed in any case. Overall sagittal alignment improved from an average preoperative 22.4°–4.6° kyphosis at the final follow-up observation. The anterior vertebral body height ratio improved from 0.61 before surgery to 0.90 after surgery,

whereas posterior vertebral body height ratio improved from 0.90 to 0.95. Spinal canal encroachment was reduced from an average 61.5% before surgery to 8.7% after surgery. Interlaminar radiological fusion was achieved within 6–8 months after surgery. No instrumentation failure was found in any patients.

Conclusion Posterior decompression, interlaminar fusion with posterior short-segment fixation provided excellent immediate reduction for traumatic segmental kyphosis and significant spinal canal clearance, and restored vertebral body height in the fracture level in patients with a thoracolumbar burst fracture and associated neurological deficit.

Keywords Burst fracture · Neurological deficit · Thoracolumbar spine · Fusion

Introduction

Burst fractures are caused by axial compressive forces and characterized by failure of the anterior and middle spinal columns [1]. These kinds of fractures most frequently affect the thoracolumbar region due to the fulcrum of increased motion at the T12–L1 junction. They often lead to collapse of the vertebral body and an associated kyphotic deformity. This vertebral collapse is usually accompanied by varying degrees of spinal canal invasion, which may or may not result in neurological compromise. Although many studies have proposed numerous guidelines, the best treatment for thoracolumbar burst fractures is still quite controversial [2–4]. Nonoperative management for burst fractures without neurological deficits has been reported to have good results, although a greater residual kyphotic angle was noted. However, greater residual deformity does not correlate with symptoms at follow-up [5, 6]. On the

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other hand, good clinical results have been reported with posterior reduction, with short-segment transpedicular screw fixation and posterior fusion [7]. Many authors found that short-segment pedicle screw instrumentation was not adequate to achieve and maintain the reduction of thoracolumbar fractures and was associated with an unacceptable rate of failure [8–11]. The placement of screws at fracture site to increase the instrumentation level and share the load has been offered as one of the alternative solutions to prevent this failure [12]. While posterolateral fusion is the most widely used technique of thoracolumbar arthrodesis for burst fractures, it is necessary to expose and decorticate the transverse processes and facet joints. Compared with posterolateral fusion, interlaminar fusion has the advantages of less operative time, less damage to the paraspinal muscles and less blood loss.

The purpose of this prospective study was to evaluate the efficacy of screw placement at the fractured vertebra or vertebrae and interlaminar fusion in correction of kyphosis, maintenance of correction, and preventing failure of fixation in thoracolumbar burst fractures.

Patients and methods

From July 2006 to June 2007, 41 patients suffered from thoracolumbar burst fractures (T11–L2) with a neurological deficit were identified and included into this prospective study. The inclusion criterion for this study was thoracolumbar burst fractures with a neurological deficit. The exclusion criteria were as follows: the polytraumatized patients, patients with severe osteoporosis (criteria of WHO), patients with preexisted spinal deformity (scoliosis, previous vertebral fracture in the area of interest), degenerative or other spinal stenosis, and patients with previous spinal operation. Among the 41 cases, 35 were single-level fractures (5 at T11, 11 at T12, 13 at L1 and 6 at L2), and the other 6 were two-level fractures (2 at T12 and L1, 4 at L1 and L2). The mechanism of injury was a fall from height in 24 patients and traffic accidents in the rest 17. Nonserious associated chest injuries were recorded in three patients, and brain injuries in another four. There were 13 women and 28 men, ranging from 21 to 65 years (average 39.5 years) of age. According to the comprehensive classification of Mager [13] for burst fractures, 10 cases belonged to subtype A 3.1, 14 cases belonged to subtype A 3.2 and the other 17 cases belonged to subtype A 3.3. On the basis of the American Spine Injury Association (ASIA) neurological grading system, 3 patients had grade A, 15 patients had grade B, 12 patients had grade C, and 11 had grade D neurological deficits. Supine anteroposterior and lateral roentgenograms, computed tomography (CT) and magnetic resonance imaging (MRI) of the thoracolumbar

region were taken on admission in all patients. After operation, the patients were followed up radiographically through anteroposterior, lateral and lateral flexion–extension roentgenograms to assess fusion and stability of the spine. CT-scans, including reconstruction images, were taken at 1 week, 6 months, and then once a year after surgery. The well-established variables that evaluated on plain radiographs were as follows: Gardner segmental kyphotic deformity (angle formed from the lines drawn on the lower endplate of the fractured and the upper endplate of the above adjacent vertebrae), anterior vertebral body height ratio (AVBHR), and posterior vertebral body height ratio (PVBHR) [14]. Spinal canal encroachment was calculated before to after surgery on CT scans [15].

Statistical analysis was performed with paired *t* test for changes of each radiographic parameter and correlation coefficient (*R*) for comparison between changes of different parameters. The values of *P* < 0.05 were considered significant.

Surgical technique

All surgical procedures were performed under general anesthesia with endotracheal intubation, with the patients placed in prone position on a Jackson frame. The spontaneous reposition of the traumatic segmental kyphosis after lying on the Jackson frame was controlled on the lateral view taken with an image intensifier. A midline approach was preferred and the paraspinal musculature was dissected. The short-segment fixation instrumentation construct included the adjacent vertebrae above and below the fractured level plus the fractured vertebrae. After insertion of all screws, laminectomy was performed and then direct decompression of the anterior thecal sac by tapping the retropulsed fragments through a posterolateral approach with a specific tool. Rods with appropriate length were contoured and inserted into the end screw extender sleeves (end vertebrae) and middle screw extender sleeve (fractured vertebra), and the position was controlled with the image intensifier. Reduction was performed with the use of interbody distractor or compressor and counter torque reduction tube. Following careful decortication of the laminae above and below the fractured level, the thecal sac was covered by the collagen protein, and then interlaminar

Table 1 Preoperative and postoperative neurologic status

	A	B	C	D	E
Preoperative neurologic status	3	15	12	11	0
Postoperative neurologic status	3	1	6	13	18

Table 2 Roentgenographic changes after surgery

	Gardner angle (°)	Spinal canal encroachment (%)	Anterior vertebral body height	Posterior vertebral body height
Preoperative	22.4 ± 9.7	61.5 ± 11.3	0.61 ± 0.17	0.81 ± 0.05
Postoperative	4.6 ± 5.1	8.7 ± 3.2	0.90 ± 0.19	0.95 ± 0.06
% changes	80.1 ± 25.3 ^a	85.9 ± 21.4 ^a	47.1 ± 8.5 ^a	17.2 ± 0.13 ^a

All values are shown as average ± standard deviation

^a Indicates statistical significant changes were shown in the preoperative values and amount of postoperative changes of the radiographic parameters

fusion was performed with bone chips from posterior iliac crest as bone graft.

with an average follow-up of 33 months (range 24–47 months).

Results

The operative time in this group was 72 min (range 45–96 min). The intraoperative blood loss was 325 mL. All patients were observed for a minimum of 24 months,

Neurological recovery

No patients deteriorated neurologically as a result of operative treatment. 35 of 38 patients (92%) with incomplete injuries improved by at least one modified ASIA grade (range 1–3 grades). None of the three patients

Fig. 1 **a** Lateral radiograph shows an L1 and L2 burst fracture in a 31-year-old man. **b** Lastest follow-up lateral radiograph shows adequate correction in sagittal balance. **c, d** Lateral flexion–extension

roentgenograms demonstrate solid fusion after removal of internal fixation. **e** Reconstruction CT, **f** sagittal CT, and **g** axial CT images demonstrated solid interlaminar fusion

categorized as ASIA A demonstrated any improvement (Table 1).

Radiographic results

Preoperative canal compromise, based on preoperative CT scan, averaged 62% (range 31–92%). Average vertebral body height loss at the injured level was 39% (range 28–66%). Mean preoperative segmental kyphosis measured 22.4° (range 9.1°–43.5°). Preoperative spinal canal encroachment was significantly correlated with Gardner angle and AVBHR ($R = 0.51$, $P < 0.05$). Preoperative Gardner angle was significantly correlated with AVBHR ($R = 0.62$, $P < 0.05$).

At the latest radiographic follow-up, angulation was significantly changed to 4.6° (range 0.2–12.1°), canal compromise was decreased to 8.7% (range 2.2–17.3°), and anterior vertebral height ratio was increased to 0.9 (range 0.8–0.9) (Table 2). Final radiographs and CT-scans showed radiologically healed fractures 6–8 months after surgery with interlaminar fusion (Figs. 1, 2). No patients had evidence of pseudarthrosis.

Complications

Perioperative complications included one superficial wound infection that was successfully treated with antibiotics. At the latest follow-up, 11 of 41 patients (27%) had donor site pain. No implant failure was noted in any patients.

Discussions

Selection of the surgical method in the treatment of thoracolumbar burst fractures remains a matter of debate [8, 9, 16–21]. Multiple parameters, such as the type and stability of the fracture, degree of canal compromise, injury of posterior ligamentous complex and neurological status, have to be considered [16, 19, 21–25]. Short-segment fixation 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. However, without vertebral body reconstruction, short-segment fixation has a 9–54% incidence of implant failure and re-kyphosis [8, 16, 26, 27].

Fig. 2 **a** Lateral radiograph shows an L2 burst fracture in a 47-year-old woman. **b** Latest follow-up lateral radiograph shows adequate correction in sagittal balance. **c**, **d** Lateral flexion–extension

roentgenograms demonstrate solid fusion after removal of internal fixation. **e** Reconstruction CT, **f** sagittal CT, and **g** axial CT images demonstrated solid interlaminar fusion

The greater residual kyphotic deformity exerts higher anterior vertebral stress on pedicle screws, and the overloading force on the instrument leads the screws to loosen, break, dislodge, or disconnect which are frequently seen in short-segment fixation [7, 9, 11, 24, 28]. Increasing the fixation level could decrease the stress on each pedicle screw and lower the chance of failure. However, the advantage of saving motion segments was diminished [29]. Anterior vertebral body reconstruction plus posterior instrumentation offers the greatest stability, but in the operative treatment of 733 patients with acute thoracolumbar fractures, Reinhold et al. [30] reported that patients treated with a single posterior approach had a better functional and subjective outcome than patients treated with combined posteroanterior surgery.

It has been speculated that posterior instrumentation fails due to the large bone defect created inside the fractured vertebral body after indirect (distraction, ligamentotaxis) height restoration in thoracolumbar burst fractures. To prevent this, several techniques have been developed to augment the anterior column in burst fractures. Transpedicular grafting in addition to short-segment fixation was suggested by several authors [31–37], whereas others either doubted its usefulness reporting on a correction loss between 2° and 10° [38] or warned of a potentially dangerous situation if graft was not placed carefully [8, 39–41]. Another option could be the fractured level screw fixation. The screws at the fractured level may provide a mass effect and prevent the vertebra from collapsing, help to support anterior column and improve biomechanical stability, and offer additional fixation points for fracture reduction and kyphosis correction. Guvan et al. [12] reported good clinical results with this technique, and our study also showed that fractured level screw combination maintained better kyphosis correction in patients with unstable thoracolumbar burst fractures.

The discussion about laminectomy as the procedure of choice for decompression in patients with a neurological deficit will probably never end completely. Marco et al. [42] demonstrated that a wide decompressive laminectomy from pedicle to pedicle above and below the area compressed by the retropulsed fragments should be performed in patients presenting with a neurological deficit or who have compromised of more than 50% of the spinal canal. Direct decompression of the thecal sac can be performed by tapping the retropulsed fragments away from the thecal sac through a posterolateral approach. Similarly, we advocated decompression as part of the operative treatment of thoracolumbar burst fractures with a neurological deficit. We decompressed the thecal sac by tapping the retropulsed fragments away with our specific tool in all patients. However, multiple studies concluded operative decompression of a traumatically narrowed spinal canal is not

indicated because of spontaneous canal remodeling [43, 44]. In the report of Leferink et al. [45], 49 patients who had a thoracolumbar fracture with a neurological deficit were treated by posterior instrumentation, and laminectomy was performed in only one patient because of progressive neurological deterioration after the initial procedure.

Posterolateral fusion is considered the golden standard in treatment of thoracolumbar burst fractures. However, it is necessary to expose and decorticate the transverse processes and facet joints for posterolateral fusion. Compared with posterolateral fusion, interlaminar fusion has the advantages of less operative time, less damage to the paraspinal muscles and less blood loss. In addition, interlaminar fusion can prevent the nerve tissues from adhesion to epidural fibrous scar. No hardware failure was noted in our study, and we postulated that solid interlaminar fusion may produce better outcome than posterolateral fusion.

One limitation of this study was the small sample size. Further, randomized controlled studies with more patients should be necessary.

In conclusion, posterior decompression, interlaminar fusion and posterior short-segment fixation with fractured level screw augmentation provided excellent immediate reduction for traumatic segmental kyphosis and significant spinal canal clearance, restored and maintained the vertebral body height in patients with a thoracolumbar burst fracture and a neurological deficit.

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Conflict of interest None.

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