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A comparative analysis of the efficacy of short-segment pedicle screw fixation with that of long-segment pedicle screw fixation for unstable thoracolumbar spinal burst fractures

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Abstract: The indications for operative treatment and type of stabilization procedures for the treatment of thoracolumbar burst fracture remain controversial. As surgical reconstruction for the thoracolumbar burst fracture, both long-segment pedicle screw fixation and short-segment pedicle screw fixation including fractured vertebral body have been used widely. The present study evaluated the efficacy of short-segment fixation compared with that of long-segment fixation in terms of the radiological and clinical outcomes in unstable thoracolumbar burst fractures. From January 2007 to December 2012, 76 patients with thoracolumbar burst fracture underwent posterior pedicle screw fixation consecutively in our hospital. These patients were divided into two groups: the short-segment group, which included patients who underwent short-segment pedicle screw fixation including the fractured vertebral body, and the long-segment group, which included patients who underwent long-segment pedicle screw fixation (2 levels above and 1 level below the fractured vertebral body). There were 44 and 32 patients in the long-segment and short-segment group, respectively. Radiological assessment of the kyphotic angle was performed using the Cobb method immediately after the operation and at 3, 6, and 12 months postoperatively. The clinical outcomes were evaluated using the modified Mcnab criteria at the last follow-up. The sex ratio, mean age of patients, and composition of the fractured vertebral body were similar in both groups. In the long-segment and short-segment group, 37 (84.1%) and 26 (81.3%) cases showed excellent or good outcomes, respectively. The mean kyphotic angle at the immediate postoperative period was 7.3° ± 5.8° and 0.6° ± 11.9° in the long-segment and short-segment group, respectively. The average loss of kyphosis correction was 5.4° ± 4.4°, 8.6° ± 6.2°, and 10.5° ± 4.8° in the long-segment group and 4.1° ± 3.6°, 6.2° ± 5.2°, and 7.5° ± 4.4° in the short-segment group at 3, 6, and 12 months postoperatively, respectively. There was no statistically significant difference in the average loss of kyphosis correction between the two groups ($p > 0.05$). In conclusion, short-segment pedicle screw fixation including the fractured vertebral body might be as effective as long-segment pedicle screw fixation for the treatment of unstable thoracolumbar spinal burst fracture.

Keywords: Loss of Kyphosis Correction, Long-Segment Pedicle Screw Fixation, Short-Segment Pedicle Screw Fixation, Thoracolumbar Burst Fracture

1. Introduction

There is controversy regarding the indications for operative treatment and type of stabilization procedures for the treatment of thoracolumbar burst fracture. Unstable fractures frequently require surgical correction. Progressive neurological deterioration is generally considered an absolute indication for early surgery [1,2]. Other strong indications for surgical intervention include incomplete neurological deficit, more than 25° to 30° angle of kyphotic deformity, more than 50% loss of vertebral body height, and more than 40% to 50% of canal narrowing.

The two main goals of surgery for traumatic thoracolumbar burst fractures are to adequately decompress the spinal canal,

maximizing neurological recovery and creating spinal stability to prevent painful deformity and potential future neurological deficit. Surgical reconstruction of the fractured vertebral body provides immediate stabilization and allows earlier mobilization, thus, it prevents or minimizes the sequelae of prolonged bed rest. As surgical reconstruction for the thoracolumbar burst fracture, long-segment pedicle screw fixation (two levels above and one level below the fractured vertebral body) has been performed usually. Short-segment pedicle screw fixation including the fractured vertebral body has also been used widely. Although long segment pedicle screw fixation has been thought to have better mechanical stability to short segment pedicle screw fixation, it has more loss of motion segments, longer operation time, more amount of bleeding and surgical muscle damage. If short segment pedicle screw fixation has similar results of mechanical strength for reduction of fracture and maintaining the vertebral column sagittal angle compared to long segment pedicle screw fixation, it becomes more valuable surgical option.

In the present study, we compared the radiological assessment and clinical outcomes of short-segment pedicle screw fixation with those of long-segment pedicle screw fixation for the treatment of unstable thoracolumbar burst fractures.

2. Materials and Methods

We retrospectively evaluated 94 patients with thoracolumbar burst fractures who underwent posterior pedicle screw fixation consecutively from January 2007 to December 2012 in our hospital through investigating the medical records, radiological data and interview at outpatient clinic. Seventy-six patients were finally included in this study, and 18 patients who were lost to follow-up were excluded. We divided our study population into two groups: the short-segment group, which included patients who underwent short-segment pedicle screw fixation including the fractured vertebral body, and the long-segment group, which included patients who underwent long-segment pedicle screw fixation (2 levels above and 1 level below with or without including the fractured vertebral body). There were 44 and 32 patients in the long-segment and short-segment group, respectively. All the patients underwent posterior pedicle screw fixation by conventional posterior approach in the same way regardless of the number of fixed levels. Patients were placed in a prone position on a Wilson frame under general anesthesia. Pedicle screw fixation and reduction was performed under C-arm guidance. Some patients who had more than 50% canal encroachment with or without progressive neurological deterioration underwent decompressive laminectomy. All patients had thoracolumbosacral orthosis for postoperative 3 months. Radiological assessment of the kyphotic angle using the Cobb method was performed immediately after the surgery and at 3, 6, and 12 months postoperatively. The clinical outcomes were evaluated using the modified Mcnab criteria (Table 1) at the last follow-up. Statistical analysis was performed using the t-test in Microsoft Office Excel 2003 (Microsoft Corp., Redmond, WA, USA). All study participants provided informed consent.

Table 1. *Modified Mcnab criteria.*

	Description
Excellent	No pain; no restriction of activity.
Good	Occasional back or leg pain of sufficient severity to interfere with the patients' ability to do their normal work or their capacity to enjoy themselves in their leisure hours.
Fair	Improved functional capacity, but handicapped by intermittent pain of sufficient severity to curtail or modify work or leisure activities.
Poor	No improvement or insufficient improvement to enable increase in activities; further operative intervention required.

3. Results

The demographic data were similar between the two groups (Table 2). The male to female ratio was 1:0.52 and 1:0.39 in the long-segment and short-segment group, respectively. The mean age of patients was 50 and 53 years in the long-segment and short-segment group, respectively. The mean follow-up period was 18.9 and 26.5 months in the long-segment and short-segment group, respectively. In the long-segment group, the fractured vertebral body level was L1, T12, T11, L2, L3, and T10 in 18 (40.9%), 15 (34.1%), 3 (6.8%), 3 (6.8%), 3 (6.8%), and 2 (4.5%) cases, respectively (Table 2). In the short-segment group, the fractured vertebral body level was L1, T12, L2, L4, and L3 in 11 (34.4%), 9 (28.1%), 5 (15.6%), 5 (15.6%), and 2 (6.3%) cases, respectively (Table 2). Patients in both groups achieved satisfactory clinical outcomes according to the modified Mcnab criteria. In the long-segment group, 15 (34.1%), 22 (50.0%), 5 (11.4%), and 2 (4.5%) cases were considered to have excellent, good, fair, and poor outcome, respectively (Table 3). In the short-segment group, 6 (18.8%), 20 (62.5%), and 6 (18.8%) cases were considered to have excellent, good, and fair outcome, respectively (Table 3). In the long-segment group, the mean kyphotic angle at the immediate postoperative period and at 3, 6, and 12 months postoperatively was 7.3° ± 5.8°, 12.9° ± 7.4°, 15.2° ± 7.7°, and 20.0° ± 6.5°, respectively, while in the short-segment group, it was 0.6° ± 11.9°, 4.1° ± 13.2°, 10.0° ± 10.9°, and 11.5° ± 11.3°, respectively (Table 4). The average loss of kyphosis correction evaluated at 3, 6, and 12 months postoperatively was 5.4° ± 4.4°, 8.6° ± 6.2°, and 10.5° ± 4.8° in the long-segment group and 4.1° ± 3.6°, 6.2° ± 5.2°, and 7.5° ± 4.4° in the short-segment group, respectively (Table 5), with no significant differences between the two groups ($p > 0.05$). There was no case of major complication after surgery and during the follow-up period.

Table 2. *Patient demographic data.*

	Long-segment group (N=44)	Short-segment group (N=32)
Sex	Men 29 Women 15	Men 23 Women 9
Age (years)	19–77 Mean 50	26–71 Mean 53
Fractured vertebral body level	T10; 2 (4.5%) T11; 3 (6.8%) T12; 15 (34.1%) L1; 18 (40.9%) L2; 3 (6.8%) L3; 3 (6.8%)	T12; 9 (28.1%) L1; 11 (34.4%) L2; 5 (15.6%) L3; 2 (6.3%) L4; 5 (15.6%)
Follow-up period (months)	3–70 Mean 18.9	3–74 Mean 26.5

Table 3. *Assessment of clinical outcome according to the modified Mcnab criteria.*

	Long-segment group (N=44)	Short-segment group (N=32)
Excellent	15 (34.2%)	6 (18.8%)
Good	22 (50.0%)	20 (62.5%)
Fair	5 (11.4%)	6 (18.8%)
Poor	2 (4.5%)	0 (0%)

Table 4. *Mean kyphotic angle measured using the Cobb method.*

	Long-segment group	Short-segment group
Immediate postoperative time	7.3° ± 5.8°	0.6° ± 11.9°
3 months postoperatively	12.9° ± 7.4°	4.1° ± 13.2°
6 months postoperatively	10.0° ± 7.7°	10.0° ± 10.9°
12 months postoperatively	20.0° ± 6.5°	11.5° ± 11.3°

Table 5. *Comparison of radiological results between the two groups: loss of kyphosis correction according to the Cobb method based on the fixed segments.*

	Long-segment group	Short-segment group	*p*-value(t-test)
3 months postoperatively	5.4° ± 4.4°	4.1° ± 3.6°	0.22
6 months postoperatively	8.6° ± 6.2°	6.2° ± 5.2°	0.24
12 months postoperatively	10.5° ± 4.8°	7.5° ± 4.4°	0.12

4. Discussion

Thoracolumbar spinal injury is commonly caused by motor vehicle accidents, falls, and direct blows to the back. Subsequent loading of the spine concentrates forces on the thoracolumbar spine in the transition zone between the relatively immobile kyphosis of the thorax and the flexible lordosis of the lumbar region. According to the Denis 3-column concept, burst fractures consist of injury of all three columns with retropulsion of bone fragments into the spinal canal, which is the radiographic hallmark [3-5]. In addition, McAfee et al distinguished an unstable burst fracture from stable burst fracture based on the disruption of the posterior elements [6]. Burst fractures are either neurologically unstable or both mechanically and neurologically unstable.

Various treatment options are available, depending on the severity of the injury, including recumbency, use of a brace, and surgery. Various surgical methods have been used for the treatment of thoracolumbar burst fractures. Among them, long-segment posterior pedicle screw fixation has been performed mainly. Baaj et al conducted a study of biomechanical instability of posterior fixation in unstable thoracolumbar junction fractures and reported that long-segment constructs were superior to short-segment constructs with index-level and that short-segment constructs with index-level were superior to those without index-level constructs [7]. Although long-segment pedicle screw fixation provides better biomechanical strength than short-segment pedicle screw fixation, short-segment (1 level above and 1 level below the fractured vertebral body) including index-level pedicle screw fixation has also been widely used. Compared with conventional long-segment fixation, short-segment constructs provide the advantage of saving motion segments [8-12], and it requires a smaller incision and causes less spinal muscle damage during the surgery. Tezeren et al reported that although long-segment fixation had a better outcome of measurements of local kyphosis, sagittal index, and anterior vertebral height compression, short-segment fixation allows for spinal stabilization while simultaneously preserving as many motion segments as possible, and there was no significant difference in the clinical outcome between short-segment and long-segment fixation [11]. Kim et al reported that short-segment pedicle

screw fixation including the fractured vertebra is an effective surgical method for restoration and maintenance of vertebral column stability in thoracolumbar burst fractures in their study of predictive factors for a kyphosis recurrence following short-segment pedicle screw fixation [13]. They reported the correction loss of 3.7° ± 2.8° of Cobb angle at the last follow-up [13]. Kana et al 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 [14].

Despite the superiority of short-segment fixation, many surgeons have reported that early implant failure and loss of correction are the most important disadvantages of this surgical method [15-17]. In the present study, although the loss of kyphosis correction (4.1°, 6.2°, and 7.5° at each follow-up visit) could not be avoided with short-segment fixation, there were no instances of hardware failure. These results demonstrated that loss of kyphosis correction progressed in both groups at each follow-up. Furthermore, according to the modified Mcnab criteria, the clinical outcomes in the short-segment (81.3%) and long-segment group (84.1%) were “good” with no significant difference between the groups. 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 [18-20].

Consistent with previous studies, the current study showed that loss of kyphosis correction was not significantly different between the long-segment and short-segment group. The results of the radiological assessment demonstrated that the loss of correction progressed similarly in both groups.

Kim et al suggested that short-segment pedicle screw fixation without bone fusion following postural reduction can be an effective and safe operative technique in the management of selected young patients with unstable burst fracture [21]. A 10-year follow-up study by Toyone et al suggested that the benefit of short-segment fixation without fusion for burst fractures involving neurological deficit is that it can preserve thoracolumbar motion without resulting in post-traumatic disc degeneration [22].

The present study had some limitations. We performed long- or short-segment fixation with or without bone graft fusion in a random manner. In the current study, we did not separate fusion cases from non-fusion cases. Although we did not analyze the difference between bone graft fusion and non-fusion cases, it seems that bone graft fusion did not affect the clinical outcome and kyphosis correction in our study.

5. Conclusion

In conclusion, short-segment pedicle screw fixation including the fractured vertebral body might be as effective as long-segment pedicle screw fixation for the treatment of unstable thoracolumbar spinal burst fracture. A more detailed evaluation is warranted to determine the extent of fusion after this procedure.

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