Transforaminal Decompression and Interbody Fusion in the Treatment of Thoracolumbar Fracture and Dislocation with Spinal Cord Injury

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Abstract

Study Design: A retrospective clinical study.

Objective: To evaluate the efficacy and safety of transforaminal decompression and interbody fusion in the treatment of thoracolumbar fracture and dislocation with spinal cord injury.

Methods: Twenty-six spinal cord injured patients with thoracolumbar fracture and dislocation were treated by transforaminal decompression and interbody fusion. The operation time, intraoperative blood loss, and complications were recorded; the Cobb angle and compressive rate (CR) of the anterior height of two adjacent vertebrae were measured; and the nerve injury was assessed according to sensory scores and motor scores of the American Spinal Injury Association (ASIA) standards for neurological classification of spinal cord injury.

Results: The operative time was 250±57 min, and intraoperative blood loss was 440±168 ml. Cerebrospinal leakage was detected and repaired during the operation in two patients. A total of 24 of 26 patients were followed up for more than 2 years. ASIA sensory scores and motor scores were improved significantly at 3 months and 6 months after operation; the Cobb angle and CR of the anterior height of two adjacent vertebrae were corrected and showed a significant difference at post-operation; and the values were maintained at 3 months after operation and the last follow-up.

Conclusion: We showed that transforaminal decompression together with interbody fusion is an alternative method to treat thoracolumbar fracture and dislocation.

Introduction

Thoracolumbar fractures and dislocations with spinal cord injury, especially those with spinal cord compression due to a damaged anterior intervertebral disc and bony fragments, lead to nerve injury. Anterior decompression or combined anterior and posterior decompression and fusion are recommended by surgeons [1,2,3].

Although the anterior approach can remove the damaged intervertebral disc and bony fragments directly, the complications and risks of anterior vascular and nerve injury are considerable [4,5]. Therefore, surgeons are always seeking better techniques that are more minimally invasive, simpler to perform, less risky, and can reach the same efficacy as traditional surgery.

Transforaminal lumbar interbody fusion (TLIF) has been reported as a treatment for lumbar disc herniation and lumbar stenosis [6,7,8]. The TLIF technique can remove the anterior compressed intervertebral disc and bony fragments, avoiding the decompression procedure of the anterior approach. In 2011, Fang et al. [9] used the TLIF technique to treat patient with an old T12/L1 fracture and dislocation. Compared to the posterior lumbar interbody fusion technique, transforaminal interbody fusion can be used to treat a fracture and dislocation above the lumbar spine [7,9,10]. Here, we retrospectively reviewed 24/26 consecutive patients (two patients were lost) with thoracolumbar fractures and dislocations treated by transforaminal decompression and interbody fusion.

Materials and Methods

Patient population

From June 2007 to August 2011, a total of 26 consecutive patients with thoracolumbar fractures and dislocations treated by
The nerve injury was assessed according to sensory scores and motor scores of the American Spinal Injury Association (ASIA) standards for neurological classification of spinal cord injury [12] at the following time points: pre-operation, 3 months after operation, 6 months after operation, 12 months after operation, and the last follow-up.

**Operation procedure**

The patient was placed on the operating table in the prone position. After general anesthesia and target segment was located by C-arm X-ray, a midline incision was made and the paraspinous muscle was separated from the lamina bilaterally.

Suitable pedicle screws were inserted into the upper and lower vertebrae or second adjacent vertebrae, and the left or right facet joint was resected. After hemostasis of the epidural and radicular veins by bipolar forceps, the intervertebral disc was exposed after protection of the nerve root and thecal sac, the damaged disc was removed, the upper and lower cortical endplates were removed with straight and curved osteotomes until the cortical endplate was stripped, and the best conditions for the bony fusion were achieved. The height of the intervertebral space was measured by a tryout cage, and then a correct-sized bone from the ilium or interbody cage packed with granulated autogenous bone was inserted into the intervertebral space.

Next, the rods were installed, to restore the height and realign the spinal sequence, and the position of the internal instruments was confirmed by C-arm X-ray. Finally, a drain was placed and the wound was checked for hemostasis and closure. The operative time and intraoperative blood loss were recorded by the anesthetists, and the data were extracted from the anesthesia record sheet.

**Ethics consideration**

This research was performed following the principles described in the Declaration of Helsinki and was approved by the Institutional Ethics Review Board of our hospital. Written informed consent was obtained from all participants.

**Statistical analysis**

The data were analyzed with standard software (SPSS, version 17.0, SPSS Inc., Chicago, IL, USA). The preoperative, postoperative (immediately, 3 months, and 6 months after operation), and final data (more than 2 years after operation, averaged 34.9 months) were tested by repeated measures analysis of variance (ANOVA). The level of significance was set at P<0.05.

**Results**

The operative time was 250±57 min, and intraoperative blood loss was 440±168 ml. Cerebrospinal leakage was detected and repaired during the operation in two patients. A total of 24 of 26 patients were followed up for more than 2 years (one male and one female were lost and could not be contacted), for an average of 34.9 months (range, 24–63 months). Intervertebral bony fusion was achieved in all patients, as confirmed by postoperative CT scans (Figure 2).

**ASIA sensory scores**

The ASIA sensory score (mean ± standard deviation) improved from 172.2±22.4 at pre-operation to 196.7±22.8 at 3 months after operation (P = 0.000), and it continued to improve to 204.2±21.7 at 6 months after operation; the improvement showed a significant difference between the 3-month and 6-month time points (P = 0.000). Slight improvements were recorded at 12 months after operation and the last follow-up; however, no significant differences were observed when compared to the previous time points, P = 0.190 and P = 0.109, respectively (Figure 3A).
ASIA motor scores

The ASIA motor score improved from 54.2±7.7 at preoperation to 71.3±10.8 at 3 months after operation (P = 0.000), and the score was 81.0±12.0 at 6 months after operation (compared to the 3-month time point, P = 0.000). Slight improvements were recorded at 12 months after operation and the last follow-up; however, no significant differences were observed when compared to the previous time points, P = 0.169 and P = 0.207, respectively (Figure 3B).

Image measurement

The Cobb angle and CR of the anterior height of two adjacent vertebrae were corrected from 20.24±8.71° and 15.82±5.29% at pre-operation to 3.88±2.47° and 4.56±2.23% at postoperation, respectively (P = 0.000). The angle and CR of the anterior height were sustained at 3 months after operation (3.95±2.29° and 5.76±4.43 mm, respectively) and the last follow-up (4.20±3.23° and 6.05±4.16%, respectively), and no significant difference was found among the time points of postoperation, 3 months after operation, and the last follow-up (Figure 3C–D).

Discussion

Thoracolumbar fractures and dislocation are caused by high-energy trauma such as falls or vehicular accidents, and the spinal cord is injured directly by an anterior damaged intervertebral disc and bony fragments. It has been reported that simultaneous combined anterior and posterior surgery can achieve sufficient decompression, reduction, and reconstruction [1,13]. However, the anterior approaches have high risks due to potential anterior vascular and nerve injury [4,14,15].

Schmid et al. [16] have reported posterior lumbar interbody fusion (PLIF) in the treatment of thoracolumbar trauma and have suggested that PLIF avoids the potential complications of anterior decompression. However, the risk of damage to the conus...
Harms et al. have developed a TLIF technique to treat degenerative disease of the lumbar spine. In addition, Humphreys et al. [7] have compared the techniques of TLIF and PLIF. They found that the TLIF technique has a similar operative time, duration of hospital stay, and blood loss as PLIF; has fewer complications than the PLIF procedure; maintains normal muscular attachments; and thus causes no disruption to the loading mechanics of the spine. Moreover, TLIF is not limited to L3–S1 levels.

Huang et al. [17] practiced the technique of transforaminal decompression and interbody fusion on a 24-year-old patient with a T11–12 Chance fracture. Similarly, Fang et al. [9] applied transforaminal decompression and interbody fusion to treat a 26-year-old man with an old T12–L1 fracture and dislocation. These two cases both achieved a good clinical outcome. Furthermore, Wang et al. [10] have reported a series of type A3 (AO classification) thoracolumbar/lumbar fractures treated by transforaminal decompression and interbody fusion; they suggest that posterior short segment pedicle screw fixation and TLIF might be an optimal surgical treatment option for A3 burst fractures and Denis type A, B, C, and E pedicle fractures.

In this study, all patients with a Type C thoracolumbar fracture and dislocation (AOSpine Thoracolumbar Spine Injury Classification System [11]) had damage mainly at the intervertebral disc, including the adjacent endplate and some part of the vertebræ. The aim of surgery is to decompress the spinal canal, reduce dislocation, and rebuild spinal stability. The transforaminal decompression and interbody fusion technique itself allows easy detection and removal of the anterior damaged intervertebral disc and bony fragments, avoiding excessive traction of the spinal cord and nerve root, thus significantly reducing the risk of nerve damage.

The follow-up data showed significant improvement of nerve function; the sensory scores and motor scores improved by $31.2 \pm 14.4$ and $26.8 \pm 9.7$, respectively, at 6 months after operation, and by $35.3 \pm 16.1$ and $28.9 \pm 9.6$, respectively, at the last follow-up. The Cobb angle was corrected by $16.36 \pm 7.98^\circ$, the CR of the anterior height of two adjacent vertebrae was restored by $11.26 \pm 4.96\%$ at postoperation, and the correction was maintained at 3 months postoperation and the last follow-up, without internal instrument breakage or failure. Therefore, we suggest that transforaminal decompression and interbody fusion is an efficient and safe procedure for thoracolumbar fracture and dislocation.

The limitations of our study included the inherent shortcomings of a retrospective study itself and the small sample size. Only 24 patients with at least 2-year follow-up were included because of the small proportion of thoracolumbar fracture and dislocation in thoracolumbar injuries. Moreover, the indication of this study was limited to patients in whom the damage was mainly focused on the intervertebral disc and the adjacent endplate.
Conclusions

Based on the results of this study, we suggest that transforaminal decompression and interbody fusion is an alternative method to treat thoracolumbar fracture and dislocation when the damage is mainly at the intervertebral disk and the adjacent endplate.

References

1. Vaccaro AR, Lim MR, Hurlbert RJ, Lehman RA Jr, Harrop J, et al. (2006) Surgical decision making for unstable thoracolumbar spine injuries: results of a consensus panel review by the Spine Trauma Study Group. J Spinal Disord Tech 19: 1–10.
2. Acaroglu ER, Schwab EF, Farcy JP (1996) Simultaneous anterior and posterior approaches for correction of late deformity due to thoracolumbar fractures. Eur Spine J 5: 56–62.
3. Wood KB, Li W, Lebl DS, Plosami A (2014) Management of thoracolumbar spine fractures. Spine J 14: 145–164.
4. Rajaraman V, Vingan R, Roth P, Heary RF, Conklin L, et al. (1999) Visceral and vascular complications resulting from anterior lumbar interbody fusion. J Neurosurg 91: 60–64.
5. Baker JK, Reardon PR, Reardon MJ, Heggeness MH (1995) Vascular injury in anterior lumbar surgery. Spine (Phila Pa 1976) 18: 2227–2230.
6. Rosenberg WS, Mummaneni PV (2001) Transforaminal lumbar interbody fusion: technique, complications, and early results. Neurosurgery 48: 569–574; discussion 574–565.
7. Humphreys SC, Hodges SD, Patwardhan AG, Eck JC, Murphy RB, et al. (2001) Comparison of posterior and transforaminal approaches to lumbar interbody fusion. Spine (Phila Pa 1976) 26: 567–571.
8. Hu XQ, Wu XL, Xu C, Zheng XH, Jin YL, et al. (2014) A systematic review and meta-analysis of unilateral versus bilateral pedicle screw fixation in transforaminal lumbar interbody fusion. PLoS One 9: e87301.
9. Fang X, Fan S, Zhao X (2011) Application of transforaminal lumbar interbody fusion in old thoracolumbar fracture and dislocation. J Spinal Cord Med 34: 612–615.
10. Wang L, Li J, Wang H, Yang Q, Lv D, et al. (2014) Posterior short segment pedicle screw fixation and TLIF for the treatment of unstable thoracolumbar/lumbar fracture. BMC Musculoskelet Disord 15: 40.
11. Vaccaro AR, Ozer C, Kepler CK, Dvorak M, Schnake K, et al. (2013) AOSpine thoracolumbar spine injury classification system: fracture description, neurological status, and key modifiers. Spine (Phila Pa 1976) 38: 2028–2037.
12. Kirshblum SC, Burns SP, Biering-Sorensen F, Donovan W, Graves DE, et al. (2011) International standards for neurological classification of spinal cord injury (revised 2011). J Spinal Cord Med 34: 535–546.
13. Xia Q, Xu BS, Zhang JD, Mao J, Li JG, et al. (2009) Simultaneous combined anterior and posterior surgery for severe thoracolumbar fracture dislocations. Orthop Surg 1: 28–33.
14. Isiklar ZU, Lindsey RW, Coburn M (1996) Ureteral injury after anterior lumbar interbody fusion. A case report. Spine (Phila Pa 1976) 21: 2379–2382.
15. Loguidice VA, Johnson RG, Goyer RD, Smith WF, Ohnmeiss DD, et al. (1986) Anterior lumbar interbody fusion. Spine (Phila Pa 1976) 11: 366–369.
16. Schmid R, Krappinger D, Seykora P, Blauth M, Katrinhe A (2010) PLIF in thoracolumbar trauma: technique and radiological results. Eur Spine J 19: 1079–1086.
17. Huang RC, Meredith DS, Taunk R (2010) Transforaminal Thoracic Interbody Fusion (TTIF) for Treatment of a Chronic Chance Injury. HSS J 6: 26–29.