

Does the fracture fragment at the anterior column in thoracolumbar burst fractures get enough attention?

Luo Deqing, MD, Lian Kejian, MD, Li Teng, MD, Zou Weitao, MD, Lin Dasheng, MD*

Abstract

Prospective cohort study. To evaluate whether failure of the fracture fragment at the anterior column reduction in thoracolumbar fracture has an influence on the final radiologic and clinical outcomes.

Cervical teardrop fracture has caused wide concern in spinal surgery field. Although similar fracture fragment at the anterior column was also observed in thoracolumbar burst fractures, the conception of teardrop fracture in thoracolumbar fractures was rarely mentioned in the literature, let alone a study.

Fifty patients who suffered from thoracolumbar burst fractures with a fracture fragment at the anterior column were prospectively analyzed. Twenty-seven patients in whom the fragments were reduced by posterior surgery, verified by postoperative X-ray or CT, were included in the reduced group, and 23 patients were included in the nonreduced group. Radiologic and clinical outcomes of both groups were compared after over 2 years follow-up.

There was no significant difference regarding to Cobb angle, Oswestry Disability Index (ODI) score, and disc grade between the 2 groups preoperatively. At final follow-up, the mean angle of kyphosis was $13.91^{\circ} \pm 3.47^{\circ}$ in the nonreduced group and $8.42^{\circ} \pm 2.07^{\circ}$ in the reduced groups ($P < 0.01$). All fractures consolidated in the reduced group, but the nonreduced group revealed 3 cases with nonunion. Besides, the average Pfirrmann grade of degenerative disc adjacent to the fractured vertebral was 2.87 ± 1.18 in the nonreduced group, higher than 1.81 ± 0.62 in the reduced group ($P < 0.01$). The ODI score in the nonreduced group was 0.54 ± 0.13 and 0.36 ± 0.12 in the reduced group ($P < 0.01$).

In the present study, failure reduction of the fracture fragment at the anterior column could result in poor radiologic and clinical outcomes of the thoracolumbar burst fractures treated with posterior surgery. Therefore, we recommend the surgeon should pay more attention to reducing the fracture fragment at the anterior column.

Abbreviations: ASIA = American Spinal Injury Association, ODI = Oswestry Disability Index.

Keywords: complications, surgery, teardrop fragment, thoracolumbar fractures

1. Introduction

Burst fractures usually caused by high-energy trauma, including motor vehicle or motorcycle accidents and fall, are so common that nearly account for up to 20% of all thoracolumbar fractures and generate a great impact on patients' quality of life.^[1–4] Although various surgical techniques have developed in step with the spinal injuries classifications, it is still unknown what is the best treatment for the burst fractures. On one hand, with the advantage of less blood loss, reduced surgical time, good

reduction of the sagittal alignment, and saving motion segments utmost, short-segment pedicle screw fixation has become the mainstream method to deal with the thoracolumbar burst fractures. On the other hand, previous literatures have shown that recurrence of kyphosis or loss of correction is not uncommon.^[5–8] Early results have demonstrated that untreated anterior instability is the main factor resulting in a high rate of failure.^[5] In some circumstances, burst fractures are accompanied by some fragments originating from the anterior column of the vertebra, and posterior surgery is not always adequate to restore this displaced fragments.

Cervical teardrop fracture, first described by Kahn and Schneider, is characterized by a triangular fragment at the anteroinferior corner of the vertebral body.^[9] On the basis of the mechanism of injury, cervical teardrop fracture is divided into 2 types and most of which was flexion type injury. Due to the highly instability and devastating outcome, the importance of treatment and rehabilitation for the flexion type of cervical teardrop fracture has caused wide concern over the recent years in spinal surgery field. Although the similar fracture fragment is also observed in the thoracolumbar burst fractures, the conception of teardrop fracture in thoracolumbar fractures is rarely mentioned in the literature. Meanwhile, there is no study addressing the relationship between the fracture fragment at the anterior column and the final results in thoracolumbar burst fractures. Therefore, the purpose of this study is to evaluate whether failure of the fracture fragment at the anterior column reduction in

Editor: Stefano Omboni.

The authors have no funding and conflicts of interest to disclose.

Department of Orthopaedic Surgery, The Affiliated Southeast Hospital of Xiamen University, Orthopaedic Center of People's Liberation Army, Zhangzhou, China.

* Correspondence: Lin Dasheng, Department of Orthopaedic Surgery, The Affiliated Southeast Hospital of Xiamen University, Orthopaedic Center of People's Liberation Army, Zhangzhou 363000, China (e-mail: linds@xmu.edu.cn).

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Medicine (2017) 96:6(e5936)

Received: 20 December 2015 / Received in final form: 16 December 2016 /

Accepted: 29 December 2016

<http://dx.doi.org/10.1097/MD.0000000000005936>

thoracolumbar has an influence on the final radiologic and clinical outcomes.

2. Materials and methods

From January 2009 to December 2011, 50 patients who suffered from thoracolumbar burst fractures with a fracture fragment at the anterior column, as confirmed by preoperative X-ray or computerized tomography and treated by short-segment posterior instrumentation, were enrolled in this study. All fractures were classified based on Magerl et al.^[10] The neurological status of the patient was recorded based on the American Spinal Injury Association (ASIA) classification.^[11] Patients with multiple-level spinal fractures, osteoporotic thoracolumbar fractures, pathologic fractures, and neurologic defects with ASIA A and B (with need for decompressive laminectomy) were excluded from this research. According to the thoracolumbar injury severity score system,^[12] the score of 5 or more were the indications for surgery. Standard surgical technique, described previously,^[13] including short-segment transpedicular fixation with the fractured vertebral and the adjacent vertebral, was performed through a routine posterior midline approach by the senior. No laminectomies were performed. Fusion was performed in all patients by using autograft and allograft bone combination. Among these patients, 27 patients (54%) in whom the fragments were reduced by short-segment instrumentation with screw insertion in the fractured level were included in the reduced group. In 23 patients (46%), the fracture fragment at the anterior column was not reduced verified by postoperative X-ray or computerized tomography, and these patients were included in the nonreduced group. The study was authorized by the Hospital's Ethics Committee.

Radiographic and functional outcomes were evaluated by 2 independent observers who did not take part in study. Serial imaging examinations were taken to confirm the reduction of the fracture fragment at the anterior column and fracture healing of vertebral. The Cobb angle was measured between the superior endplate of upper and the inferior endplate of the lower according to Cobb methods on the lateral radiograph. Besides, MRI scan was taken to assess the discs adjacent to the fractured vertebral preoperatively and at most recent follow-up. Discs adjacent to the fracture vertebra were graded based on the grading system validated by Pfirrmann on the T2-weighted sagittal images.^[14]

The Oswestry Disability Index (ODI) has stood the test of time and many reviews.^[15] It is usable in a wide variety of applications as a condition-specific outcome measure of spine-related disability. All the patients were asked to complete the questionnaire preoperatively and at the final follow-up.

Statistical analyses were performed using SPSS 13.0 for windows. Student *t* test was used to analyze the difference in Cobb angle and ODI score between the 2 groups. The scores of the preoperative and postoperative MRI disc grading systems were evaluated using Mann–Whitney *U* nonparametric tests. Any value of *P* less than 0.05 were considered statistically significant.

3. Results

No significant difference was found between the groups with respect to age, fracture level, neurological deficit, thoracolumbar injury severity score, Magerl type, the duration of operation, amount of blood loss, and follow-up period (Table 1). In terms of kyphosis, there was no significant difference between the groups both in preoperative and immediately after surgery (*P* = 0.86, and *P* = 0.83). At final follow-up, the average kyphosis angle were

Table 1

Summary of the data in 2 groups.

Characteristic	Reduced (n=27)	Nonreduced (n=23)	<i>P</i>
Age, years	39.04 ± 7.53	37.30 ± 7.57	0.42
Follow-up, months	31.56 ± 5.18	32.13 ± 4.98	0.69
Fracture level			0.97
T11	2	2	
T12	7	5	
L1	14	13	
L2	4	3	
Neurological deficit			0.98
ASIA A	0	0	
ASIA B	0	0	
ASIA C	8	7	
ASIA D	10	8	
ASIA E	9	8	
TLICS	5.96 ± 0.81	6.13 ± 0.92	0.55
Magerl type			0.58
A1	15	10	
A2	2	3	
A3	9	10	
B1	1	0	
C	0	0	
Operation time, minute	93.44 ± 11.92	99.04 ± 16.05	0.34
Blood loss, mL	184.19 ± 20.95	192.43 ± 23.68	0.20

ASIA = American Spinal Injury Association, TLICS = Thoracolumbar Injury Classification and Severity Score.

13.91° ± 3.47° in the nonreduced group and 8.42° ± 2.07° in the reduced group (*P* = 0.000). The loss of correction was higher in nonreduced group (8.23° ± 1.92°) compared with reduced group (3.78° ± 1.23°) (*P* = 0.000) (Table 2). All the fractures in the reduced group healed with no implant failure at the final follow-up but the nonreduced group revealed 3 cases with nonunion. At the same time, 1 screw breakage and 1 rod breakage were observed in the 3 ununited fractures.

The preoperative MRI showed that almost all the discs adjacent to the fractured vertebral had grade 1 or 2 according to the grading system validated by Pfirrmann, whereas the difference around the 2 groups had no statistical significance (*P* = 0.368). At the final follow-up, the average Pfirrmann disc score was 2.87 in the nonreduced group and 1.81 in the reduced group, with statistical significance (*P* = 0.001) (Table 3) (Figs. 1, 2).

In the present study, the average preoperative ODI score of all the patients was 0.79. There was no significant difference in the

Table 2

Angle of kyphosis (Cobb angle).

	Reduced (n=27)	Nonreduced (n=23)	<i>P</i>
Preoperation, °	20.16 ± 6.51	20.50 ± 6.96	0.86
Immediately after operation, °	4.61 ± 1.98	5.63 ± 2.05	0.83
At final follow-up, °	8.42 ± 2.07	13.91 ± 3.47	0.000
Correction loss, °	3.78 ± 1.23	8.23 ± 1.92	0.000

Table 3

Disc grade in 2 groups.

	Reduced (n=27)	Nonreduced (n=23)	<i>P</i>
Preoperation	1.89 ± 0.58	2.00 ± 0.60	0.368
At final follow-up	1.81 ± 0.62	2.87 ± 1.18	0.001

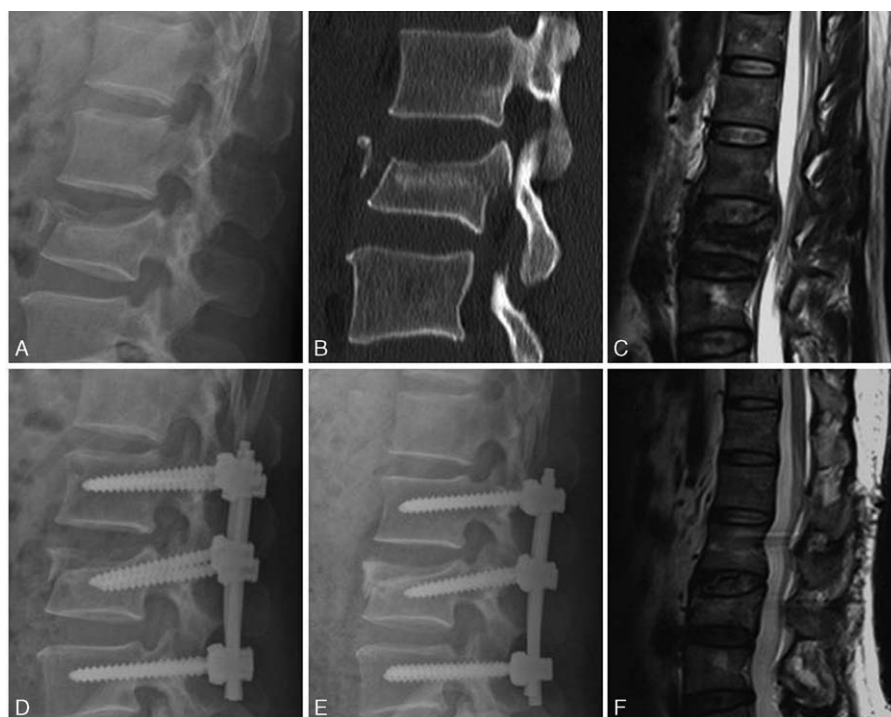


Figure 1. A 46-year-old man, with L2 burst fracture. Preoperative lateral radiograph (A) and CT (B) showed L2 vertebral fracture with a fragment in the vertebral anterior edge. Preoperative MRI (C) showed Pfirrmann grade 1 of L1-L2 disc and Pfirrmann grade 2 of L2-L3 disc. X radiograph immediately after surgery (D) revealed the teardrop fragment was not reduced completely. After follow-up for 2 years, X radiograph (E) showed no healing of L2 fracture. MRI (F) showed Pfirrmann grade 3 of L1-L2 disc and Pfirrmann grade 3 of L2-L3 disc. CT=computerized tomography, MRI=magnetic resonance imaging.

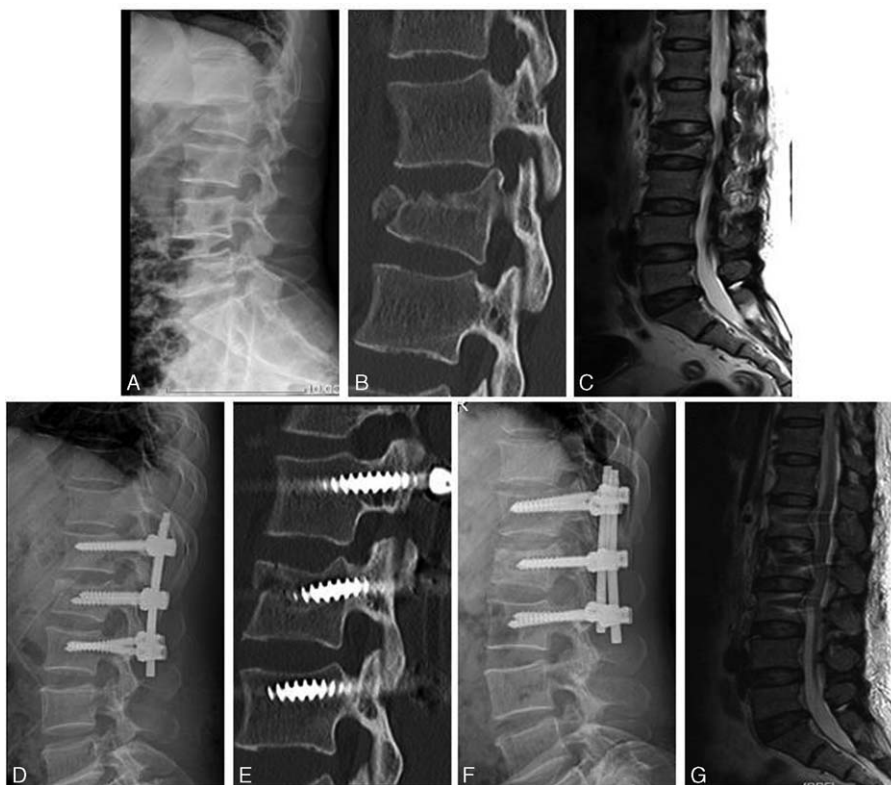


Figure 2. A 48-year-old woman who had a burst fracture at L2 vertebra. Preoperative lateral radiograph (A) and CT (B) showed a fracture fragment at the anterior column of L2 vertebra. Preoperative MRI (C) showed Pfirrmann grade 1 of L1-L2 disc and Pfirrmann grade 2 of L2-L3 disc. X radiograph and CT immediately after surgery (D, E) revealed the fracture fragment at the anterior column was reduced. After follow-up for 12 months, X radiograph (F) showed healing of T12 fracture and MRI (G) showed no progress to degeneration. CT=computerized tomography, MRI=magnetic resonance imaging.

Table 4
Oswestry Disability Index (ODI) scores in 2 groups.

	Reduced (n=27)	Nonreduced (n=23)	P
Preoperation	0.78±0.13	0.81±0.12	0.38
At final follow-up	0.36±0.12	0.54±0.13	0.000

ODI score between the 2 groups ($P=0.38$). At final follow-up after operation, the score in the nonreduced was 0.54 and reduced group was 0.36 ($P=0.000$) (Table 4).

The neurological status of the patients was recorded based on the ASIA classification. In the reduced group, 9 patients without neurologic deficit (ASIA E) remained unchanged, 15 patients (ASIA C, D) improved to ASIA E, and 3 patients improved from ASIA C to D. In the nonreduced group, 8 patients with no neurologic compromise did not deteriorate. Twelve patients (ASIA C, D) increased to ASIA E and 3 patients improved from ASIA C to D.

4. Discussion

The typical cervical teardrop fracture is characterized by a triangular fragment at the anteroinferior corner of the vertebral body.^[9] Its name is derived from the characteristic triangular fragment which resembles a drop of water dripping from the vertebral body. The flexion teardrop fracture caused by flexion and compression anteriorly, usually accompanied by complete disruption of both the anterior and posterior ligamentous structures, is a highly unstable injury.^[16] What is more, the injury also leads to a nerve injury because of the posterior fragment of the divided body shifting backward into the spinal canal. Therefore, open reduction and internal fixation were performed to obtain adequate stabilization of the fractures.^[17,18]

Thoracolumbar burst fracture, usually caused by high energy, is the result of various causative force including compression, flexion, distraction, and translation.^[1] In our experience, the similar vertebral wall fragment is also observed in thoracolumbar burst fractures. Although these characteristics do not match exactly those of the fragments in the cervical teardrop fractures, mechanism of injury is somewhat similar. AO throacolumbar fracture classification, first described by Magerl et al in 1994,^[10] has gained popularity in last 3 decades because of its systematic description of injury severity and pathomorphology. However, the concept of thoracolumbar teardrop fracture has not been brought forward separately. In addition, fracture fragment at the anterior column was rarely mentioned in the literature. To our knowledge, this is the first study focusing on the influence of the fracture fragment at the anterior column reduction on the result of the thoracolumbar burst fracture.

In the present study, compared with reduced group, all the patients in the nonreduced group had a loss of angle of kyphosis over 8° at the final follow-up, and the difference between the 2 groups also showed statistically significance. The reasons for the high rate of loss of reduction in this special fracture maybe manifold. First, at the thoracolumbar junction, the center of gravity normally falls in the anterior half of the vertebral body and the fracture fragment destroy the integrity of the anterior column which result in a progress of kyphosis under persistent axial stress.^[19] Early results have demonstrated that untreated anterior instability was the main factor resulting in a high rate of failure.^[2,5] Therefore, attempts have been made to rebuild the integrity of the anterior column, such as transpedicular bone graft

or percutaneous kyphoplasty.^[20,21] However, the result and safety of these techniques were still on debate. Besides, fragment at the anterior column may accompany with the destruction of the anterior longitudinal ligament which lead to segmental instability in the sagittal plane. To our knowledge, our study first showed that failure reduction of fracture fragment at the anterior column in the thoracolumbar was a significant factor responsible for the progress of kyphosis. Therefore, our results indicated that when treat the patients with a fracture fragment at the anterior column, the surgeons should pay more attention to the reduction of the fragment. If the fragment is initially inadequately reduced, additional methods such as interbody fusion or longer segmental instrumentation fixation will be needed to reach a stable fixation and prevent the occurrence of kyphosis and disc degeneration.

In cervical flexion teardrop fracture, the disc space between the posterior fragment and the vertebral body below was narrowed and the changes disk space showed plenty of possibilities for variation depending on the different treatment.^[16] In our study, we found that nearly all the discs adjacent to the fracture vertebral showed slight changes in signal intensity (in T2-weighted images) after reviewed preoperative MRI. The results were in accordance with other literatures.^[22,23] However, after treated with short-segment pedicle instrumentation with screw insertion in the fractured level, the discs in the 2 groups appeared to be a different outcome at the final follow-up. Most of the discs in the reduced group showed no progress of disc degeneration, whereas many new disc degenerations were observed in the nonreduced group and 6 patients progressed to grade 4 or 5. Some authors thought the small variation in signal intensity in the affected discs were mainly of a morphological instead of degenerative nature.^[24] At the same time, other authors hold the opinion that disc degeneration had a strong correlation with age.^[25,26] The natural course of disc degeneration may explain the high rate of mild signs of degeneration directly postinjury. Although the exact reasons for the high incidence of disc degeneration are still unknown, 2 reasonable explanations may help us to grasp it. One, the endplate normally constitutes the cranial/caudal anatomic boundaries and main nutritional pathways of the intervertebral disc. Once destruction, like a fracture fragment at the anterior column described in our study, the disc degeneration is inevitable due to destruction of the vascularity. Another rational explanation is that disc degeneration maybe the result of stress shielding of the disc after treated with short-segment pedicle instrumentation with screw insertion in the fractured level. The thoracolumbar burst fracture with no reduction of fracture fragment at the anterior column showed a progressive kyphosis accompany with disc degeneration. Previous study has suggested that the collapse of the disc space is the major contribution to the loss of correction.^[8] We thought this finding was not a curious coincidence. On the contrary, the finding demonstrated the speciality and severity of this fracture type compared with other burst fracture.

The ODI remains a valid and vigorous measure of condition-specific disability and be widely utilized to assess the outcomes following spine trauma. So, we selected the ODI in order to make the evaluation of the outcome of the fractures more reasonable and comprehensive. Compared with the normal population with an average of 10,^[15] there is a great increase of the ODI score postinjury, which means thoracolumbar burst fracture is a serious disease generating a vital influence on patients daily life. At the same time, we have found that the patients in the nonreduced group have a higher ODI score, with statistical difference. The current opinions regarding the correlation between the angle of kyphosis and the physical function or pain were conflicting.^[27,28] Several

studies have demonstrated the angle of kyphosis have no influence on the back pain for the patients. On the contrary, some authors showed that the patients with a sagittal index more than 15° had an increased incidence of significant pain.^[7] Similarly, our data suggested that at the most recent follow-up, the patients with Cobb angle over 10° have more degree of spine-related disability. The finding indicted that the failure reduction of the fracture fragment at the anterior column reduction also results in a poor functional outcome.

In conclusion, our study suggested that failure reduction of the fracture fragment at the anterior column could result in progress of disc degeneration and a recurrent kyphotic deformity. What is more, fracture nonunion and implant failure were also happened in the nonreduced group. Above all, failure reduction of the fracture fragment at the anterior column reduction made a tremendous difference in the quality of life. Therefore, we recommend the surgeon should pay more attention to reducing the fracture fragment at the anterior column. If the fragment is initially inadequately reduced, additional methods such as interbody fusion or longer segmental instrumentation fixation will be performed to reach a stable fixation and prevent the occurrence of kyphosis and disc degeneration. The limitations of this study are the small cohort of patients and not draw a conclusion about choosing a perfect surgical technique for the treatment of this special thoracolumbar fracture. More clinical experience and high-quality, multiple-center, large-sample randomized controlled trials will be necessary to systemically assess the results of failure reduction of fracture fragment at the anterior column in thoracolumbar fracture.

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