The radiological outcomes of short-segment pedicle screw fixation combined with transforaminal interbody fusion for treatment of thoracolumbar burst fracture

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Summary

Objective: This study aims to evaluate radiological outcomes of short-segment pedicle screw fixation with transforaminal interbody fusion (TIF) using bone chip graft for treatment of unstable thoracolumbar burst fracture, Denis type IIB. *Subject and method:* The data in this study were retrospectively collected from all patients with isolated unstable thoracolumbar burst fractures treated by posterior short segment pedicle screw fixation and TIF from January 2013 to January 2017. All patients were followed up for a minimum time interval of 1 year. For radiologic outcome evaluation, a loss percentage of anterior vertebral body heights (%ABC), vertebral kyphotic angle (VKA) and regional kyphotic angle (RKA) were collected preoperatively, postoperatively and at final follow-up. *Result:* There were 36 patients who met the inclusion criteria with a mean follow-up duration of 53 months (range, 17-73 months). The mean % ABC, VKA and, RKA at the time of admission were 49.9%, 24.6° and 19.7°, respectively. These values were 17.6%, 11.5°, 8.5° postoperatively, and 27.5%, 14.4° and 14.1° at final follow-up, respectively. Fusion rate at final follow-up was 91.7% based on Bridwell's criteria. There were 6 patients (16.7%) with hardware failure at final follow-up. *Conclusion:* Short-segment pedicle screw fixation with TIF using bone chip graft is an effective surgical management for unstable thoracolumbar burst fracture with the acceptable radiological outcomes in Vietnamese patients.

Keywords: Thoracolumbar burst fracture, short-segment pedicle screw fixation, transforaminal interbody fusion.

1. Background

The optimal management for thoracolumbar burst fracture is still controversial [1]. Currently, the short-segment posterior fixation and fusion is considered as a preferred option as it can reduce the blood loss, preserving segmental motion with an acceptable anatomic and functional outcome. However, progressive kyphosis and high rate of hardware failure due to lack of the anterior column supporting remains a concern [2]. Several procedures aiming to reinforce the anterior column have been introduced to solve this limitation of short-posterior fixation. They include transpedicular bone grafting, balloon-assisted vertebroplasty, pedicle screw fixation at fractured level and corpectomy and cage placement. Recently, some authors reported the good results of TIF combined with short-segment pedicle screw fixation in treatment of unstable thoracolumbar burst fracture [3, 4]. To our knowledge, there are few reports about posterior short-pedicle screw fixation with TIF using bone chip graft for unstable thoracolumbar burst fracture in Vietnam. The purpose of this study is to evaluate the radiological outcomes of TIF using bone chip graft combined with short-segment pedicle screw fixation for treatment of unstable thoracolumbar burst fracture in Vietnamese patients.

2. Subject and method

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2.1. Patient selection

From Jan. 2013 to Jan. 2017, 40 consecutive patients underwent the posterior short-segment pedicle screw fixation in combination with TIF. All patients involved a single level thoracolumbar burst fracture of Denis type IIB. Among 40 patients, 2 were lost to follow-up and 2 patients, quality of plain radiograph was not sufficient for analysis. Finally, this study included 36 patients for radiologic analysis.

This study was approved by our institution review board and informed consent was obtained from all patients.

2.2. Surgical indication

Surgical indications were the presence of any one or more of the following: 1. Presence of neurological involvement caused by the fracture; 2. Computed tomography (CT) scanning of the affected level showed more than 50% spinal canal compromise, 3. More than 50% loss of anterior vertebral height, 4. Vertebral kyphosis angle > 30° [5].

All patients were evaluated using load sharing classification (LSC) [6] and underwent posterior short-segment pedicle screw fixation with TIF.

2.3. Surgical technique

The patient was placed in prone position on a radiolucent spine table. Fluoroscopy was used to identify the fractured vertebral body. Conventional longitudinal incision at the midline was routinely used to expose one level above and one level below the fractured vertebra. Subperiosteal dissection was carried out with an electric cuter until the facet joints on both sides were visualized. Pedicle screws were introduced one level below and one level above the affected level without insertion of the pedicle screw at the vertebral fracture. The screws of both sides were distracted axially with contoured longitudinal rods to restore the anterior vertebral body height and realign the spinal columns and perform indirectly the reduction of the retropulsed fragment. Then exposure of the ipsilateral transforaminal zone of the affected level was performed by Kerrison rongeurs to remove a part of the lamina and facet joint until the nerve root and thecal sac were revealed. Epidural veins and radicular veins were cauterized with bipolar forceps to avoid massive bleeding. Any adhesions between the posterior longitudinal ligament and the anterior surface of the thecal sac are released in order to retract the thecal sac easily. This provided better exposure of the posterior portion of the vertebral body and the intervertebral discs. Then, the thecal sac and nerve root were gently retracted, and the adjacent intervertebral discs were completely removed.

If the patient had neurologic deficit and or the stenotic degree of the spinal canal was more than 50% of its normal value, then the retropulsed fragment of the fractured vertebral body were hammered anteriorly by using an 'L' angle dissector to recontour the posterior wall of the fractured vertebral body.

After that, the local bone graft which was taken from lamninae and facet process, was packed into the intervertebral space. If local bone was not enough, additional allograft or autograft from iliac bone were used. Decompression procedure was done with recheck of all the neural elements involved. A drain was placed, and wound were closed in standard fashion.

2.4. Radiographic assessments

All the patients underwent plain radiography preoperatively, postoperatively and at final follow-up. Analysis of plain radiographs included measurements of % ABC and VA and RA. The RA was measured as the angle between the superior endplate of the upper adjacent vertebra and the inferior endplate of the lower adjacent vertebrae by the Cobb method (Figure 1A). VA was measured as the angle between a line drawn parallel to the superior endplate and a line drawn parallel to the inferior endplate of the fracture vertebra (Figure 1A). Anterior body height of the injured vertebrae and the non-injured adjacent vertebrae above and the non-injured adjacent vertebrae below were measured on the lateral X-ray film, and % ABC was calculated as the anterior height of the injured vertebra divided by the mean of the anterior height of the adjacent two vertebrae using the formula % ABC = 100 - 2b/(a + c)100, where a is the anterior vertebral body height of the proximal vertebra; b is the anterior vertebral body height of fractured vertebra; and c is the anterior vertebral body height of the distal vertebra (Figure 1B).

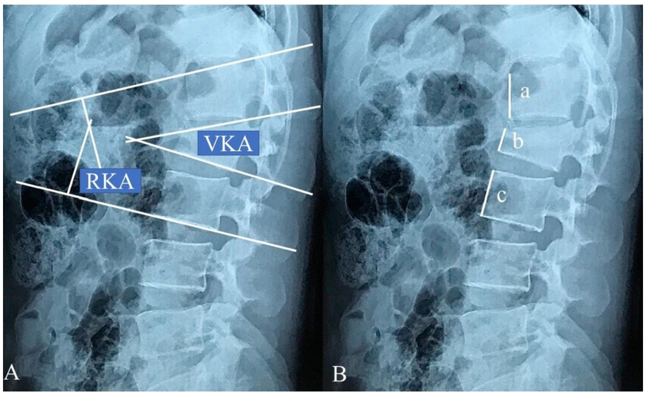

Figure 1. Parameters on plain X-rays (Figure A): Regional kyphotic angle (RKA), vertebral kyphotic angle (VKA); (Figure B): Anterior edge height of fractured vertebra above (a), anterior edge height of vertebra above the fractured vertebra (b), anterior edge height of vertebra below the fractured vertebra (c).

In addition, a fracture severity score was constructed by using the LSC using plain radiographs and CT scans.

Fusion was defined based on the criteria of Bridwell [6] using CT scan which was taken for all patients at the final follow-up. We also defined the unfavorable radiological outcomes as a correction loss of more than 10° of the RKA values at the final follow-up compared with that of the immediate postoperative period, or pedicle screw(s) or rod(s) breakage.

2.5. Statistics

SPSS 20.0 was used for statistical analysis. The paired t-test was used to analyze differences between preoperative, postoperative, and final follow-up radiographic data within each group. The Mann-Whitney test was used to analyze numerical data between the 2 groups. The level of statistical significance was set at $p<0.05$.

3. Result

3.1. Demographic data

The patients aged from 18 to 59 years (mean 47 years) with 20 men and 16 females. The mean follow-up duration was 53 months (range, 17–73 months). The affected levels were T12 level in 4 patients, L1 in 22, L2 in 10. The reasons for trauma included a fall from height in 28 cases; traffic accidents in 4 cases; sport accidents in 3 cases, and direct trauma in 1 case. All the cases were type IIB according to the Denis classification system. The mean LSC was 6.8 (range, 5-9).

3.2. Radiographic data

Table 1 shows the mean VKA, RKA, % ABC, and the loss of kyphotic correction. All of the parameters were significantly improved after surgery, but they were deteriorated considerably with statistical significance at the final observation when compared with that of the immediately postoperative. The VKA and RKA were improved from 24.6°, 19.7° to 11.5°, 8.5° after surgery, and progressed to 14.4°, 14.1° at the last follow-up, respectively. Preoperative mean % loss of anterior vertebral body heights of the fractured level was 49.1%, the right postoperative value was 17.3%, and the last follow-up value was 27.5%.

Table 1. Radiological parameters evaluated at the admission, postoperation, and final observation

Parameters	Pre-operative	Immediately post-operative	Final follow-up	Correction loss
VKA ± SD (°)	24.6 ± 5.7	11.5 ± 4.3*	14.4 ± 4.5$^{+,**}$	2.9 ± 2.8
RKA ± SD (°)	19.7 ± 8.2	8.5 ± 5.3*	14.1 ± 6.7$^{+,**}$	5.6 ± 5.2
% ABC ± SD (%)	49.1 ± 11.0	17.3 ± 9.3*	27.5 ± 11.4$^{+,**}$	10.2 ± 8.1

*VKA, Vertebral kyphotic angle; RKA, Regional kyphotic angle; % ABC, loss percentage of anterior vertebral body heights *, p<0.05, the immediately postoperative versus the preoperative; $^{+}$, p<0.05, the latest follow-up versus the preoperative; **, p<0.05, the latest follow-up versus the immediatly postoperative. SD, standard deviation.*

Table 2 shows the radiological outcome evaluation. 83.3% of the patients satisfied the criteria for good radiographic outcomes while 16.7% had hardware failure. There were no patients who demonstrated screw loosening or loss of RKA > 10°.

Table 3. Radiological outcomes of short segment pedicle screw fixation and TIF for 36 patients

Poor radiological outcomes	No (%)	Total %
-	30 (83.3)	83.3
+Screw/rod breakage below fracture level	2 (6.6)	16.7
Screw/rod breakage above fracture level	4 (11.1)	
Loss of regional kyphosis angle > 10°	0	
Screw loosening	0	

According to Bridwell's fusion grade which was evaluated by CT for 36 patients, 63.9% of the patients had grade I, fusion grade II was 27.8%, and 8.3% had grade III. Three out of six cases with hardware failure had fusion grade I, two cases were evaluated grade II and the last one was grade III.

4. Discussion

Here, we reported the outcomes of short posterior fixation with TIF in the treatment of thoracolumbar burst fracture, Denis IIB, and the mean follow-up was 53 months. In our study, the kyphotic deformity was corrected to a considerable extent with posterior fixation and indirect reduction. With the help of intact anterior longitudinal ligament and annulus, it is easy to reduce the loss of anterior vertebral body height by posterior pedicle screw devices. The problem is how to deal with a large amount of bone defect inside the fractured vertebral body. The large bone defect created inside the fractured vertebra after height restoration had been speculated to be the most essential cause of that correction loss. Moreover, the restoration of the intervertebral disc height may contribute to the loss of kyphotic correction [8].

We hypothesized that the TIF might solve these problems by minimizing the correction loss. Wang et al [4] reported the favorable outcomes of short segment pedicle screw fixation for treatment of thoracolumbar burst fracture without significant correction loss and hardware failure. However, their study just included 20 cases, and the average follow-up was 29.5 months. In our study, the correction of kyphotic deformity, which was evaluated by VKA and RKA, was gradually lost, and hardware failure occurred in 6 patients (16.7%) during the follow-up period. These outcomes mean that the TIF with bone chip graft did not completely prevent the correction loss and hardware failure of short segment pedicle screw fixation for the treatment of thoracolumbar burst fracture. The radiographic results of Wang's study is better than our study and we suppose that the main reason of this issue that is the pedicle screw at injuried vertebral level and two levels of interbody fusion with PEEK cages were used in Wang's study which resulted in the further prevention of implant failure and correction loss of short - segment posterior instrumentation.

McLain et al [2] recorded 52.5% of poor postoperative radiological results in their research about short segment fixation for thoracolumbar burst fracture treatment which means the radiological outcomes of our study are better in term of reducing the implant failure because our technique provides the anterior support for the thoracolumbar unstable burst fracuture. Therefore, our study's radiological outcomes may be accepted for the treatment of patients with unstable thoracolumbar burst fracture because the cost of this technique is not as expensive as other methods like vertebroplasty or insertion of pedicle screws at the injured vertebrae. Besides that, 4 out of 6 cases with hardware failures had good interbody fusion with Bridwell grade I or II, and all of such cases did not need to perform the revision surgery (Figure 2). Moreover, we did not use the cage insertion into the vertebral disc to provide better support for the anterior column because of financial reasons. If we could have inserted the cage in these patients, the outcome might be more favorable.

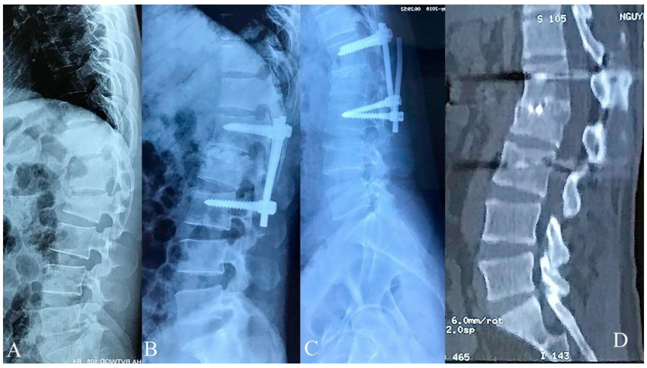

Figure 2. (A) Preoperative X-ray, (B) Postoperative X-ray, (C) Final follow-up X-ray with hardware failure, (D) Sagittal CT at last follow-up with good bone union.

While a usual laminectomy for the management of thoracolumbar burst fractures might lead to further spinal instability 13 [9]. Our TIF technique removes a part of articular process at one side, and almost all spinal structures can be preserved. By impact bone graft into the intervertebral space and even into the vertebral body through the fractured endplate after disc excision, it is possible to reconstruct the anterior and middle columns of the spine. Therefore, it provides additional stability with short pedicle screw fixation.

The posterior short-segment pedicle screw fixation combined with intermediate screw at the fractured vertebrae improved biomechanical stablility and achieved better reduction, less correction loss, fewer hardware fairlures 14 [10]. Thus, we suppose that if this technique combined with TIF using bone chip graft may get better outcomes. Howerver, the addition of screw at the fracture level increases the cost of treatment.

Our study has some limitations. Firstly, all the patients involved in our research were classified as Denis type IIB of a thoracolumbar burst fracture. However, considering Denis type IIB thoracolumbar burst fracture is one of the most common type of fractures, this study is worth studying. Secondly, this study evaluated the radiological outcomes without clinical variables, and the clinical outcomes do not always correlate to the radiological outcomes. The correlation between radiological findings and clinical results is still a matter of discussion.

5. Conclusion

Short-segment pedicle screw fixation with transforaminal interbody fusion is effective therapeutic management for the correction of thoracolumbar burst fracture deformities. However, the hardware failure and correction loss after surgical management following this technique in long-term follow up may happen, but the radiological outcomes are acceptable. For these reasons, we think that the short-segment screw fixation with the transforaminal interbody fusion technique could be a desirable surgical option for patients with a thoracolumbar bursting fracture in Vietnamese patients.

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