CLINICAL ARTICLE

Wiltse Approach *Versus* Conventional Transforaminal Interbody Fusion for Unstable Thoracolumbar Fracture with Intervertebral Disc Lesions

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Objective: To compare the clinical results of two surgical techniques, Wiltse approach and conventional transforaminal interbody fusion, for the treatment of unstable thoracolumbar fracture associated with traumatic intervertebral disc lesion (TIDL).

Methods: A total of 76 patients with unstable thoracolumbar fracture associated with TIDL treated by posterior pedicle screw fixation and transforaminal thoracolumbar interbody fusion from June 2010 and July 2016 were reviewed retrospectively. These patients including 48 male and 28 female patients were divided into Wiltse approach transforaminal thoracolumbar interbody fusion (W-TLIF) group (n = 38) and conventional transforaminal thoracolumbar interbody fusion (C-TLIF) group (n = 38). Patients were followed up for about 33 months. Clinical and radiological records, kyphotic angle, fractured vertebral body height, visual analogue score (VAS), Oswestry Disability Index (ODI), complications, neurological improvement and fusion rate were compared between two groups.

Results: All patients underwent posterior surgery successfully. Blood loss, operation time and hospital stay in the W-TLIF group was 437.84 ± 143.98 ml, 118.64 ± 20.55 min and 12.32 ± 2.87 days, respectively. While those parameters in the C-TLIF group was 862.70 ± 300.24 ml, 141.35 ± 31.72 min and 15.51 ± 2.08 days, respectively. Average operation time and hospital stay time were significantly shorter, and blood loss was significantly less in the W-TLIF group than in the C-TLIF group ($P < 0.05$). VAS and ODI in the W-TLIF group were significantly less than those in the C-TLIF group at 1 week after operation and final follow-up. The kyphotic angle and vertebral body height were improved. There was 1–2 grade improvement in patients with neurological deficit. Thirty-three patients in the W-TLIF group and 32 patients in the C-TLIF group had achieved fusion during follow-up. No internal fixation failure was observed in two groups.

Conclusions: The both techniques of W-TLIF and C-TLIF were feasible and effective for unstable thoracolumbar fracture with TIDL. Compare to C-TLIF, The technique of W-TLIF was a relatively less invasive way to decompress the neural elements and an easy method to reconstruct the anterior column using the same posterior approach.

Key words: Thoracolumbar fracture; Transforaminal thoracolumbar interbody fusion; Traumatic intervertebral disc lesion; Wiltse approach

Introduction

Thoracolumbar fracture i a very common injury in clinical practice. Meanwhile, this fracture has become a heavy health problem in modern society because the injury usually leads to spine deformity, disability as well as neurological deficit. However, the optimal management strategy for thoracolumbar fractures continues to elude a consensus[1]. Most stable thoracolumbar fractures can be treated

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conservatively. But surgical treatment is generally recommended for patients with unstable fractures or those with associated neurological deficit[2].

The goal of surgical treatment for thoracolumbar fracture is to decompress the neural elements, facilitate neurological recovery, restore the spinal alignment, prevent spinal instability, and prevent loss of correction. Various surgical approaches including anterior, posterior and combination of approaches are described[3,4]. Every procedure has its own pros and cons. The anterior approach remains one of the reliable methods for indicated patients because it has the advantages of permitting direct decompression of the neural tissue and allowing effective reconstruction of the anterior column[3]. But its disadvantages of trauma and bleeding limit the application. Currently, posterior pedicle screw fixation is advocated. The short-segmented posterior internal fixation can not only reduce the surgical trauma, but also achieve three column steadily fixation, However, without additional treatment of the anterior column, progressive kyphosis and instrumentation failure are key limitations of the posterior approach[5].

To minimize the drawbacks of surgery by the posterior approach, use of several procedures such as transpedicular bone grafting[6,7], and balloon-assisted vertebroplasty[8] is well-documented. However, since the traumatic intervertebral disc lesion (TIDL) adjacent to the fractured body is not reinforced, efficacy of these methods remains debatable. Sasani and Ozer[9] reported a surgical method using a single-stage posterior corpectomy technique and expandable cage placement for treatment of thoracic or lumbar burst fractures. Wong et al[10] reported pedicle screw fixation with anterior column reconstruction by transpedicular corpectomy of the fractured vertebral body and bilateral cage filled with autograft bone chips. However, the procedure is technically demanding and the learning curve is relatively steep. Additionally, some modified techniques such as posterior lumbar interbody fusion (PLIF)[11] and transforaminal lumbar interbody fusion (TLIF)[12] allow for neural decompression as well as reconstruction of anterior column including the disc lesion in a single-stage procedure using a single approach. However, these surgical procedures involve removal of the posterior elements, which may possibly be intact. Thus, in view of the drawbacks of the conventional TLIF for the treatment of unstable thoracolumbar fracture associated with traumatic intervertebral disc lesion, it will be reasonable to hypothesize that a modified Wiltse approach transforaminal thoracolumbar interbody fusion (W-TLIF) may be a relatively less invasive way to decompress the neural elements and an easy method to reconstruct the anterior column using the same posterior approach.

In this study, we mainly aimed at three points: (i) to develop a new surgical technique of W-TLIF for patient with unstable thoracolumbar fracture and TIDL; (ii) to compare the clinical results and radiological parameters of two surgical techniques, W-TLIF and C-TLIF, including the intraoperative parameters and the following parameters; and (iii) to discuss the superiority in clinical application of this new surgical technique.

Materials and Methods

Inclusion and Exclusion Criteria

Inclusion criteria were: (i) patients were diagnosed as acute thoracolumbar fracture (T_{11}-L_2) with thoracolumbar AO Spine injury classification (TL AOSIS) of four or more[13] and TIDL of grade 2 or 3, according to classification proposed by Sander et al[14]; (ii) the patients received posterior approach pedicle interfixation and transforaminal thoracolumbar interbody fusion; (iii) the related surgical records and follow-up outcomes of patients were comprehensively recorded and compared; and (iv) it was a retrospective study. Exclusion criteria were: (i) patients with pathological fracture (such as bone metastasis of cancer, primary bone tumor); (ii) patients with severe osteoporosis; and (iii) patients with old fractures.

Patients Demographics

A total of 76 patients with unstable thoracolumbar fracture associated with TIDL, who were treated by posterior pedicle screw fixation and transforaminal thoracolumbar interbody fusion (TLIF) from June 2010 and July 2016 were included.

These patients included 48 male and 28 female patients with an average age of 48.16 years old (range, 21–73 years old). Anatomical levels were T_{11}, T_{12}, L_1 and L_2 (Table 1). TIDL were grade 2 in 28 patients and grade 3 in 48 patients. Sixty-five patients had one disc lesion and 11 patients had lesions at two levels. Causes of injuries were as follows: motor vehicle accident (20 patients), falling (48 patients), and thump injury (eight patients). Furthermore, 21 (27.6%) patients suffered from multiple injuries, including cervical fracture (three patients), sacrococcyx fracture (two patients), pelvic fracture (four patients), limb fracture (eight patients), and rib fracture (four patients). According to AO classification, there were 47 patients of A3, 14 of B2, six of B3, nine of C. To AO Spine injury score, average AOSIS was 6.06 (range, 4–9), average injury surgery interval was 5.85 days (range, 2–15 days).

Patients Grouping

Patients were divided into two groups including W-TLIF group (n = 38) and C-TLIF group (n = 38). No significant differences in age, gender, and other basic information were found between two groups (Table 2). Modified Wiltse

TABLE 1 Anatomical level distribution

Groups	Total	T_{11}	T_{12}	L_1	L_2	*P* Value*
W-TLIF (n)	38	4	10	18	6	0.812
C-TLIF (n)	38	6	12	15	5	

* Chi square test.

TABLE 2 Comparison of general data between two groups

Data	W-TLIF	C-TLIF	*P* Value
Age (year)	48.70 ± 15.17	47.62 ± 15.51	0.758
AO SIS	6.16 ± 1.59	5.97 ± 1.53	0.533
ISI (day)	5.92 ± 2.62	5.78 ± 2.18	0.801
FT (months)	15.64 ± 5.32	17.08 ± 6.40	0.299
FU (months)	33.62 ± 11.01	35.51 ± 10.74	0.527

AO SIS, thoracolumbar AO Spine injury score; FT, fusion time; FU, follow-up; ISI, injury surgery interval.

approach transforaminal thoracolumbar interbody fusion was used in the W-TLIF group during surgical operation, while conventional open TLIF method was used in the C-TLIF group.

The study was conducted in accordance with the declaration of Helsinki and with approval from the Ethics Committee of the local Hospital. Informed consent was obtained from each patient prior to surgery.

Surgical Technique

Anesthesia and Position

Surgical position was same in the two groups. After administration of general anesthesia, the patient was placed in prone position. Sterilization and draping were done taking care to render iliac crest accessible for possible graft harvesting. C-arm fluoroscopy was used for locating the fractured level. After exposure, pedicle screws were placed before TLIF.

W-TLIF Technique

Approach and Interfixation. A modified Wiltse approach was performed. Namely, a posterior midline incision was made and the subcutaneous tissue and lumbodorsal fascia incised. The incision was lateral traction and the intermuscular plane was identified between the multifidus medially and the longissimus laterally. The muscles were teased apart in the avascular plane down to the outer edge of the facet joints and the transverse processes. The pedicle entry point was identified clearly by medial retraction of the multifidus and lateral retraction of the longissimus. Bilateral pedicle screws were inserted into the fractured vertebral body, the cephalad, and caudal adjacent levels using fluoroscopic guidance. After six monoaxial screws were inserted, a bent rod was installed at each side. The interfixation system was produced by Shandong Kangsheng Medical Devices Co., Ltd. (Shandong, China).

Transforaminal Exposure and Decompression

In the next step, W-TLIF was performed *via* the same Wiltse approach from one side. The rod at the side was taken out with the contralateral rod holding. The lateral superior and inferior facet, as well as the lateral lamina at the traumatic

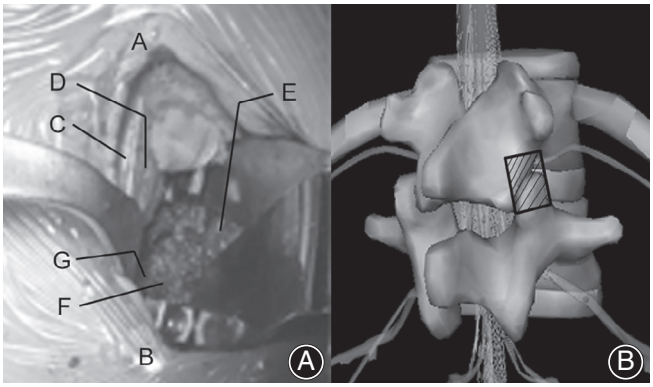

Fig. 1 Exposure of the facets in the affected level by Wiltse approach. (A) intraoperative picture: A, cranial; B, caudal; C, lumbodorsal fascia; D, longissimus; E, multifidus; F, superior articular process; G, inferior articular process; (B) diagram (black frame indicated the enlarged transforaminal exposure).

intervertebral disc lesion was exposed by stripping the facet of the capsule and muscle attachments using monopolar cautery. The bony landmarks were identified with the help of traction by a common retractor medially and mini semi laminal retractors laterally (Fig. 1). Then, the foramen was expanded with resection of bone structures and clearance of lateral ligamentum flavum. Similarly, the nerve and lateral dural sac were protected by nerve dissectors. The lateral traumatic disc was then exposed clearly after coagulation of bleeding vessels using bipolar cautery.

Subsequently, discectomy was performed at the target level. The damaged disc can be removed with curettes and rongeurs. Similarly, the endplate was decorticated to achieve arthrodesis. Any retropulsed bone fragment in the canal was pushed using a special "L" shaped instrument forward into the broken vertebral body to decompress the dural sac. If necessary, contralateral transforaminal decompression was also performed.

Grafting and Transforaminal Interbody Fusion

Then, a special funnel was inserted into the intervertebral space. The ideal insertion position was in the center of the target intervertebral space, which was confirmed by C-arm fluoroscopy (Fig. 2). Morselized bone harvested from the local zone and the iliac crest was packed into the space from the funnel. Absorbable gelatin sponges were used for sheltering the grafted bone. The funnel was then removed and the rod was installed again (Fig. 3). Meanwhile, the facet joints and/or adjacent lamina were decorticated and fused with morselized bone grafting. If necessary, another level of intervertebral disc lesion was managed and fused in the same way. Finally, routine closure was carried out, and a drain was left in the decompression side, as needed.

Fig. 2 A special bone graft funnel was used for interbody fusion. The target point is the middle point of the intervertebral space.

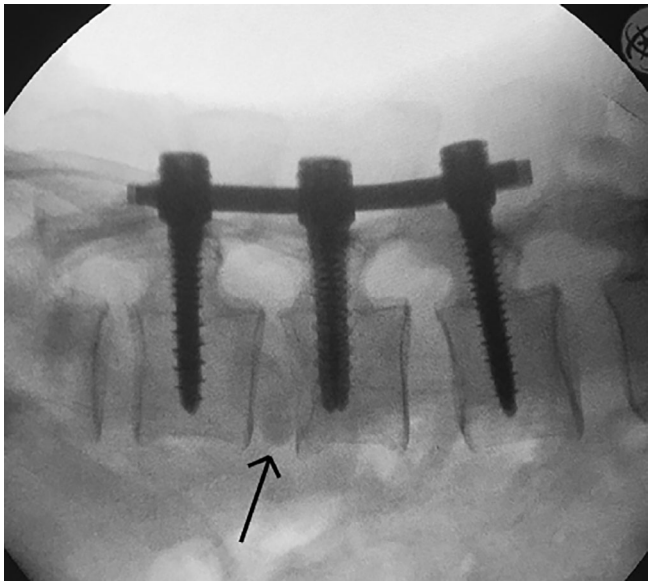

Fig. 3 Morselized bone was packed into the space *via* the bone graft funnel. The arrow marks the intervertebral space fused by morselized bone.

C-TLIF Technique

Approach and Interfixation

Conventional open TLIF was similar to the Wang L method[12], namely, a posterior midline straight incision was made at the target segment and the paraspinal muscle along the spinous process and the vertebral lamina was subperiosteal dissected. The facet joints and roots of the transverse process were exposed by a retractor. Pedicle screws were placed into the fractured vertebral body and one level below and above the affected level. Rods were installed into the screws at each side for reduction and fixation.

Exposure and Decompression

Then, spinal process and both lamina of the affected level were removed to decompress the posterior element. After the rod at the more severe damaged side was taken out with the contralateral rod holding, the ipsilateral facet joint was resected. With the thecal sac and nerve root gently retracted and protected by nerve retractors, the damaged disc was removed and the retropulsed fragment of the fractured vertebral body are hammered anteriorly back into the broken vertebral body for decompression of the anterior elements.

Grafting and Interbody Fusion

Then granulated bone graft and appropriate size of cage were put into the intervertebral space. If necessary, the same decompression and fusion procedure were done on the contralateral side or in another intervertebral disc lesion. Finally, fluoroscopy was used for verification of the screws and cages positioning. Then, a drain was installed and the fascia and skin were closed in standard fashion.

Parameters Assessment

Visual Analogue Scale

The visual analogue score (VAS) system has been widely used in recent research to assess lower back pain. The VAS system (score from 0 to 10) is calculated as: 0 means painless; 1–3 indicates mild pain that can tolerate; 4–6 indicates that the patient is in pain that could be tolerated and is able to sleep; and 7–10 indicates that the patient has severe pain and is unable to endure the pain. VAS score was used for assessment of low back pain at following time-points: preoperation, 1 week after operation, and final follow-up.

Oswestry Disability Index

The ODI has been widely used to assess patients' disability as a result of lower back pain. The ODI score system includes 10 sections: pain intensity, personal care, lifting, walking, sitting, standing, sleeping, sex life, social life, and traveling. For each section of six statements, the total score is 5. Intervening statements are scored according to rank. If more than one box is marked in each section, the highest score is taken. If all 10 sections are completed, the score is calculated as follows: total scored out of total possible score $\times$ 100%. If one section is missed (or not applicable), the score is calculated as: (total score/(5 $\times$ number of questions answered)) $\times$ 100%. Scores of 0%–20% are considered mild dysfunction, 21%–40% is moderate dysfunction, 41%–60% is severe dysfunction, and 61%–80% is considered a disability. For cases with scores of 81%–100%, patients are either long-term bedridden or exaggerating the impact of pain on their life. ODI score was used for assessment

of low back pain at following time-points: pre-operation, 1 week after operation, and final follow-up.

Kyphotic Angle

The Kyphotic angle (KA) referred to the angle between the upper endplate of the vertebra body above the fractured level and the lower endplate of the vertebral body below the fractured level in the sagittal radiograph. The KA was measured at three time-points: pre-operation, 1 week after operation, and final follow-up.

Anterior Vertebral Body Height Remaining Percentage

AHR was the anterior vertebral body height remaining rate of the fractured level. The AHR is calculated as: (The anterior vertebral body height (H1)/The average value of the anterior vertebral body height of the upper and lower vertebral body of the fracture level $(H2 + H3)/2) \times 100\%$ (Fig. 4). The AHR was measured at the three time-points: pre-operation, 1 week after operation, and final follow-up.

Spinal Canal Narrowing Percentage

Spinal canal narrowing percentage (SCN) was measured at the three time-points. SCN was the ratio of anteroposterior diameter of fractured block of invading spinal canal to that of normal spinal canal, which was measured on the axial CT scans.

Frankel Grade

The Frankel grade classification is widely used as an assessment of spinal cord function and is graded A to E: Grade A, complete neurological injury; Grade B, preserved sensation only; Grade C: preserved motor, nonfunctional; Grade D: preserved motor, functional; Grade E: normal motor function. Neurological assessment was performed using the Frankel grade system at pre-operation and final follow-up.

Other Assessments

In addition, intraoperative parameters including blood loss (BL), operation time (OT), hospital stay (HS) and complications were assessed and compared carefully. Fusion rate and complications were recorded and compared in the both group.

Statistical Analysis

Measurement (measured parameters) data were expressed as mean ± SD. and compared with Student's *t*-tests (two tailed). Count data (FC/NFC case, neurological assessment) were compared with chi square test or Wilcoxon rank-sum test. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) software (version 22.0; SPSS Inc., Chicago, IL, USA). *P* value <0.05 was considered to be statistically significant.

Results

Intraoperative Outcomes

All patients in the two groups underwent posterior pedicle screw-rod fixation and TLIF for intervertebral disc lesion successfully. As shown in Table 3, BL, OP and HS in W-TLIF group were 437.84 ± 143.98 ml, 118.64 ± 20.55 min and 12.32 ± 2.87 days, respectively. While those parameters in C-TLIF group was 862.70 ± 300.24 ml, 141.35 ± 31.72 min and 15.51 ± 2.08 days, respectively. Average operation time and hospital stay time were significantly shorter ($P < 0.05$), and blood loss was significantly less in W-TLIF group than in C-TLIF group ($P < 0.01$).

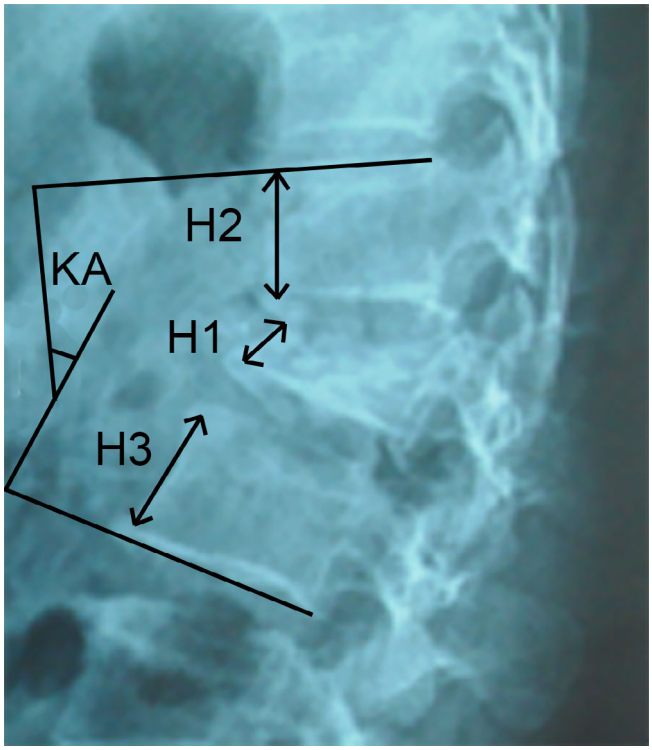

Fig. 4 Measurement of kyphotic angle (KA) and anterior vertebral height (AH) in X-ray lateral fluoroscopy image. KA represents local kyphosis angle, which referred to the angle between the upper endplate of the vertebra body above the fractured level and the lower endplate of the vertebral body below the fractured level in the sagittal radiograph. H1 represents the anterior vertebral body height of the fractured vertebral body. H2 represents the anterior vertebral body height of the vertebra body above the fractured level. H3 represents the anterior vertebral body height of the vertebra body below the fractured level. AH was determined by anterior vertebral body remaining percentage with the formula $AH = 2H1 / (H2 + H3) \times 100\%$.

Visual Analogue Scale

VAS in W-TLIF group at three time points including pre-operation, 1 week after operation and final follow-up were 6.51 ± 1.42, 3.29 ± 1.08 and 1.16 ± 0.88, respectively; VAS in C-TLIF group at three time points were 6.45 ± 1.24, 4.05 ± 1.04, and 2.05 ± 0.69 respectively. No significant difference of VAS was found between two groups at pre-operation (*P* value = 0.924). At 1 week

TABLE 3 Comparison of intraoperative parameters between two groups

Indexes	W-TLIF	C-TLIF	*P* Value
BL (ml)	437.84 ± 143.98	862.70 ± 300.24	<0.001
OT (min)	118.64 ± 20.55	141.35 ± 31.72	0.001
HS (day)	12.32 ± 2.87	15.51 ± 2.08	<0.001

BL, blood loss; HS, hospital stay; OT, operation time.

after operation and final follow-up, VAS in the W-TLIF group was significantly less than those in the C-TLIF group and the *P* value were 0.024 and 0.002, respectively (Table 4).

Oswestry Disability Index

ODI in W-TLIF group at three time points were (67.08 ± 10.09)%, (34.97 ± 9.37)%, and (7.18 ± 2.97)% respectively; ODI in C-TLIF group at three time points were (63.48 ± 10.28)%, (40.54 ± 8.46)%, and (11.40 ± 5.31)% respectively. Comparison of ODI at different time points showed that, compared with pre-operation levels, ODI was significantly improved in both groups at 1 week after operation ($P < 0.05$). Significant improvement was observed at final follow-up ($P < 0.05$). No significant difference of ODI was found between two groups at pre-operation ($P = 0.124$). At 1 week after operation and final follow-up, ODI in the W-TLIF group was significantly less than those in the C-TLIF group and the *P* value were 0.046 and less than 0.01, respectively (Table 4).

Kyphotic Angle, Anterior Vertebral Body Height Remaining Percentage, and Spinal Canal Narrowing Percentage

KA, AHR, and SCN at different time points showed that, compared with pre-operation levels, they were significantly improved in both groups at 1 week after operation ($P < 0.05$). No further significant improvement or

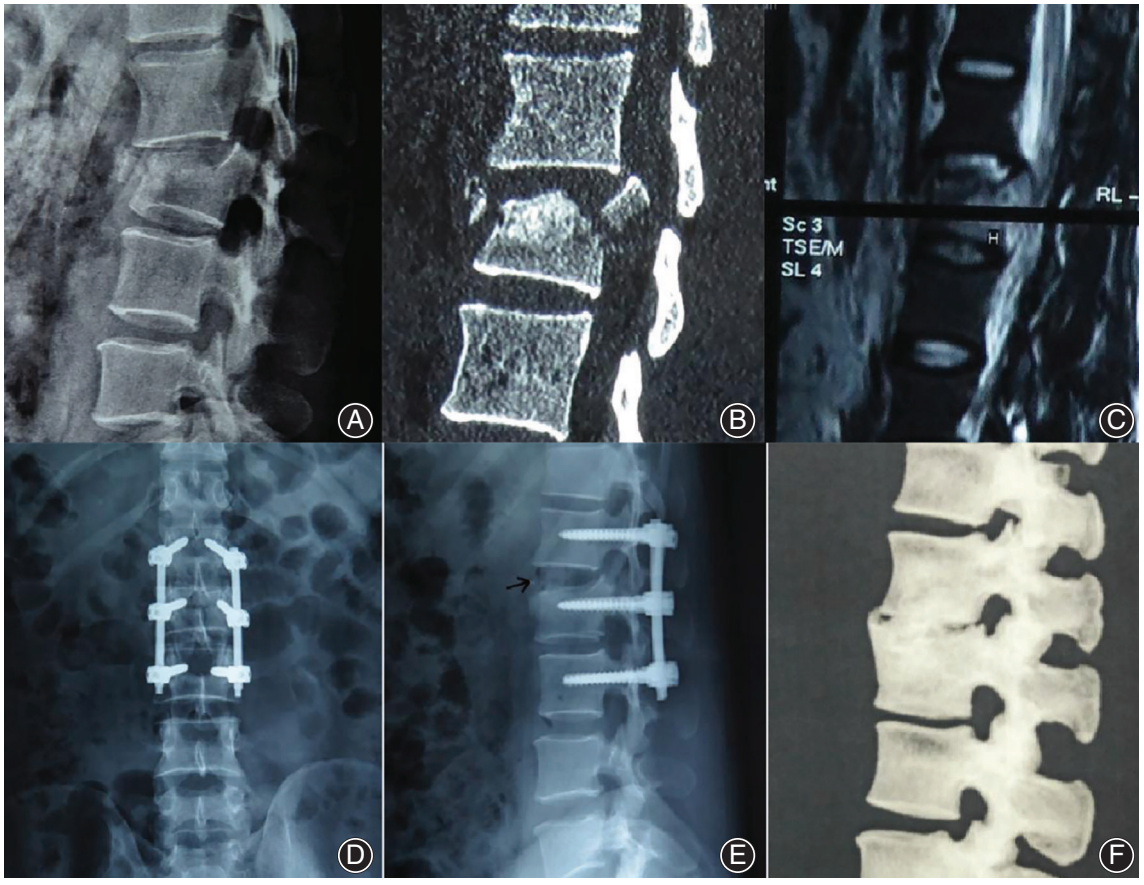

Fig. 5 A typical case in W-TLIF group: A 40-year-old male patient suffered from a fall from a height to low back pain and limited mobility. Before the operation, X-ray fluoroscopy (A), CT scan (B) and MRI (C) were showed a L2 vertebral burst fracture. The postoperative AP view (D) and lateral view (E) of the lumbar were showed that the fracture was well reduced, and the position of the intervertebral bone graft and internal fixation was satisfactory. The internal fixation was removed 24 months after the operation and 3D-CT confirmed that the height of the fractured vertebral body was not lost and the intervertebral bone graft was fused well (F).

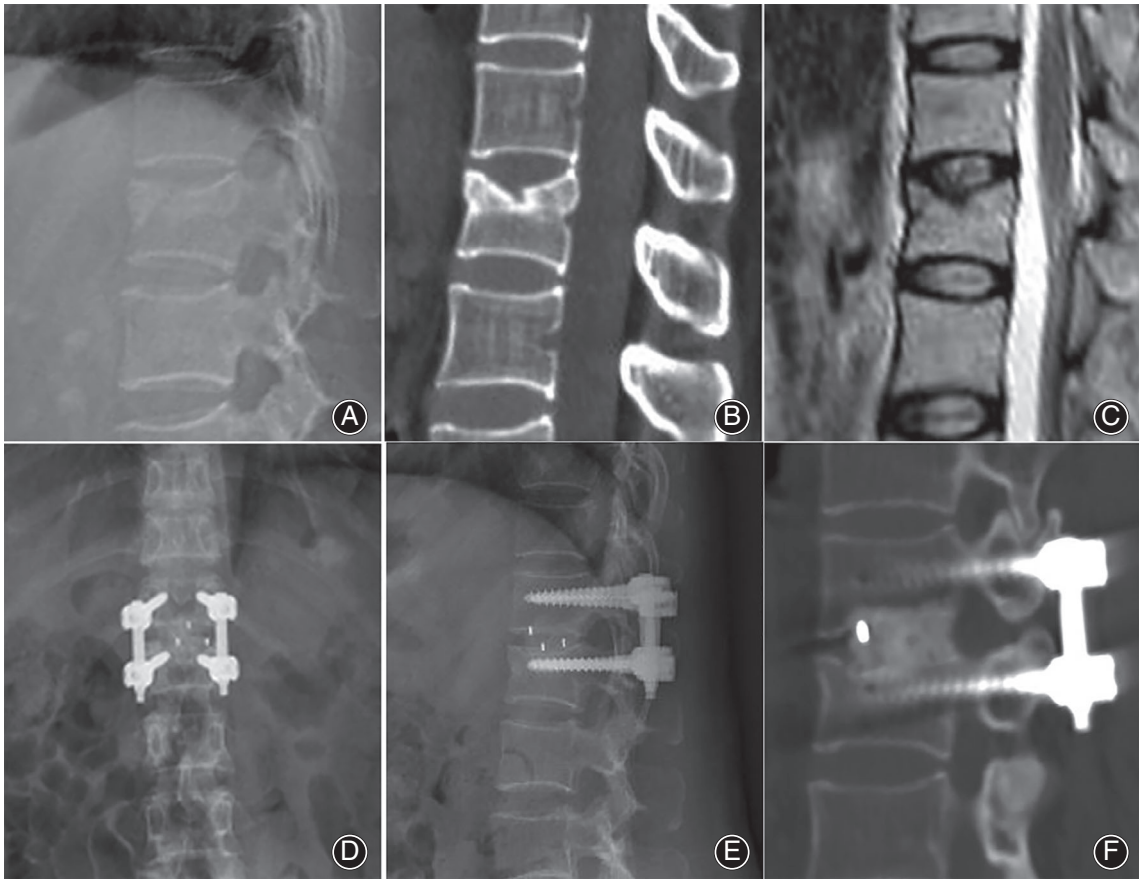

Fig. 6 A typical case in C-TLIF group: A 48-year-old female patient, suffered from a fall 7 months ago, complained of continuous low back pain with conservative treatment. Before the operation, X-ray fluoroscopy (A), CT scan (B) and MRI (C) were showed a L1 vertebral compressed fracture with disc and endplate injured. The postoperative AP view (D) and lateral view (E) of the lumbar were showed that the fracture was well reduced, and the position of the cage and internal fixation was satisfactory. 3D-CT showed that the intervertebral bone graft was fused well (F).

deterioration was observed at the end of follow-up ($P > 0.05$). No significant differences in KA, AHR, and SCN were found between two groups at each time point ($P > 0.05$). See Table 4 for details.

Neurological Assessment

Neurological assessment was performed based on Frankel grade system before operation and at the end of follow-up. As shown in Table 5, compared with pre-operation levels,

TABLE 4 Parameter assessment at the pre- and post- operative

	Pre-operation		One week after operation		Final follow-up	
Parameter	W-TLIF	C-TLIF	W-TLIF	C-TLIF	W-TLIF	C-TLIF
VAS	6.51 ± 1.42	6.45 ± 1.24	3.29 ± 1.08*	4.05 ± 1.04	1.16 ± 0.88*	2.05 ± 0.69
ODI (%)	67.08 ± 10.09	63.48 ± 10.28	34.97 ± 9.37*	40.54 ± 8.46	7.18 ± 2.97*	11.40 ± 5.31
KA (°)	20.18 ± 6.03	18.54 ± 7.73	4.21 ± 2.81	5.24 ± 2.04	4.02 ± 1.93	4.72 ± 2.61
AHR (%)	51.40 ± 13.51	48.45 ± 13.63	92.29 ± 5.37	90.40 ± 7.01	89.47 ± 6.78	88.62 ± 8.60
SCN (%)	30.56 ± 13.06	27.70 ± 10.89	6.18 ± 3.04	5.91 ± 3.21	6.51 ± 2.98	5.18 ± 3.25

AHR, anterior vertebral body height remaining percentage; KA, kyphotic angle; ODI, Oswestry Disability Index; SCN, spinal canal narrowing percentage; VAS, Visual Analogue Score.; * Compared with the C-TLIF group, *P* value < 0.05.

TABLE 5 Comparison of neurological assessment scores obtained through Frankel grade system at different time points in two groups

Groups	Time point	A	B	C	D	E	*P* Value
W-TLIF	Pre-operation (*n*)	1	3	7	10	17	0.041
	The final follow-up (*n*)	1	1	3	4	29	
C-TLIF	Pre-operation (*n*)	1	2	7	17	17	0.048
	The final follow-up (*n*)	1	1	4	5	27	

neurological functions were significantly improved in both groups ($P < 0.05$, chi-square test). No significant differences in neurological scores were found between W-TLIF and C-TLIF groups at both time points ($P > 0.05$, chi-square test).

Fusion Time

Patients in the W-TLIF group were followed up for 33.62 ± 11.01 months and patients in the C-TLIF group were followed up for 35.51 ± 10.74 months. No internal fixation failure was observed in the two groups. FT was 15.64 ± 5.32 months in the W-TLIF group and 17.08 ± 6.40 months in the C-TLIF group. Thirty-three patients (86.8%) in the W-TLIF group and 32 patients (84.2%) in the C-TLIF group achieved bony fusion or partial fusion. A typical case in the W-TLIF group was shown in Fig. 5 and a typical case in the C-TLIF group was shown in Fig. 6. No significant differences in FU and FT were found between the two groups ($P > 0.05$, Table 2). Patients with bony fusion were re-admitted to our hospital for removal of instrumentation, one to 2 years post-operation.

Complications

One patient in the W-TLIF group and one in the C-TLIF group with deep surgical site infection (SSI) were treated by irrigation and drainage, as well as antibiotic therapy. One patient in the W-TLIF group and two patients in the C-TLIF group with cerebrospinal fluid (CSF) leakage were treated with drainage for 1 week. One patient with lung infection in the W-TLIF group and three patients in the C-TLIF group with urinary infection recovered with antibiotic therapy. Two patients in the C-TLIF group with transient abdominal swelling improved 2–5 days post operation. These patients with complications recovered without any adverse consequences. The cases of complications were too small and were not compared in the two groups.

Discussion

Thoracolumbar fractures are usually complicated by varying degrees of intervertebral disc lesions[5,14]. Owing to its avascular morphology, intervertebral discs in adults lack self-repair ability. Further, an injured disc is liable to impinge into the fractured vertebral body; therefore, traumatic disc lesions are one of the key factors that influence postoperative spinal stability and prognosis[15]. Martiniani *et al.*[5] argued that, for some thoracolumbar burst fractures, posterior fixation alone was not sufficient to prevent the late kyphotic deformity. However, there is still no consensus on the classification of TIDL[14,16]. Sander *et al.*[14] classified TIDL based on the morphological changes and signal alterations of the intervertebral discs, as seen on magnetic resonance imaging. In this classification, disc lesions were divided into four categories, where grade 2 and grade 3 suggested severe disc injuries. In our study, disc lesion was classified according to Sander's classification. In our study population, all patients were unstable thoracolumbar fracture with 2–3 grades TIDL and underwent posterior pedicle screw rod fixation with transforaminal thoracolumbar interbody fusion.

Our study developed a modified Wiltse approach transforaminal thoracolumbar interbody fusion (W-TLIF) method for decompression of the neural elements and reconstruction of the anterior column in one procedure. This method is an improvement on conventional open transforaminal thoracolumbar interbody fusion (C-TLIF). The method is a relatively less invasive method to fix the unstable segments and to decompress the neural elements. Fixation, decompression, and fusion may be performed with the posterior approach in a single incision, which is convenient to serves to protect the posterior elements[17]. Actually, our data showed that, compared with C-TLIF, W-TLIF significantly reduced the operation time, which in turn reduced blood loss and accelerated postoperative recovery. Similar procedure has been advocated by other authors[11,12]. Schmid *et al.*[11] in a technical and radiological study of 100 patients with thoracolumbar trauma presented a method (PLIF) to reconstruct the anterior column with monocortical iliac crest autograft by using a single dorsal approach. Wang *et al.*[12] introduced a technique for isolated thoracolumbar burst fractures with posterior short segment pedicle screw fixation and TLIF. The methods were effective in restoring the weight bearing capability of the anterior column *via* a single posterior approach (not Wiltse approach). However, the posterior elements, which may be intact, were removed and injured in the operations. In our W-TLIF group, the posterior elements of spine were preserved as much as possible. The involved segments were fused with non-structural bone grafting *via* the modified Wiltse approach. Compared with C-TLIF, postoperatively the back pain was more obviously relieved, and low back function had better recovery as the ODI in the W-TLIF group was less than that in the C-TLIF group. The outcome was largely attributable to the relatively less invasive surgery and the preserved posterior elements.

The technique of W-TLIF is technically demanding. In operation, a funnel is used for bone grafting. The funnel method was earlier reported by Daniaux[6], who grafted bone into the broken vertebra *via* one or two pedicles with a funnel.

However, intracorporeal grafting alone is not effective in minimizing secondary kyphosis since the intervertebral disc space plays an important role in averting postoperative loss of correction[17]. Similarly, structural bone grafting in thoracolumbar intervertebral space is difficult and technically demanding, where the burst fractured vertebral body may not offer a supporting plane for a cage or an iliac crest graft[11,12]. Moreover, the fractured endplate in thoracolumbar fracture with TIDL will collapse to affect intervertebral fusion. Our technique represents an improvement on the previous method. From the funnel, morselized bone can be packed into the intervertebral space. If the anterior portion of the annulus was disrupted, some gelatin sponges were packed into the anterior intervertebral space prior to bone grafting. Meanwhile, some bone graft should be packed into the burst vertebra from the injured endplate. Thus, placement of bone graft in the space and intracorporeal grafting were achieved simultaneously. In our experience, the W-TLIF is an easy and effective way of bone grafting. Thus, operation time is saved, which in turn reduced blood loss. Although, many minimally invasive techniques, such as tube-assisted technique, robot-assisted pedicle screw implantation, were reported in the literature[18]. These minimally invasive techniques may be with steep learning curve or with expensive instrument, which were not suitable for general hospital or for young doctors. Our technique was easy to learn and was available for general hospital and young doctors.

The clinical results of our study in the two groups demonstrated the advantages of posterior fixation with anterior supporting fusion for thoracolumbar fractures.[4,19] The kyphotic angle was corrected and the correction lasted satisfactorily, and the anterior vertebral body height improved sharply. These results are similar to those reported earlier[4,11,12]. Non-fusion with resorbed bone is still a concern in case of non-structural bone grafting by this technique, as several researchers have achieved different fusion rates. Tan *et al.*[4] reported fusion rate of 63% after 12 months and 81% after 32 months of additional anterior plating fusion. Schmid *et al.*[11] reported an anterior intervertebral fusion rate of 83%. In the current study, Thirty-three patients (86.8%) in the W-TLIF group and 32 patients (84.2%) in the C-TLIF group achieved bony fusion or partial fusion. These results are similar to those reported earlier. Five patients (13.2%) in the W-TLIF group without fusion showed bone graft resorption without any complications such as pseudarthrosis or instrumentation failure. To improve the fusion rates, a rigid fixation, and a satisfactory discectomy with massive autograft may be recommended. In the current study, rigid fixation was achieved in all patients. To perform W-TLIF, the discectomy was performed with the operation table in a 15° inclined position. Thus, the contralateral disc could be removed *via* the unilateral Wiltse approach. The bone graft could be harvested from the local surgical site or from the iliac crest. Additionally, allografts can also be used as an alternative.[20] The risk of morselized bone graft moving into the spinal canal is another concern, which can be avoided by 1 week compulsory bed rest. None of our patients developed this complication.

Conclusion

The both techniques of W-TLIF and C-TLIF were feasible and effective for unstable thoracolumbar fracture associated with TIDL. Compare to C-TLIF, The technique of W-TLIF represented a relatively less invasive technique to decompress the neural elements and allows for reconstruction of the anterior column in a single-stage procedure. The limitations of the current study include its retrospective design, single-center scope and the small number of patients. We carefully suggest that W-TLIF is an alternative technique for unstable thoracolumbar fracture with grade 2 or 3 disc lesions.

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Author Declaration

All authors listed meet the authorship criteria according to the latest guidelines of the International Committee of Medical Journal Editors, and all authors are in agreement with the manuscript.

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