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Original Article

A minimally invasive surgical strategy for the treatment of type A thoracolumbar fracture: percutaneous stabilization combined with mini-open anterior intracorporeal bone grafting

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Abstract: Objective: To explore the efficacy of an intracorporeal bone grafting technique in the treatment of type A thoracolumbar fracture. Methods: From Feb 2010 to March 2012, a series of 28 patients type A thoracolumbar fracture with moderate to severe osteoporosis who met our inclusion criteria were treated by a combination of percutaneous pedicle screws posteriorly and intracorporeal grafting through mini-open anterior approaches. Radiographic (kyphosis angle, anterior height percentage of compressed vertebral body) and clinical outcomes (visual analogue scale of back pain, Oswestry disability index) were retrospectively studied to evaluate the patients' outcome in this new procedure. All the patients were followed up with a mean duration of 59.14±6.4 months. The evaluation for clinical outcomes were excellent and good. Radiograph indicated fracture healing in all cases and there was no instrumentation failure. The anterior height percentage of compressed vertebral body and kyphosis angle were 71.7%±7.2% and 19.6°±3.3° preoperatively, 95.4%±2.8% and 5.5°±2.2° postoperatively, 88.4%±3.7% and 10.3±2.7° at the 12-month follow-up, 88%±3.7% and 10.8±2.8° at the last visit. Percutaneous pedicle screw fixation combined with mini-open anterior bone intracorporeal grafting is an effective minimally invasive technique for treating type A thoracolumbar fracture.

Keywords: Spinal fracture, minimal invasive surgery, percutaneous pedicle screw fixation, intracorporeal bone grafting

Introduction

Fractures of the spine usually occur in the thoracolumbar area. Although conservative treatment can lead to favorable clinical outcomes in neurologically intact patients with type A thoracolumbar fractures, it appears that the kyphosis progresses and vertebral body collapses gradually over time, especially for those patients with osteoporosis [1, 2]. The surgical treatment for type A thoracolumbar fractures is getting more and more popular in these several decades [3]. But the ideal surgical options are still controversial. Traditional pedicle-screw instrumentation is the most common intervention that enables an indirect reduction and kyphosis correction by ligamentotaxis [4-7]. But without vertebral body reconstruction, the incidence of early instrumentation failure and progressive deformity are high [8, 9], especially for those patients with osteoporosis [10]. Consequently, some authors advocated anterior instrumentation with strut grafting or mesh cage [11], even combination of the anterior and posterior procedures. Although the anterior or combined anteroposterior approach yielded the best results in long-term maintenance of kyphosis correction, the longest total operative time, the most intraoperative blood loss, serious complications and difficulty skills always disappointed the surgeons [12, 13].

With the advent of minimal invasive surgical methods, percutaneous pedicle screws and mini-open anterior approaches have been successfully introduced to overcome the shortcom-

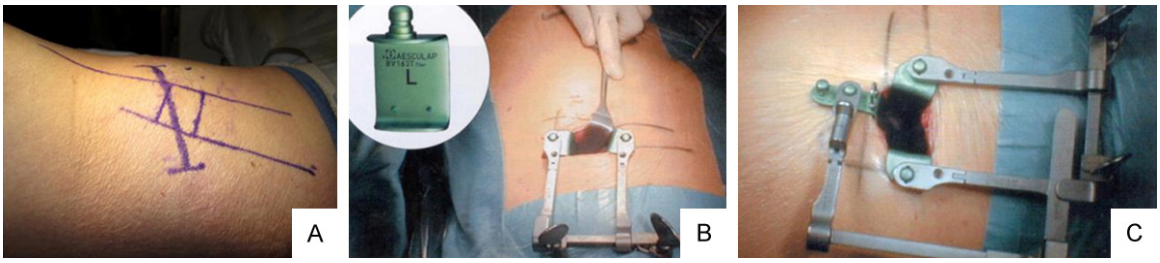

Figure 1. Intra-operative image of the surgical procedure. A. Image of the mark for the mini-lateral approach. B, C. Intra-operative image for mini-lateral approach.

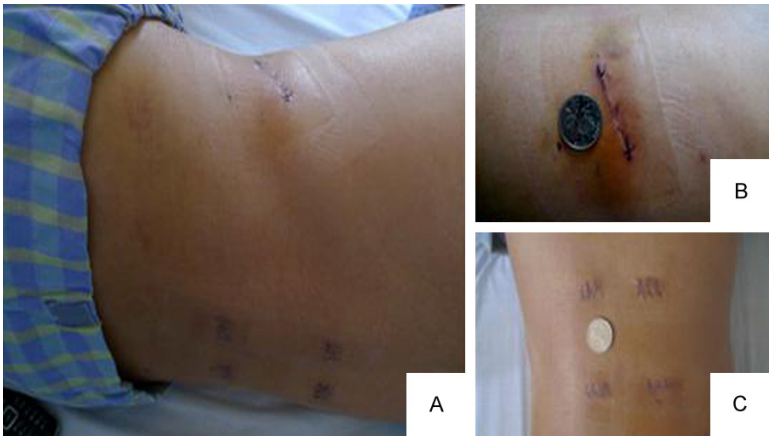

Figure 2. Intra-operative image of the surgical procedure. A. It shows the whole shape of the patients' wound, B. It shows a small lateral wound, C. It shows the wound of inserted percutaneous pedicle screws.

ings of conventional procedures [14]. We tried to manage the type A thoracolumbar fractures accompanying with moderate to server osteoporosis by a combination of percutaneous pedicle screws posteriorly and intracorporeal grafting through mini-open anterior approaches. The aim of this study was to evaluate the efficacy of this new procedures.

Materials and methods

From Feb 2010 to March 2012, a consecutive series of 28 patients due to type A thoracolumbar fractures (T10-L2) were included in this study. According to the AO fracture classification [15], type A1 fracture occurred in 16 cases, A2 in 8 and A3 in 4. Plain X-radiographs, computed tomography (CT) scans and magnetic resonance imaging (MRI) were obtained from the patients to determine the type of fracture, anterior height percentage of compressed vertebral body, kyphosis angle, and whether there was an injury of posterior ligamentous complex (PLC), etc.

Patient selection

Inclusion criteria were: (1) Type A fractures between T10 and L3 without neurologic impairment. (2) Single-level fresh thoracolumbar fracture (within two weeks). (3) The kyphosis angle exceeding 15° or the loss of anterior body height exceeding 50%. (4) Suffering from moderate to server osteoporosis identified by the bone mineral density examinations.

Treatment and operation technique

Posterior reduction, percutaneous short-segment pedicle screw fixation, and one-stage mini-open anterior intracorporal grafting was given.

Posterior approach: percutaneous pedicle screw fixation

After endotracheal intubation and induction of general anesthesia, the patient was placed in prone position on Jackson table with transverse gel rolls across the chest and the pelvis. All patients underwent postural reduction and simultaneous axial traction firstly. C-arm fluoroscopy was used to identify the fracture level and confirm it had been reduced satisfactorily. A standard anteroposterior (AP) view of the segment to be instrumented should be obtained. A small, 1 to 2 cm incision was made lateral to the lateral border of the pedicle. Then the Jamshidi needle was introduced. The entry point was usually selected at the lateral border of the pedicle. Under the fluoroscopic control, the needle was slowly advanced into the verte-

Table1. Demographic data of the 28 included patients

Patient No.	Age (yr)/Gender	Cause of injury	Level of Injury	AO Classification	Osteoporosis classification	Follow-Up (months)
1	43/F	Falls	T11	A1	Osteoporosis	75
2	57/F	Falls	L2	A1	Severe osteoporosis	70
3	47/M	Falls	L2	A1	Osteoporosis	68
4	56/F	Traffic accident	L2	A2	Severe osteoporosis	67
5	59/M	Falls	L1	A1	Severe osteoporosis	62
6	63/F	Traffic accident	L1	A3	Severe osteoporosis	59
7	58/M	Falls	T11	A2	Osteoporosis	58
8	55/F	Falls	L1	A1	Osteoporosis	58
9	56/F	Falls	L2	A1	Osteoporosis	57
10	53/F	Falls	L2	A2	Severe osteoporosis	54
11	58/M	Traffic accident	L1	A1	Severe osteoporosis	53
12	62/M	Falls	L2	A1	Severe osteoporosis	53
13	60/F	Falls	L1	A3	Severe osteoporosis	51
14	57/F	Falls	T12	A1	Osteoporosis	50
15	51/F	Falls	L2	A1	Osteoporosis	63
16	49/F	Traffic accident	L1	A2	Severe osteoporosis	63
17	49/M	Traffic accident	L2	A1	Osteoporosis	60
18	56/F	Falls	L2	A2	Severe osteoporosis	57
19	45/M	Falls	T12	A1	Osteoporosis	51
20	58/F	Traffic accident	L1	A3	Osteoporosis	57
21	62/F	Falls	T11	A2	Osteoporosis	66
22	59/F	Traffic accident	L2	A1	Osteoporosis	69
23	57/M	Falls	T12	A1	Severe osteoporosis	51
24	61/F	Falls	T12	A2	Severe osteoporosis	60
25	57/F	Falls	L1	A3	Osteoporosis	54
26	51/M	Traffic accident	T11	A1	Osteoporosis	53
27	46/M	Falls	L2	A2	Osteoporosis	57
28	60/F	Falls	L1	A1	Osteoporosis	60

bra body. The tip of the needle should not violate the medial border of the pedicle before it arrives at the posterior wall of body. Once the needle was within the body, the guidewire was introduced through the Jamshidi needle. Then Jamshidi needle was withdrawn, and the wire was kept in place. A cannulated awl was used to penetrate the cortical bone at the entry point, followed by self-tapping cannulated screws with appropriate diameter and length to be inserted over the wire. Then the rod with appropriate length was attached to the introducer and introduced subfascially through the slots of the pedicle screws. The nuts were then inserted and tightened. Final tightening was performed with an antitorque wrench to prevent rod rotation in the coronal plane. The incisions were irrigated and closed in layers, and no drainage were placed (**Figure 1**).

Mini-open anterior approach: intracorporeal grafting

In general, a left-sided approach was used to access the thoracolumbar junction. The way access to the targeted injured vertebra was varied depending on the level of the injured vertebra. For injured T11-T12 vertebra, a transthoracic approach was selected to reach the targeted vertebra. For injured L1 or L2 vertebra, a retroperitoneal approach was selected (**Figure 2**).

Transthoracic approach: The level of the injured vertebra was identified by lateral fluoroscopic imaging, and projection of the skin was marked on the lateral chest wall. About a 4 cm long arc incision was performed along the intercostal space according to the marker. After cutting

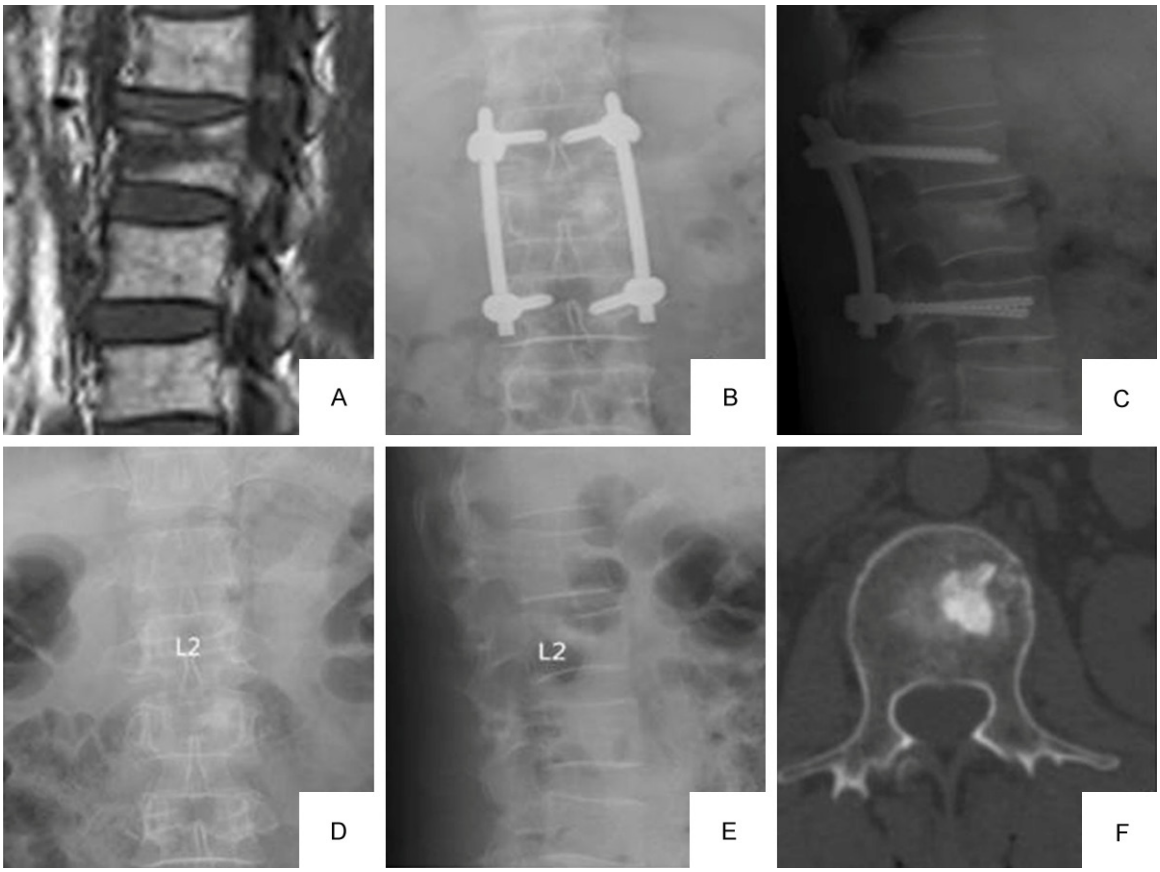

Figure 3. Pre-operative and post-operative films of a 47-year old male with L2 compressive fracture caused by falling from a height. A. Pre-operative films showing a kyphotic deformity and loss of the anterior vertebral body height. B, C. Film in the one week after surgery showing the significant improvement of anterior vertebral body height and kyphotic deformity. D-F. Films in the sixteen months after surgery with the removal of in-fixation indicating no significant correction loss of CA and AVBH.

parietal pleura, a retractor was used to fix the lung. The lateral side of the injured vertebral was exposed and identified. An electric coagulation hemostasis was used to ligature the related segment blood vessels. When the anterolateral wall of fractured body was exposed, about a 1.5 cm×1.5 cm window was opened with an osteotome along the fracture line. Then a periosteal elevator was applied to reduce the collapsed endplate. About 10 g allogenic morselized bone was tamped to fill in the space left.

Retroperitoneal approach: After exposing the thoracolumbar spine laterally, the level fractured was precisely identified with fluoroscopic imaging. More attention should be paid not to injure the lumbar plexus in psoas. The segmental vessels can be ligated. About a 1.5 cm×1.5 cm incision was performed with an osteotome along the fracture line. The subside end-plate were reset, and allogeneic bone were tamped to fill in the space left. The amount of bone graft was about 10 grams.

Good location of the grafting bone and satisfactory correction of kyphosis were confirmed by AP and lateral fluoroscopy. Finally, incisions were irrigated and closed layer-by-layer, and a vacuum sealing drainage was placed for transthoracic approach operation.

Postoperatively, prophylactic antibiotic was given intravenously for 2 days. The ambulatory activities were allowed after wearing a brace on day-3 postoperatively and the brace was kept for 3 months. The implants were removed 1 year after the surgery for the motion segments were preserved.

The duration of surgery and intraoperative blood loss were recorded. The visual analogue

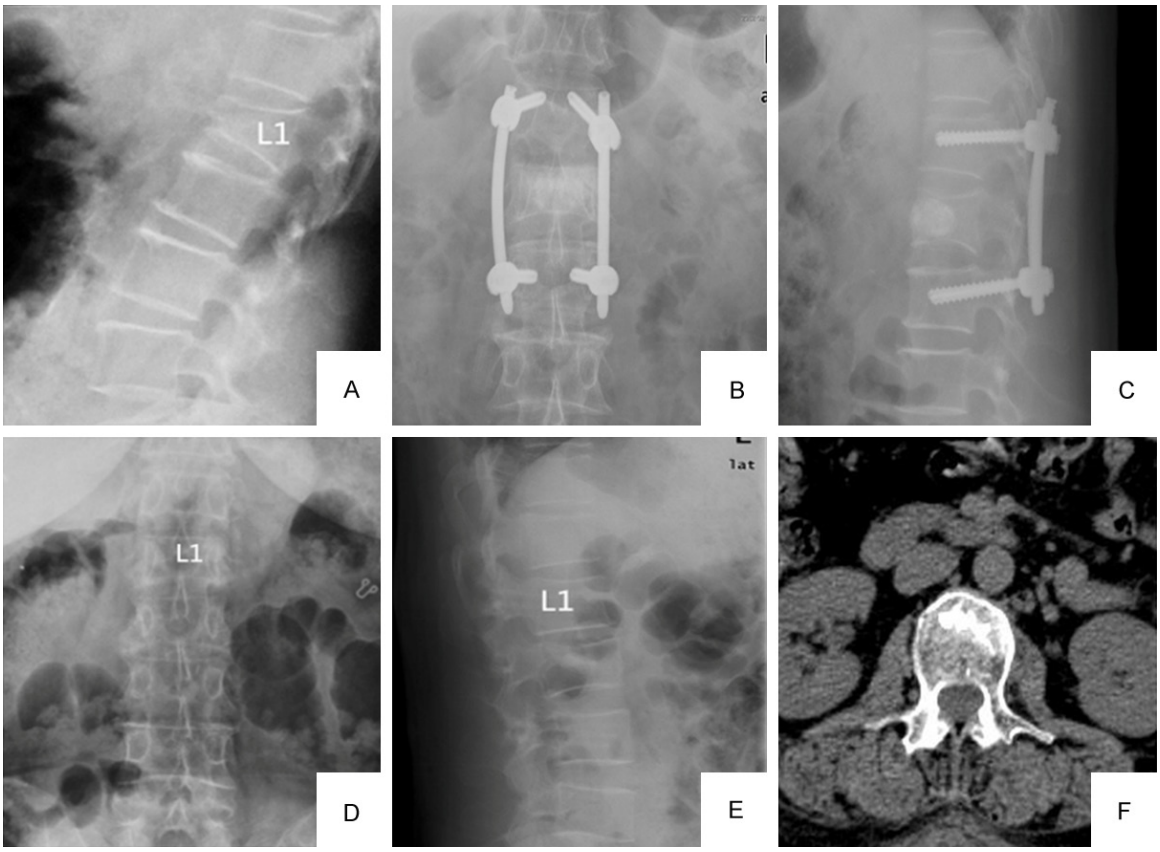

Figure 4. Pre-operative and post-operative films of a 57-year old female with L1 compressive fracture caused by falling from a height. A. Pre-operative films showing a kyphotic deformity and loss of the anterior vertebral body height. B, C. Film in the one week after surgery showing the significant improvement of anterior vertebral body height and kyphotic deformity. D-F. The pictures show a favourable restoration of anterior height of L1 vertebra and correction of Cobb angle when the inter-fixation was removed one year post-operative.

scale (VAS) of back pain and Oswestry disability index (ODI) scores were measured to assess the clinical effect at the time of pre-operative, a week after operation, 12 months postoperative and the final follow-up. Segmental kyphosis was determined by measuring the Cobb angle (CA) between the superior endplate of the vertebral body cephalad to the injury and the inferior endplate of the vertebral body caudad to the injury. The percentage loss of the anterior vertebrae body height (AVBH) of the fractured vertebra was calculated by dividing the height of the fractured vertebra by the average height of the cephalad and caudad vertebrae and then subtracting this number from 100% [16]. CT or/and MRI assessment including reconstruction images were performed at the time of pre-operative and a week postoperative, 12 months postoperative, and the last visit to evaluate the CA and AVBH. All radiographic measurements were taken by an orthopedic spine fellow who was not involved in the surgery.

Statistical analysis

A paired t test was used to measure the statistical significance of the CA, AVBH, VAS scores and ODI between time points. A *P* value less than 0.05 was regarded as statistically significant.

Results

A total of 28 patients (10 males and 18 females) with single type A thoracolumbar fracture who met our selection condition were involved in our study. The age of the included patients was 54.1±7.1 years (range, 43-63 years). Most of the patents included in our study were accompanying with a moderate to server osteoporosis confirmed by the bone mineral density testing.

Table 2. The detailed information of patients' preoperative and postoperative clinical and radiologic outcomes

Patient No.	Operative time (min)	Blood loss (ml)	CA (°)				AVBH (%)			
			Preoperative	Postoperative	12 months	Final visit	Preoperative	Postoperative	12 months	Final visit
1	200	270	17.6	3.5	6.2	6.7	70.1	94.4	90.2	90
2	140	250	18.3	6.9	7.7	7.9	66.2	97	94.5	94.1
3	160	195	20.5	5.9	11.9	12.4	72.3	92.1	86.1	85.9
4	170	230	22.7	7.4	14.5	15.1	62.7	93.5	84.8	84.2
5	180	200	16.1	3.2	5.6	6.1	82	98.1	92.4	91.9
6	210	345	19.2	4.8	11.3	11.9	71.6	93.7	86.2	85.8
7	150	220	25.4	4.1	13.4	14.1	64	96.1	88.7	88.2
8	180	205	21.7	11.5	14.1	14.8	84.5	98.2	90.3	90.1
9	160	260	17.5	3.6	9.6	10.3	68.4	99.6	89.9	89.6
10	190	280	19.9	4.2	9.3	9.8	77.1	97.3	91.3	91.1
11	230	300	15.8	3.2	8.2	8.4	65.8	89.5	82.6	82.2
12	195	240	14.9	6.5	10.2	10.5	82.1	97.8	92.5	92.1
13	175	285	26.3	7.3	12.5	12.6	61.9	95.3	83.2	83.0
14	180	220	18.2	5.4	10.3	10.6	75.3	92.3	84.3	84.1
15	220	210	23.5	8.2	11.4	12.5	70.9	92.7	89.4	89.2
16	190	260	17.9	6.4	8.5	9.1	82.6	99.5	95.6	95.2
17	205	275	18.7	7.6	10.2	11.0	74.8	92.3	84.6	84.1
18	210	340	24.6	7.1	11.7	12.2	76.1	94.8	90.1	89.5
19	165	315	21.6	6.5	8.7	9.4	68.7	90.7	85.3	84.8
20	180	310	19.8	8.5	10.2	10.9	64.3	87.4	84.7	84.3
21	190	270	25.1	6.7	9.5	10.2	78.2	91.2	82.6	82.2
22	205	220	24.6	8.1	12.9	13.8	63.9	88.1	85.4	85.0
23	225	215	17.4	5.4	7.6	8.2	81.4	97.4	92.9	92.4
24	170	260	20.6	6.6	9.2	9.9	83.7	95.6	91.7	91.3
25	220	330	16.4	4.6	11.7	12.4	75.4	95.8	91.2	91.0
26	200	215	17.3	5.8	8.3	.8.8	71.6	96.3	89.4	88.7
27	160	265	16.9	7.3	12.1	12.9	67.1	89.5	86.1	85.7
28	175	235	24.2	9.4	11.4	12.2	69.7	92.1	89.3	88.8

CA: Cobb angle; AVBH: anterior vertebrae body height.

Table 3. The summarized of patients' preoperative and postoperative clinical and radiologic outcomes

	VAS	ODI (%)	CA (°)	Correction loss	AVBH (%)
Pre-operative	7.4±1.2	79.2±9.1	19.6±3.3	-	71.7±7.2
1 week Post-operative	2.6±0.8	25.8±5.8	5.5±2.2	-	95.4±2.8
12 months after operative	2.1±0.5	9.3±4.5	10.3±2.7	4.8±2.1	88.4±3.7
At the final follow up	1.9±0.3	8.9±3.1	10.8±2.8	5.3±2.2	88±3.7

VAS: visual analogue scale; ODI: Oswestry disability index; CA: Cobb angle; AVBH: anterior vertebrae body height.

Causes of injury included fall from height (20 cases), traffic accidents (8 cases). Injured levels involve T11 (4 cases), T12 (4 cases), L1 (9 cases), and L2 (11 cases) (**Table 1**). All the operations were performed by the same surgeon. All patients accepted the surgery of instrumentation removal during the period of 12 months to 18 months when plain X-radiographs confirmed good healing of fractured vertebra (**Figures 3** and **4**).

Operation time and intra-operative blood loss

The operation time was 187±23.1 minutes, and the amount of blood loss was 257.9±42.8 ml. The mean postoperative follow-up period

was 59.14±6.4 months (range, 50 to 75 months) (**Tables 1** and **2**).

Clinical outcomes

The VAS scores for back pain and ODI scores were collected from all the cases. All of the patients in our study achieved solid fusion and favorable clinical result. The VAS for back pain decreased from 7.4±1.2 preoperatively to 2.6±0.8 a week postoperatively to 2.1±0.5 at 12 months after surgery. The VAS scores for back pain was 1.9±0.3 at the final follow-up.

The ODI scores before the operation were 79.2±9.1 and decreased to 25.8±5.8 a week after operation. At 12 months' follow-up, the ODI scores was 9.3±4.5, and ended to 8.9±3.1 at the last visit. It showed statistical significance between the preoperative and a week after the operation for VAS and ODI scores (**Table 3**).

Radiologic outcomes

This procedure provided excellent immediate reduction of post-traumatic local kyphosis. In terms of CA, the preoperative was 19.6±3.3°, decreasing to 5.5±2.2° at the time of a week postoperatively (71.9% correction), to 10.3±2.7 12 month postoperatively (65.9% correction) and ended to 10.8±2.8° at final follow up (47.4% correction). There was a significant difference in the kyphotic angle between before and after surgeries ($P < 0.05$), and before surgery and at the final follow-up ($P < 0.05$). The correction losses of the CA were 4.8±2.1° at 12 month follow up (34% loss) and 5.3±2.2 at the last visit (37.5% loss) (**Table 3**).

The AVBH, before the operation, was 71.7±7.2 and improved to 95.4±2.8 immediately after operation (33% correction). At 12 months' follow-up, the AVBH was 88.4±3.7 (23.3% correction), and ended to 88±3.7 at final follow-up (22.7% correction). There was a significant difference in the AVBH between before and after surgeries ($P < 0.05$), and before surgery and at the final follow-up ($P < 0.05$).

Surgery-related complication

There were no major complications such as massive bleeding, neurological deterioration, pleural effusion and atelectasis in this study. There were 2 cases of intercostal neuralgia and post-thoracotomy pain, 2 of transient groin or thigh paraesthesias. These symptoms were usually resolved after 4-8 weeks postoperatively. Pseudoarthrosis or instrumentation failure in the process of follow-up were also not existed.

Discussion

In our study, although neurologic impairment was not detected among the patients, we did not choose the non-operative treatment. The reasons can be concluded as follows: firstly, the patients included in our study suffering from the kyphosis exceeding 15° or the loss of anterior body height exceeding 50%; secondly, moderate to server osteoporosis was identified by the bone mineral density examinations for the participants. Severe kyphotic deformity may happen for these patients if non-operative treatment was taken [17].

Thus, we selected the surgical treatment for the patients. However, the surgical treatment of thoracolumbar burst fractures remains controversial, especially for patients without neurological deficit. Although short-segment fixation (1 level above and below the site of fracture) is the most common and simplest treatment of burst fractures [17] without anterior construction, the loss of restoration will be greater because of the recollapse of the vertebral. Some authors suggested that 2 levels above and 2 levels below the fractured vertebra of posterior stabilization can preserve the initial correction and achieve more than 90% fusion rates, but this will lead to a loss of more motion segments [18]. During the posterior approach surgery, some authors suggested transpedicular grafting in addition to short-segment pedicle-screw fixation to increase stiffness of the fractured vertebral body, which may serve as a possible solution [19]. But in the clinical practice, some researchers have argued against the effectiveness of transpedicular grafting. Their studies showed that transpedicular grafting of the injured vertebral body was not effective in preventing correction loss and implant failure [14, 20]. This is because that the angle between pedicle and vertebral body is fixed. Grafting through pedicle is so difficult and for the passage is not direct to position of bony defect, the defect cannot be filled adequately.

Some authors attempted additional vertebroplasty or kyphoplasty with polymethyl methacrylate (PMMA) or calcium phosphate cement injection to augment the anterior column supplementing short segment pedicle screw instrumentation [19, 20]. But treatment with PMMA has serious drawbacks. PMMA is not a biodegradable (resorbable) material which makes it unsuitable for young patients. What is more, cement leakage, pulmonary embolism are severe complications [21]. Calcium phosphate is the biocompatible material without local heating or toxic effect. Usually it will be absorbed in 2 or 3 months after surgery [24]. The creeping substitution of new bone trabeculae is not completed at that time, which would lead to the late loss of alignment correction.

With the development of anterior surgery, many surgeons found anterior procedures had some advantages in treating thoracolumbar compression fracture [25]. Despite favorable results were reported for anterior-only approaches, several authors claimed that the combined procedures can increase primary stability, optimize reduction capability and decrease postoperative correction loss. They held that pedicle screws used to augment posterior tension band and anterior column reconstruction with or without instrumentation can restore the function of bearing weight [33]. However, the traditional anterior approach or the combined procedures are more invasive, which is associated with prolonged operation and hospitalization time, more blood loss, donor site complaints and increased morbidity [12, 17, 30].

With the advent of minimal invasive surgical technique, mini-open approaches have been introduced to overcome these disadvantages with the use of self-retaining retractor system [26]. The self-retaining retractor system and aspirator with illumination enable the surgeon to work in deep and narrow surgical fields. When the anterolateral wall of fractured body was exposed, a window was opened at the fracture line. Then a periosteal elevator was used to reduce the collapsed endplate. The allogenic morselized bone was tamped to fill in the space left. This process was just like the treatment of tibia plateau fracture. The amount of bone graft was about 10 grams, much greater than the transpedicular grafting [19]. With the restore of vertebral height, the tension of tissue around vertebrae was also restored. The fractured vertebrae being filled up with morselized bone was similar to sandbag filled up with sand, additional with posterior pedicle screw, which is solid enough to bear weight. In addition, pedicle screw can also be implanted percutaneously. So, combination of percutaneous pedicle screw and mini-open anterior approach offers a less-invasive alternative.

At the same time, the satisfactory outcomes in our study further confirmed this procedure in the treatment of type A thoracolumbar fracture. Some authors had reported unacceptably high failure rates in a posterior approach surgery: 20% to 50% incidence of pedicle screw failure and 50% to 90% loss of reduction of kyphosis [27]. However, in our study, there was no incidence of pedicle screw failure, and the loss of correction angle of posterior surgery at 12 months follow up was 4.8±2.1° (34% loss), 5.3±2.2° (37.5% loss) at the last visit. For traditional open combined surgery, the mean loss of correction was 2.6° to 4°, which seems better than ours [28-33]. This is because expandable titanium corpectomy cages were implanted in traditional combined surgery to help achieve a relative stable fixation. What is more, most patients included in our studies were associated with moderate to severe osteoporosis, which may easier to get loss of correction angle. In our study, most of the correction loss occurred within the first 12 months postoperatively, which got the similar result comparing with other studies [28-33].

In our procedure, the whole operations were done in one time. The operation time was 187±23.1 minutes, and the amount of blood loss was 257.9±42.8 ml. According to several studies [17, 32, 34], the mean blood loss in traditional anterior approach was 640-1750 ml, 396-710 ml for posterior method. For traditional combined surgery, the operation time ranged from 331 to 569 min and blood loss varied from 1800 to 2541, which suggested more invasive than our procedure [28-31]. In our study, as described in other studies [33, 34], the satisfactory mean ODI and VAS scores were achieved at the 1-year follow-up and the last visit.

A minimal invasive circumferential short-segment fusion may offer the best biomechanical

solution, but any benefit must be carefully weighed against the morbidity of additional surgical intervention. For traditional combined anteroposterior surgery, the incidence of complications was ranged from 1/3-1/2 [28-31]. In our study, there were no major complications such as massive bleeding, neurological deficit, pleural effusion, atelectasis. There were 2 cases of intercostal neuralgia and post-thoracotomy pain, 2 of transient groin or thigh paraesthesias. These symptoms were usually resolved after 4-8 weeks postoperatively. The latter was mainly caused by the stimulation of the psoas and the lumbar plexus in operation. Complications encountered with surgical management of thoracolumbar fractures are predictable and can be minimized through careful operative planning, meticulous technique and postoperative care. A recent anatomical investigation has validated that the lumbar plexus are lied in the posterior half of the psoas, so dissection within the anterior half may help to reduce the risk of injury to the lumbar plexus.

Maybe some scholars would question that why we not use thoracolumbar injury classification, load sharing classification system or severity scores (AO-ASIF) to assess the classification of fracture [35]? This is because that the patients in our group were much elder (the average age was 54.1, range, 43 to 63) and most were accompanied with osteoporosis. But the classification system was summarized from a group of younger patients (range 19-47 years). The conclusion was just according to the complication of instrumentation failure. But the loss of the vertebral body height or kyphosis correction was not included into the observation index. So, those classification system does not apply to patients of this elder age group in our study. On the base of least trauma, this new technique provides the maximum stability to meet the patients' demand of early ambulation.

Above all, in our procedure, we combined the advantage of anterior and posterior, and minimized the complication and clinical course in a mini-invasive way.

There are three main limitations in our study. Firstly, the study failed to use sagittal index to describe sagittal deformity, which influenced the accuracy of the results to some extent. Secondly, this small series is not powered enough to resolve this issue, and larger studies are required to form precise clinical indications. Thirdly, a control group was lacking in our study.

Although the combined procedure and adequate decompression of the spinal canal, it is more invasive than the anterior or posterior procedure alone. The combined procedure presented in this study has the advantages as the conventional combined one including immediate strong stability, complete correction of kyphosis, maintenance of the correction of kyphosis. But it is less invasive and finally achieved shorter stabilization, resulting in preservation of motion segments. This procedure seems to be a reasonable treatment option for thoracolumbar fractures.

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Disclosure of conflict of interest

None.

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