Comparing the efficacy of short-segment pedicle screw instrumentation with and without intermediate screws for treating unstable thoracolumbar fractures

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Abstract

It is generally acknowledged that short-segment pedicle screw instrumentation is the preferred surgical method for thoracolumbar fractures. However, the use of short-segment instrumentation with or without intermediate screws at the fracture level remains controversial.

We retrospectively evaluated 44 patients (28 men, 16 women) with unstable thoracolumbar fractures. The patients were divided into 2 groups according to the surgical method used. In group 1, 24 patients underwent surgery with a posterior approach via short-segment pedicle screw instrumentation (1 level above and 1 level below the fractured level). In group 2, 20 patients received an additional 2 screws at the fractured vertebrae. Clinical and radiologic parameters were evaluated before surgery and at 1 week, 6 months, and 1 year after surgery.

We found no significant difference in the demographic characteristics between the 2 groups. No significant difference was observed in the operative time and intraoperative blood loss between the 2 groups. Clinical outcomes also showed no significant differences between the groups preoperatively or at all follow-up periods. The correction of the Cobb angle (CA) 1 week after surgery was better in group 2, whereas the anterior vertebral body height of the fractured level (AVHF) and compression ratio of the AVHF (AVHFCR) were not significantly different between the 2 groups 1 week after surgery. Moreover, group 2 had better maintenance of restored CA, AVHF, and AVHFCR at the fractured level than did group 1 at 6 months and 1 year postoperatively. In addition, the reduction of mid-sagittal diameter (MSD) of spinal canal 1 week and 1 year after surgery was better in group 2. Besides, bone fragments in the spinal canal have a tendency to be less in group 2 1 week and 1 year after surgery.

Reinforcement with intermediate screws for a single thoracolumbar fracture not only enhanced the stability of the internal fixation system, but it was also conducive to the correction of kyphosis and the maintenance of the reduction effects. Furthermore, this method is helpful to restore the spinal canal and reduce the bone fragments in the spinal canal. However, more long-term follow-up studies are needed.

Abbreviations: AVHF = anterior vertebral body height of the fractured level, AVHFCR = compression ratio of the anterior vertebral body height of the fractured level, BMI = Body Mass Index, CA = Cobb angle, LAVH = anterior vertebral body height of the lower level, MSD = mid-sagittal diameter, ODI = Oswestry Disability Index, SAVHF = standard anterior vertebral body height of the fractured level, UAVH = anterior vertebral body height of the upper level, VAS = visual analog scale.

Keywords: anterior vertebral height, intermediate screws, short segment pedicle screw fixation, spinal canal, thoracolumbar fractures

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1. Introduction

The most frequent site of spinal injuries is reportedly the thoracolumbar junction as it is the transition zone between the relatively rigid thoracic and the more flexible lumbar spine.[1,2] During the past 3 decades, its treatment has undergone immense advances.[3] For unstable thoracolumbar fractures, surgical intervention is preferred.[4] The goals of treatment for unstable thoracolumbar vertebral fracture include repairing vertebral column stability, preventing or reducing deformity, spinal canal decompression, and early mobilization.[5–10] Among all operative strategies, posterior short-segment pedicle instrumentation is most widely used for thoracolumbar fractures worldwide because of its 3-column fixation.[11,12] In addition, its ease of application, use of fewer surgical fixation materials, reduction of blood loss, and smaller incision field also make it more popular in clinical practice.[13–18]

However, short-segment pedicle instrumentation has also been reported to cause several problems, such as inadequate long-term reduction, instrumentation failure, and increased kyphosis and pain.[13,19–23] In such cases, the use of intermediate screws for fractured vertebrae has been suggested in some studies to result in greater biomechanical stability of the anterior column by forming a more segmental structure.[8,14,24] Nevertheless, there is no consensus in clinical practice as to whether to use intermediate screws. Surgeons usually make this decision based on their preference and experience.

Thus, in the present study, we sought to confirm the efficacy of the use of additional intermediate screws at the fracture level compared with that of traditional short-segment pedicle screw instrumentation for improving clinical outcomes, correcting the deformity, and maintaining correction in unstable thoracolumbar fractures.

The First Affiliated Hospital of Nanchang University ethical review committee approved this study. Written informed consent was obtained from the participants, and if a patient was less than 18 years old, his/her relatives also gave informed consent.

2. Materials and methods

After acquiring ethics committee approval for this research, we retrospectively reviewed a consecutive series of 63 patients who had undergone surgery for thoracolumbar fracture between 2013 and 2015. The inclusion criteria were as follows: the use of short-segment pedicle screw instrumentation; a single-segment fracture; fracture type A (according to the AO-Magerl classification)[25]; intact neurological function; and a follow-up period of >1 year. Our exclusion criteria were as follows: incomplete data; neurologic impairment; dual or multiple segment fractures; fracture types other than type A; the use of long-segment instrumentation; combined anterior–posterior surgeries; a follow-up period of <1 year; and the presence of pathological fractures of any kind, such as those resulting from tumors or infections.

After the inclusion and exclusion criteria were applied, 44 patients were enrolled in the present study. They were divided into 2 groups according to the surgical method used. The demographic characteristics of the 2 groups were evaluated and are listed in Table 1. In group 1, 24 patients underwent operation with a posterior approach via short-segment pedicle screw instrumentation (1 level above and 1 level below the fractured level). In group 2, 20 patients received an additional 2 screws at the fractured vertebrae. Clinical and radiologic parameters were

Table 1

Baseline demographics of the patient cohort.

Parameter	Group 1	Group 2	P
Number of patients	24	20	
Age, mean±SD	39.6±12.0	38.7±12.2	.79
	(R: 16–63)	(R: 14–60)	
Gender, Male/female	15/9	13/7	.86
Smoking status, yes/no	11/13	8/12	.70
BMI	23.1±2.4	23.0±2.6	.88
Fracture level, n			.44
T10	1	0	
T12	4	1	
L1	11	10	
L2	6	4	
L3	2	5	
AO-Magerl classification			.76
A2	20	15	
A3	4	5	
Mechanism of fracture			.32
Traffic accident	9	8	
Fall from height	10	11	
Fall	5	1	

BMI = body mass index, R = range, SD = standard deviation.

evaluated before surgery and at 1 week, 6 months, and 1 year postoperatively.

2.1. Surgery

Patients receiving general anesthesia were placed in the prone position with U-shaped pillows under the chest and both ilia. Following the use of intraoperative plain radiography to locate the fracture with C-arm fluoroscopic equipment, a posterior median incision was made at the center of the fractured vertebra to expose the vertebral plate and the articular process layers. In group 1, 2 pedicle screws were implanted into the upper vertebra and the lower vertebral body of the fractured vertebra. In group 2, 2 additional pedicle screws were implanted into the fractured vertebral body. The upper and lower pedicle screws were disconnected, and the upper and intermediate ones were locked to a prebent connection rod. Subsequently, the lower and intermediate screws were longitudinally distracted to restore the fractured vertebral body's height, and then the connection was locked. The same brand of hardware was used in all patients. In general, the screw size is 45 mm in length and 6.5 mm in diameter. However, the size of screws used in the operations was determined according to the different sizes of the fractured vertebrae. The size of linkage to rods is 80 mm in length and 5 mm in diameter. The rod diameter is 5.5 mm. Besides, the degree of rod curve is usually 10 to 15°. Two patients in group 1 and 1 patients in group 2 who underwent spinal canal decompression were given bone graft between transverse processes with bones generated from the decompression progress. All operations were managed by the same experienced surgeons.

2.2. Clinical and radiographic review

The operative time and intraoperative blood loss were recorded based on patient records. The visual analog scale (VAS) and Oswestry Disability Index (ODI) were used to evaluate patients before surgery and at 1 week, 6 months, and 1 year after surgery.

To determine the efficacy of the use of additional intermediate screws, radiographs of the patients were evaluated in terms of the

Table 2

The differences of operative time and intraoperative blood loss.

Group	Operative time, min	Intraoperative blood loss, mL
Group 1	160.2±45.7	507.5±300.0
Group 2	142.0±30.0	483.5±186.6
P	.13	.76

min = minute.

Cobb angle (CA), anterior vertebral body height of the upper level (UAVH), anterior vertebral body height of the lower level (LAVH), and anterior vertebral body height of the fractured level (AVHF). The compression ratio of the AVHF (AVHFCR) was calculated by comparing the LAVH with the standard AVHF (SAVHF), which was defined as the mean of the UAVH and LAVH. The CA was calculated by measuring the angle between the upper endplate of the upper level and the lower endplate of the lower level.[26,27] The dimension of the spinal canal was evaluated by calculating the mid-sagittal diameter (MSD). In each case, preoperative and postoperative CT scans were selected at the level of maximum canal compromise. The CT scans were also used to detect bone fragments in the spinal canal.

2.3. Statistical analysis

SPSS 19.0 (IBM Corp.) was used to conduct the statistical analysis of all data. Chi-square statistics were used to compare categorical measurements between groups, and independent t tests were used to compare numerical measurements between groups. Statistical significance was assumed as $P < .05$ for all tests.

3. Results

The age range of the patients in group 1 was 16–63 (average: 39.6) years, and the male:female ratio was 15:9. The age range in group 2 was 14–60 (average: 38.7) years, and the male:female ratio was 13: 7 (Table 1). The smokers versus nonsmokers were 11/13 in group 1 and 8/12 in group 2. The body mass index (BMI) in group 1 and group 2 were 23.1±2.4 and 23.0±2.6 kg/m², respectively. Thoracolumbar fractures between the T10 and L3 vertebrae were included in this study. When groups 1 and 2 were compared according to the fracture level, the results were as follows: T10: 1/0, T12: 4/1, L1: 11/10, L2: 6/4, and L3: 2/5, respectively. The fracture type comparison between groups 1 and 2 was as follows: A2 type: 20/15 and A3 type: 4/5, respectively. The comparison of the mechanism of fracture between groups 1 and 2 was as follows: traffic accident: 9/8, fall from height: 10/11, and fall: 5/1, respectively. As shown in Table 1, there was no difference in age, sex, smoking status, BMI, fracture level, fracture type, or mechanism of fracture between the 2 groups (P = .79, .86, .44, .76, and .32, respectively).

Table 3

The change of VAS in the pre- and postoperative periods.

Group	Preop	1 w postop	6 m postop	1 y postop
Group 1	7.7±0.5	2.4±0.3	1.5±0.2	1.2±0.2
Group 2	7.9±0.5	2.3±0.3	1.4±0.2	1.1±0.2
P value	.09	.59	.07	.06

VAS = visual analog scale, preop = preoperative, postop = postoperative.

Table 4

The change of ODI in the pre- and postoperative periods.

Group	Preop	1 w postop	6 m postop	1 y postop
Group 1	76.9±4.2	25.0±5.8	18.3±2.6	14.0±3.7
Group 2	78.0±4.7	25.1±4.8	16.8±2.8	12.9±3.5
P value	.44	.95	.07	.30

ODI = Oswestry Disability Index, preop = preoperative, postop = postoperative.

3.1. Operative time and intraoperative blood loss

The operative times in group 1 and group 2 were 160.2±45.7 minutes and 142.0±30.0 minutes, respectively, and the values of intraoperative blood loss were 507.5±300.0 mL and 483.5± 186.6 mL, respectively. There was no significant difference in the operative time and intraoperative blood loss between the 2 groups (P = .13 and P = .76) (Table 2).

3.2. Clinical outcomes

Preoperative VAS scores were 7.7±.5 and 7.9±.5 points in group 1 and group 2, respectively, and the scores were significantly reduced in both groups during the follow-up periods. There was no significant difference in VAS scores before surgery, 1 week after surgery, 6 months after surgery, and 1 year after surgery between the 2 groups (P = .09, .59, .07, and .06, respectively) (Table 3). ODI scores in both groups were also significantly improved compared to those before surgery. However, as with the VAS scores, no significant difference was observed in ODI scores between the 2 groups before surgery and at all follow-up periods (P = .44, .95, .07, and .30, respectively) (Table 4). There were no deep vein thrombosis, pulmonary embolism, or postoperative infection in all the patients. Time from operation to ambulation in each group was usually 3 to 5 days according to the case-by-case situation of the patients. Two patients in group 1 and 1 patients in group 2 underwent delayed wound healing owing to fat liquefaction. However, the wounds of the 3 patients healed well after dressing change.

3.3. Radiologic outcomes

Significant improvements in the CA, AVHF, and AVHFCR were observed in both groups after surgery. However, the reduction of the CA 1 week after surgery was better in group 2, whereas the AVHF and AVHFCR were not significantly different between the 2 groups 1 week after surgery (P = .01, .35, and .49, respectively). Moreover, at 6 months and 1 year after surgery, group 2 showed better maintenance of the CA, AVHF, and AVHFCR than did group 1 (P = .001 and .001; P = .002 and $P < .001$; $P < .001$ and $P < .001$, respectively). The reduction of MSD of the spinal canal 1 week and 1 year after surgery was better in group 2 (P = .01 and $P < .001$). Additionally, bone fragments in the spinal canal tended to be less in group 2 one week and 1 year after surgery, though there was no statistical difference (P = .66 and P = .46) (Table 5).

4. Discussion

The optimal surgical management of thoracolumbar burst fractures remains controversial, and to date, there are no evidence-based guidelines for the most suitable surgical approach or instrumentation technique.[13,27–30] Among all surgical

Table 5

The pre- and postoperative CA, UAVH, LAVH, SAVHF, AVHF, AVHFCR, MSD, and bone fragments.

Variable	Group 1	Group 2	P
CA			
Preop	13.7 ± 5.2	11.8 ± 6.3	.29
1 w postop	4.4 ± 2.5	2.8 ± 1.4	.01
6 m postop	7.6 ± 4.5	3.8 ± 1.3	.001
1 y postop	9.1 ± 6.0	4.3 ± 1.5	.001
UAVH			
Preop	29.1 ± 3.2	29.8 ± 2.6	.45
1 w postop	29.6 ± 3.3	30.2 ± 2.1	.46
6 m postop	29.7 ± 3.3	30.1 ± 2.0	.61
1 y postop	29.8 ± 3.6	30.1 ± 2.0	.79
LAVH			
Preop	31.3 ± 3.3	32.2 ± 2.0	.31
1 w postop	31.8 ± 3.2	32.5 ± 2.1	.42
6 m postop	31.9 ± 3.3	32.4 ± 1.7	.59
1 y postop	32.4 ± 3.3	32.4 ± 1.7	.99
SAVHF			
Preop	30.2 ± 3.1	31.0 ± 2.0	.35
1 w postop	30.7 ± 3.1	31.4 ± 1.8	.40
6 m postop	30.8 ± 3.2	31.2 ± 1.6	.57
1 y postop	31.1 ± 3.3	31.3 ± 1.5	.88
AVHF			
Preop	18.5 ± 4.1	19.4 ± 5.7	.52
1 w postop	29.7 ± 3.0	30.4 ± 1.9	.35
6 m postop	27.5 ± 2.7	29.7 ± 1.6	.002
1 y postop	26.7 ± 2.7	29.4 ± 1.7	<.001
AVHFCR			
Preop	38.6 ± 12.9	37.3 ± 17.8	.79
1 w postop	3.4 ± 1.2	3.1 ± 1.3	.49
6 m postop	10.7 ± 2.3	4.8 ± 1.6	<.001
1 y postop	14.1 ± 2.8	6.0 ± 1.9	<.001
MSD			
Preop	11.0 ± 0.8	11.0 ± 0.7	.85
1 w postop	12.0 ± 0.6	12.4 ± 0.3	.01
1 y postop	12.8 ± 0.6	13.4 ± 0.3	<.001
Bone fragments, yes/no			
Preop	10/14	8/12	.91
1 w postop	6/18	3/17	.66
1 y postop	4/20	1/19	.46

AVHF = anterior vertebral body height of the fractured level, AVHFCR = compression ratio of the anterior vertebral body height of the fractured level, bone fragments = bone fragments in the spinal canal, CA = Cobb angle, LAVH = anterior vertebral body height of the lower level, MSD = mid-sagittal diameter of the spinal canal, preop = preoperative, postop = postoperative, SAVHF = standard anterior vertebral body height of the fractured level, UAVH = anterior vertebral body height of the upper level.

methods, posterior transpedicle short-segment instrumentation is the most frequently applied surgical treatment for these fractures because of its low morbidity and comorbidity.[6,22,31–33]

However, some studies have reported a high risk of failure because of screw breakage, screw pullout, and loss of correction, even though material failure did not always influence the clinical outcome.[34] Under the circumstances, the use of 2 additional screws for the fractured vertebrae has been introduced and is thought to result in stronger biomechanical stability of the anterior column by forming a more segmental structure, thereby improving efficacy in some studies.[8,14,24] Nevertheless, in recent years, few in-depth studies focusing on this technology have been conducted, and clinical studies on the management of thoracolumbar fractures utilizing this method are scarce. Hence, we conducted the present study to evaluate the value of applying intermediate pedicle screws to the fractured level by comparing short-segment pedicle screw instrumentation with and without additional screws.

We found no significant difference in the demographic characteristics between the 2 groups. Additionally, no significant difference was observed with respect to the operative time, intraoperative blood loss, or VAS and ODI scores. The CA, AVHF, and AVHCR were also similar between groups before surgery and 1 week after surgery. However, at 6 months and 1 year after surgery, the CA, AVHF, and AVHCR were significantly different between the 2 groups. Group 2 had a better maintenance of reduction than did group 1. Furthermore, the reduction of MSD of the spinal canal 1 week and 1 year after surgery was better in group 2. In addition, bone fragments in the spinal canal had a tendency to be less in group 2 1 week and 1 year after surgery though there was no statistical difference. Therefore, we concluded that although using short-segment pedicle screw instrumentation with intermediate screws had little effect on the immediate restoration of fractured vertebrae after surgery, this method could maintain better long-term reduction than could traditional short-segment pedicle screw instrumentation. Besides, short-segment pedicle screw instrumentation is helpful to restore the spinal canal and reduce the bone fragments in the spinal canal.

McLain[11] observed a progressive deformity within 6 months postoperatively in most patients with residual anterior column instability. According to Mahar et al, applying limited posterior segmental instrumentation in thoracolumbar burst fractures was an approach that results in short-segment fixation. Segmental construction utilizing pedicle screws at the fractured level has been determined to be better and more reliable for reduction in terms of biomechanical stability than is nonsegmental construction.[8] All the aforementioned information may help interpret the advantages of using intermediate screws in short-segment pedicle screw instrumentation.

We recognize that there are some limitations to the present study. First, the study was retrospective and included a small number of patients, which could have contributed to a selection bias. Second, the clinical outcomes were reported merely based on the VAS and ODI scores, whereas comorbidities, additional fractures of extremities, and postoperative complications were not deeply investigated. Finally, this study focused on relatively short-term follow-up outcomes (only up to 1 year); hence, the findings may not be indicative of long-term conditions, particularly after the removal of implants. Further studies, a larger patient population, and longer follow-up period are urgently needed to assess the efficacy of this technique more accurately.

In conclusion, short-segment pedicle screw instrumentation with intermediate screws has a better effect on maintaining the reduction of unstable thoracolumbar fractures than did traditional short-segment pedicle screw instrumentation. It may exert this advantage by providing stiffer anterior column support. However, future prospective studies with more patients and a much longer follow-up period are warranted.

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