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Analysis of the short-term effect of three different level pedicle screws in the treatment of thoracolumbar type A fractures

Alimujiang Yusufu[1,2], Abudula Abulaiti[2], Abuduwupuer Haibier[2], Junyi Ma[2] and Yuan Ma[2*]

Abstract

Objective The effects of three short-segment vertebral fixation methods—short-segment fixation (4s group), short-segment fixation across the injured vertebra (6s group), and long-segment fixation (8s group)—on the surgical efficacy of patients with type A thoracolumbar fractures were compared to identify the optimal fixation method.

Methods Data from 277 patients who underwent posterior pedicle screw fixation for thoracolumbar fractures between September 2018 and January 2023 were retrospectively analyzed. Surgery-related indicators, laboratory parameters, clinical functional measures (VAS and ODI), and postoperative imaging findings were compared among the three groups.

Results Baseline data showed no significant differences among the three groups. The operation time in the 4s group (75.352 ± 15.458 min) and intraoperative blood loss (188.65 ± 42.728 ml) were significantly lower compared to the 8s group (operation time: 108.243 ± 19.529 min; intraoperative blood loss: 209.93 ± 50.542 ml), with statistically significant differences ($p < 0.05$). Postoperative hematocrit (33.277 ± 4.639) and albumin levels (34.971 ± 4.116) in the 6s group were significantly higher than those in the 8s group (hematocrit: 31.820 ± 4.323; albumin: 33.170 ± 3.553), with $p < 0.05$. Other outcome indicators did not show statistically significant differences ($p > 0.05$).

Conclusion Short-segment fixation across the injured vertebra (6s) provides results comparable to short-segment fixation (4s) while causing less trauma. Furthermore, the 6s method demonstrates similar efficacy to long-segment fixation (8s) in maintaining long-term deformity correction. These findings offer valuable insights for clinicians in selecting surgical fixation methods, optimizing treatment strategies, and improving patient outcomes.

Keywords Thoracolumbar fracture, Posterior pedicle screw fixation, Long-level fixation, Short-level fixation

*Correspondence:
Yuan Ma
xjjgyymy@126.com
[1]Xinjiang Medical University, Urumqi 830000, China
[2]The Sixth Affiliated Hospital of Xinjiang Medical University, Urumqi, Xinjiang Uygur Autonomous Region 830092, China

Background

Thoracolumbar fractures are among the most prevalent types of spinal trauma, comprising nearly half of all spinal fractures. These injuries not only compromise spinal stability but also pose significant risks to the nervous system [1–4], as thoracolumbar vertebral displacement following fractures can lead to compression of the spinal cord or cauda equina. Some patients experience paralysis, pressure sores, and infections, which severely impair quality of life and jeopardize health and safety [5]. Posterior pedicle screw fixation remains a well-established and effective surgical approach for treating thoracolumbar fractures [6–10].

There is ongoing debate among spinal surgeons regarding the optimal fixation length required to stabilize these fractures effectively [11]. Some researchers argue that long-segment fixation is highly effective for restoring the height of the injured vertebra and correcting kyphotic deformity, maintaining long-term results, and preventing complications such as screw and rod breakage due to internal fixation fatigue [12]. A recent biomechanical analysis concluded that long-segment fixation offers superior protection for the fractured vertebra compared to other methods [13]. However, this technique is associated with significant surgical trauma, greater blood loss, and immobilization of more motion segments [14, 15]. Short-segment fixation, on the other hand, preserves the spinal range of motion and reduces the risk of degeneration in adjacent segments of the injured vertebra [6]. Nevertheless, studies have reported a high incidence of late-stage complications such as loosening and rupture of internal fixation following short-segment pedicle fixation [12, 16].To address these limitations, a new technique known as trans-injured vertebral fixation (6 screws) has been developed. Luo et al. [17] demonstrated that in short-segment fixation techniques, the stress on connecting rods distributed across the injured vertebra is concentrated at the ends, while long-segment fixation provides a more even stress distribution. Furthermore, biomechanical studies have shown that adding screws at the fracture level significantly improves spinal stability, facilitates stronger reduction, and reduces stress on pedicle screws in non-fractured vertebral bodies [1, 18, 19]. Despite these advantages, trans-injured vertebral fixation has been reported to have drawbacks in several small clinical trials, limiting the robustness of evidence supporting this technique [20, 21].

Therefore, this study hypothesizes that differences exist in surgical trauma and recovery speed between short-segment fixation and long-segment fixation. It also postulates that while short-segment cross-injured vertebra fixation and trans-injured vertebra fixation have similar clinical efficacy and long-term stability, they may differ in specific indicators. This study aims to address existing knowledge gaps and provide a foundation for clinicians in selecting the most appropriate fixation method.

Materials and methods

General materials

This study was conducted from September 2018 to January 2023 at the Spinal Surgery Department of the Sixth Affiliated Hospital of Xinjiang Medical University. During this period, data were retrospectively collected from 277 patients hospitalized for thoracolumbar fractures who underwent posterior pedicle screw fixation using long segments, short segments, or short segments including the injured vertebra (Fig. 1). The patients were categorized into three groups: long-segment fixation (8 screws; 8s group; $n=74$), short-segment fixation (4 screws; 4s group; $n=71$), and short-segment fixation through the injured vertebra (6 screws; 6s group; $n=132$). The study adhered to the principles outlined in the Declaration of Helsinki and received ethical approval from the Ethics Committee of the Sixth Affiliated Hospital of Xinjiang Medical University (Ethics Approval Number: LFYLLSC20250108-01).All participants provided written informed consent.

Inclusion and exclusion criteria

Inclusion criteria ① Patients aged over 18 years, as their skeletal maturity ensures that fracture types and treatment responses are similar to those of adults, facilitating consistency in analyzing study outcomes. ② Neurological examination confirmed no nerve damage, with unrestricted limb movement and the ability to perform daily self-care activities. ③ Preoperative imaging data, including X-ray, CT, and MRI, were reviewed independently by two experienced spinal surgeons. Type A fractures, classified under the internationally recognized AO classification system (simple compression, split, or burst fractures without complications such as nerve injury or fracture-dislocation), were identified. ④ Patients provided informed consent, complete data, and had a follow-up period of at least 12 months.

Exclusion criteria ① Pathological fractures caused by factors such as tumors (primary or metastatic), severe osteoporosis, or infections (e.g., tuberculosis, osteomyelitis), as these fractures differ in mechanism and treatment strategy compared to traumatic fractures. ② Fractures involving multiple vertebral bodies, as these have complex morphologies and require different surgical approaches and prognoses compared to single-level fractures. ③ Patients with incomplete data or those lost to follow-up. To address this, comprehensive medical records and multiple follow-up methods were implemented during the study. If the lost-to-follow-up rate exceeded 10%, the reliability of the results was carefully evaluated. ④ Patients

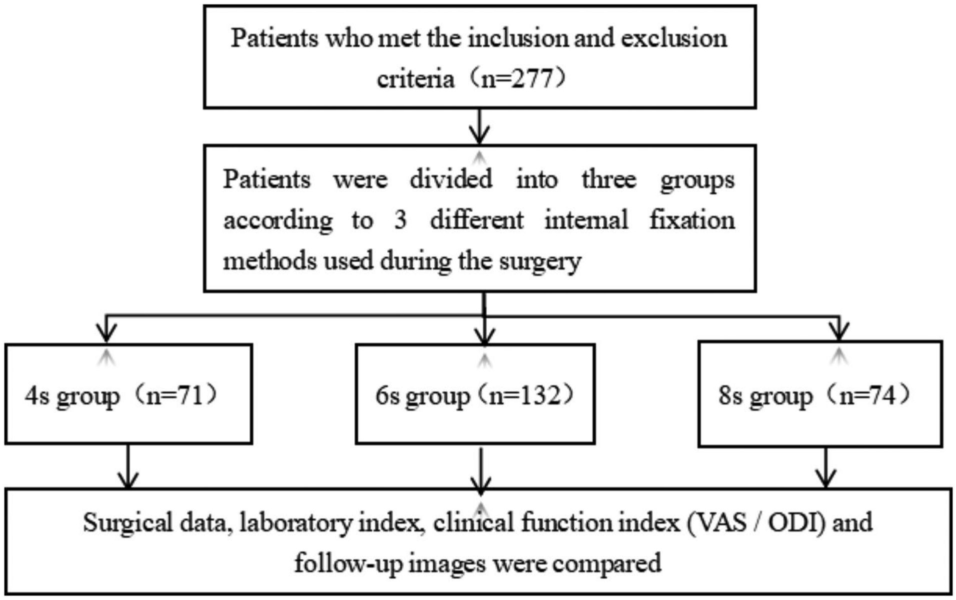

Fig. 1 Patient flow chart

with severe osteoporosis, as reduced bone density could compromise screw fixation and fracture healing. (It should be noted that for fractures with paraplegia, long-segment fixation is mandatory to prevent complications such as nail or rod breakage [22]).

Surgical method

All patients underwent preoperative X-rays, CT scans, and MRI to identify the fracture site, type, pedicle integrity, and thoracolumbar injury classification. Postoperative X-rays were performed on the first day after surgery to confirm the proper placement of the internal fixation.

Under general anesthesia, patients were positioned prone, with soft pillows placed under the chest and bilateral iliac ridges to elevate the abdomen. This positioning reduced intraoperative bleeding and minimized compression of the spinal nerves. A posterior median incision was made at the level of the fractured vertebra. The skin, subcutaneous tissue, and lumbar fascia were incised sequentially, and the paravertebral muscles were stripped bilaterally along the spinous process to expose the lamina, articular process joints, and transverse process. Under C-arm fluoroscopy, the pedicle positions of the fractured vertebra and its upper and lower adjacent vertebrae were determined. Typically, the “herringbone” apex method or the intersection of the transverse process’s central axis with the outer edge of the superior articular process was used for localization. An awl was employed to create an entry point at the designated location, followed by the insertion of a positioning needle. Fluoroscopy confirmed the needle’s correct position, after which a hollow drill or tap was used to expand the pedicle channel. In the 8s group, long pedicle screws (8 screws) were inserted into the pedicles of two vertebrae adjacent to the fractured vertebra (one above and one below). In the 6s group, long pedicle screws were inserted into the pedicles of one adjacent vertebra above and below the fractured vertebra, and short pedicle screws (6 screws) were placed into the pedicles of the fractured vertebra itself. In the 4s group, long pedicle screws (4 screws) were inserted into the pedicles of one vertebra immediately above and below the fractured vertebra.

After surgery, the drainage tube is removed when the drainage volume decreases to less than 50 ml/day, and sutures are removed within 10 to 14 days. Early postoperative management includes strict bed rest, with appropriate axial turning (simultaneous movement of shoulders and hips) to avoid twisting the spine. Based on the recovery progress, activity levels are gradually increased under medical supervision. Initial rehabilitation focuses on limb movements and back muscle exercises while in bed, progressing to sitting, standing, and walking. Patients are advised to wear braces when sitting or walking. The type and duration of brace use, typically around three months, are determined by the physician to ensure spinal protection and stability. Follow-up evaluations are conducted at 1, 3, 6, and 12 months postoperatively, and subsequently every six months. All medical records and imaging data were independently collected by two investigators.

Observation indicators

The data collected included general patient information, surgery-related metrics, laboratory and imaging findings, and clinical functional indicators.

General Data: Age, gender, body mass index (BMI), underlying conditions (e.g., Diabetes, Nervous system diseases, and Cardiovascular diseases), cause of injury, fracture site, and fracture type. Surgery-Related Data: Operating time, intraoperative blood loss, postoperative drainage volume, and length of hospital stay (LOS).

Laboratory Tests: Hemoglobin (HB), red blood cells (RBC), hematocrit, albumin, and C-reactive protein (CRP). HB and RBC levels indicate surgical blood loss and hematopoietic compensation. Hematocrit reflects the degree of blood concentration or dilution. Albumin assesses nutritional status, while CRP monitors inflammatory responses.By analyzing changes in these laboratory parameters before and after surgery, the degree of surgical trauma and the patient's recovery can be evaluated. These findings also allow indirect comparisons of the benefits and drawbacks of different fixation methods.

Imaging assessments included the height ratio of the anterior edge of the injured vertebra, the compression rate of the anterior edge of the injured vertebra, and the Cobb angle, evaluated preoperatively, immediately postoperatively, and one year after surgery. Height Ratio of the Anterior Edge of the Injured Vertebra: Calculated as the height of the anterior edge of the injured vertebra divided by the average height of the anterior edges of the adjacent vertebral bodies [23]. Compression Rate of the Anterior Edge of the Injured Vertebra: Determined using the formula: (height of the posterior edge of the vertebral body - height of the anterior edge of the vertebral body) / height of the posterior edge of the vertebral body × 100%. Cobb Angle: Measured as the angle formed by the vertical lines of the upper edge of the vertebral body above the injured vertebra and the lower edge of the vertebral body below the injured vertebra (Fig. 2). The height ratio and compression rate of the anterior edge provide a direct assessment of the height recovery of the fractured vertebra. The Cobb angle reflects the degree of spinal sagittal deformity. Changes in these parameters before and after surgery demonstrate the ability of different fixation methods to realign, correct, and maintain the fracture. These indicators are critical for evaluating spinal stability and functional recovery.

Clinical functional outcomes were assessed using the visual analogue scale (VAS) and the Oswestry Disability Index (ODI) at three time points: before surgery, one week after surgery, and at the final follow-up (12 months).

Quality control

To ensure the reliability of the study, a senior spinal surgeon involved in the research assisted in data collection. Additionally, to verify the authenticity of the findings, a statistics expert from the Sixth Affiliated Hospital of Xinjiang Medical University conducted an independent review of the trial data.

Statistics method

The study data were entered into Excel spreadsheets and analyzed using SPSS 26.0 statistical software. For comparisons of measurement data among the three groups, one-way analysis of variance (ANOVA) was applied. Covariates such as patient age, gender, BMI, and underlying conditions (e.g., diabetes, hypertension, bone mineral density) were included in the model to account for potential confounding factors. If the ANOVA results indicated statistically significant differences, the LSD-t test was performed for pairwise comparisons between groups. Categorical data were presented as [n(%)], and comparisons were made using the χ^2 test. A p value indicating statistical significance was applied to determine the validity of the results.

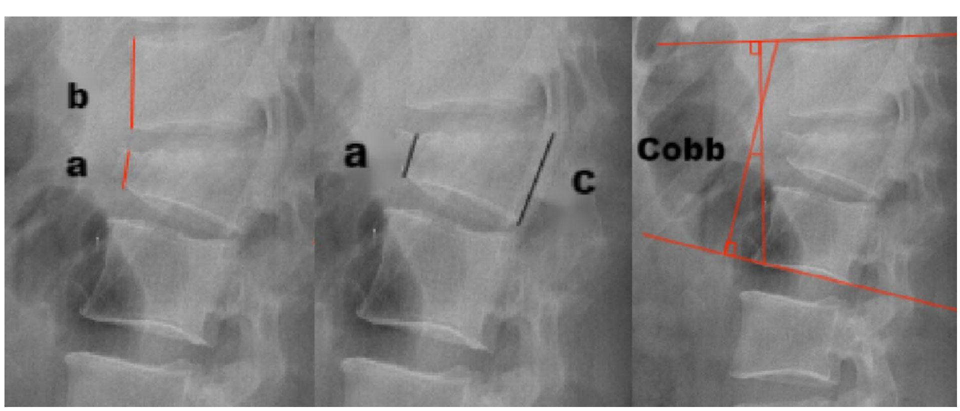

Fig. 2 In lateral view, measure the the anterior and posterior heights of the injured vertebra and adjacent vertebrae. The height ratio of the anterior edge of the injured vertebra is calculated as a/ba/ba/b, where aaa is the height of the anterior edge of the injured vertebra, and bbb is the average height of the anterior edges of the adjacent vertebrae. The compression rate of the anterior edge is calculated as (c – a)/c×100(c-a)/c \times 100(c – a)/c×100, where ccc is the height of the posterior edge of the injured vertebra. The Cobb angle is measured as the angle between the vertical line of the upper edge of the vertebral body above the injured vertebra and the vertical line of the lower edge of the vertebral body below the injured vertebra

Table 1 Comparison of the baseline data

Variable	4s group	6sgroup	8s group	F/X^2	*P*
Age(($\bar{X}\pm$S)	44.732 ± 11.869	43.553 ± 11.554	44.824 ± 10.923	0.392	0.676
Sex(Male/Female)	23/48	51/81	18/56	4.408	0.110
BMI(kg/m^2, $\bar{X}\pm$S)	24.122 ± 3.658	23.839 ± 3.172	24.983 ± 3.398	15.429	< 0.001
Basic disease					
Diabetes mellitus (Yes / No)	6/65	13/119	7/67	0.107	0.948
Nervous system disease (Yes / No)	4/67	8/124	3/71	0.382	0.826
Cardiovascular system disease(Yes / No)	5/66	10/122	4/70	0.355	0.838
Fracture site				10.220	0.116
T11	15	38	14		
T12	20	37	25		
L1	26	29	26		
L2	10	28	9		
AO Type				0.176	0.996
A1	32	58	31		
A2	23	44	25		
A3	16	30	18		
Preoperative HB	123.24 ± 13.601	126.08 ± 13.490	123.35 ± 14.237	1.419	0.244
Preoperative RBC	3.99 ± 0.546	4.03 ± 0.611	3.89 ± 0.627	1.370	0.256
Preoperative HCT	37.25 ± 4.575	38.43 ± 4.978	37.11 ± 4.928	2.293	0.103
Preoperative ALB	39.88 ± 4.934	40.36 ± 3.438	39.41 ± 3.600	1.408	0.246
Preoperative CRP	41.386 ± 49.620	38.148 ± 43.889	33.473 ± 34.902	0.610	0.544
Preoperative VAS	6.944 ± 1.033	6.879 ± 1.008	6.973 ± 1.052	0.221	0.802
Preoperative ODI	71.296 ± 3.736	71.076 ± 3.634	70.838 ± 3.849	0.272	0.762

The continuous value was given as the mean and the standard deviation. Categorical values are given as the number of patients. BMI Body mass index; T11 Thoracic 11 fracture; T12 Thoracic 12 fracture; L11 Lumbar 1 fracture; L2 Lumbar 2 fracture; HB hemoglobin; RBC red blood cells; HCT hematocrit; ALB albumin; CRP C-reactive protein

Table 2 Comparison of procedure-related data among the three groups

Variable	4s group	6sgroup	8s group	F	*P*
Operation time(min)	75.352 ± 15.458	88.371 ± 12.997#	108.243 ± 19.529#*	81.569	< 0.001
Blood loss(ml)	188.65 ± 42.728	189.96 ± 33.609	209.93 ± 50.542#*	6.732	0.001
Drainage(ml)	70.859 ± 15.445	74.811 ± 29.800	76.635 ± 18.629	1.096	0.336
LOS(day)	7.169 ± 1.540	7.515 ± 1.864	7.757 ± 1.842#	1.998	0.138

#Meaningful compared to 4s group; * Meaningful compared to 6s group; LOS Length of hospital stay

Results

Comparison of patient general information

A comparison of the patients' general data revealed no statistically significant differences among the three groups in terms of age, gender, BMI, underlying diseases (diabetes, cardiac diseases, and nervous system diseases), cause of injury, fracture site, and fracture classification ($p > 0.05$). This allowed for subsequent analyses, as shown in Table 1.

Comparison of surgical data

The operation time was shortest in the 4s group (75.352 ± 15.458 min), followed by the 6s group (88.371 ± 12.997 min), and longest in the 8s group (108.243 ± 19.529 min), with the differences being statistically significant ($p < 0.001$). Intraoperative blood loss was least in the 4s group (188.65 ± 42.728 ml) and comparable to the 6s group (189.96 ± 33.609 ml), while the 8s group had the highest blood loss (209.93 ± 50.542 ml), a statistically significant difference from the other two groups ($p < 0.001$). Postoperative hematocrit and albumin levels were higher in the 6s group (hematocrit: 33.277 ± 4.639, albumin: 34.971 ± 4.116) compared to the 8s group (hematocrit: 31.820 ± 4.323, albumin: 33.170 ± 3.553), with albumin levels showing a statistically significant difference ($p = 0.010$), while hematocrit differences were not significant ($p = 0.083$). Postoperative RBC values were lowest in the 8s group (3.379 ± 0.393) and showed statistically significant differences compared to the 4s group (3.618 ± 0.519) and the 6s group (3.576 ± 0.545) ($p < 0.007$). Details are provided in Table 2.

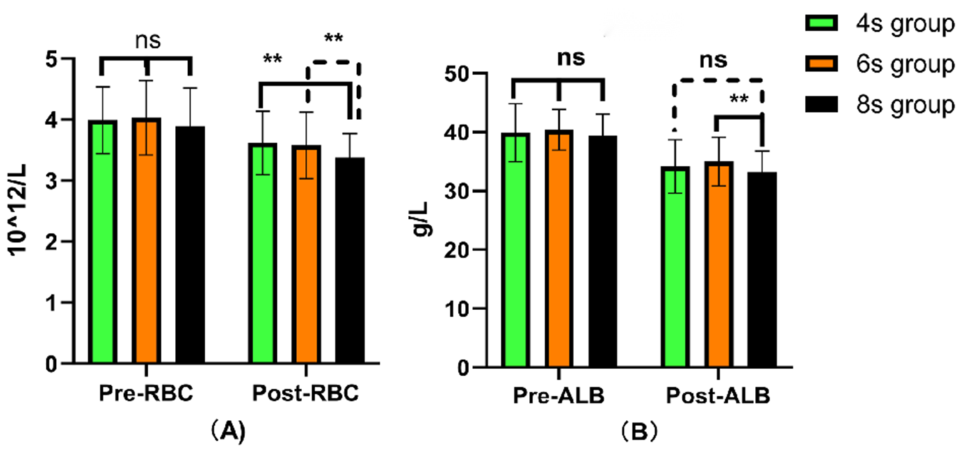

Fig. 3 This figure illustrates the preoperative and postoperative changes in RBC and ALB levels across the three patient groups. The green box represents the 4s group, the orange box represents the 6s group, and the black box represents the 8s group. **A** displays RBC levels. **B** shows ALB levels. Key Observations: Preoperative Levels: There are no significant differences in RBC and ALB levels among the three groups before surgery (indicated as "ns" for no statistically significant difference). Postoperative RBC Levels: The RBC levels in the 8s group are significantly lower compared to those in the 4s and 6s groups. Postoperative ALB Levels: ALB levels in the 8s group are also significantly lower than those in the 4s and 6s groups. Statistical significance is denoted as follows: "*" indicates $p<0.05$. "**" indicates $p<0.01$. These results visually and statistically demonstrate that the 6s group has an impact on patients' blood system and nutritional status comparable to the 4s group and superior to the 8s group

Table 3 Comparison of postoperative laboratory indicators among the three groups

Variable	4s group	6sgroup	8s group	F	*P*
HB	109.49 ± 11.226	109.27 ± 14.694	106.61 ± 11.657	1.190	0.306
RBC	3.618 ± 0.519	3.576 ± 0.545	3.379 ± 0.393#*	4.984	**0.007**
HCT	32.763 ± 4.297	33.277 ± 4.639	31.820 ± 4.323*	2.516	0.083
ALB	34.137 ± 4.533	34.971 ± 4.116	33.170 ± 3.553*	4.656	**0.010**
CRP	75.807 ± 41.023	69.606 ± 40.289	62.316 ± 39.082	2.032	0.133

#Meaningful compared to 4s group; * Meaningful compared to 6s group; HB hemoglobin; RBC red blood cells; HCT hematocrit; ALB albumin; CRP C-reactive protein

Comparison of postoperative laboratory parameters

Postoperative RBC values were significantly lower in the 8s group compared to the 4s and 6s groups [3.379 ± 0.393 vs. 3.618 ± 0.519 vs. 3.576 ± 0.545, ($p<0.05$)]. Postoperative albumin levels in the 8s group were significantly lower compared to the 4s and 6s groups [33.170 ± 3.553 vs. 34.137 ± 4.533 vs. 34.971 ± 4.116, ($p<0.05$)], as illustrated in Fig. 3. No statistically significant differences were observed among the three groups in terms of postoperative HB, hematocrit, and C-reactive protein ($p>0.05$). These results are summarized in Table 3.

Comparison of postoperative VAS and ODI scores

Patient follow-up was conducted via outpatient visits or telephone to compare VAS and ODI scores one week and one year after surgery. One Week Postoperative Scores: VAS Scores: 4s group: 4.90 ± 1.197; 6s group: 4.89 ± 1.13; 8s group: 4.66 ± 0.911 ($p=0.304$). ODI Scores: 4s group: 28.169 ± 3.730; 6s group: 28.076 ± 3.795; 8s group: 27.446 ± 4.054 ($p=0.447$). Final Follow-Up (12 Months Postoperative): VAS Scores: 4s group: 3.380 ± 0.845; 6s group: 3.394 ± 0.842; 8s group: 3.284 ± 0.831 ($p=0.652$). ODI Scores: 4s group: 23.634 ± 3.481; 6s group: 23.265 ± 3.595; 8s group: 22.703 ± 3.809 ($p=0.299$). No statistically significant differences in VAS or ODI scores were observed among the groups at any time point ($p>0.05$), as shown in Table 4.

Comparison of imaging data before and after surgery

Imaging data were analyzed preoperatively, immediately postoperatively, and one year postoperatively during outpatient follow-up (Fig. 4). Preoperative Imaging: Height Ratio of the Anterior Edge of the Injured Vertebra: 4s group: 54.479 ± 4.961; 6s group: 54.621 ± 4.733; 8s group: 55.351 ± 4.317 ($p=0.467$). Compression Ratio of the Anterior Edge: 4s group: 42.873 ± 4.125; 6s group: 42.742 ± 4.426; 8s group: 42.595 ± 4.448 ($p=0.929$). Cobb

Table 4 Comparison of postoperative VAS and ODI scores in the three groups

Variable	Follow-up time	4s group	6sgroup	8s group	F	*P*
VAS	One week after surgery	4.90 ± 1.197	4.89 ± 1.13	4.66 ± 0.911	1.196	0.304
	The last follow-up(12mo)	3.380 ± 0.845	3.394 ± 0.842	3.284 ± 0.831	0.429	0.652
ODI	One week after surgery	28.169 ± 3.730	28.076 ± 3.795	27.446 ± 4.054	0.808	0.447
	The last follow-up(12mo)	23.634 ± 3.481	23.265 ± 3.595	22.703 ± 3.809	1.212	0.299

VAS visual analogue scale; ODI Oswestry disability index; mo month

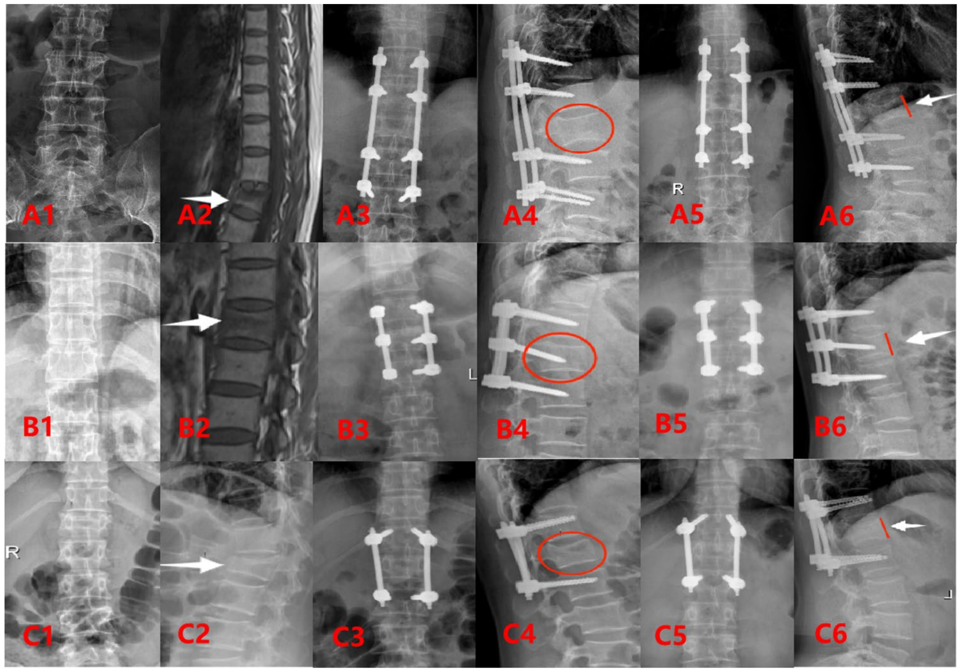

Fig. 4 This figure presents the preoperative and postoperative follow-up imaging data for the three groups undergoing different internal fixation methods (4s group, 6s group, and 8s group). Group 4s: A1–A2: Preoperative imaging showing an L2 vertebral fracture. A3–A4: Postoperative X-rays taken immediately after surgery, indicating significant recovery of vertebral height compared to preoperative imaging. Long-segment internal fixation was applied, spanning the injured vertebral body. A5–A6: Imaging one year after surgery. The white arrow highlights the recovery of the injured vertebral height and the stability of the internal fixation. Group 6s: B1–B2: Preoperative imaging showing an L1 vertebral fracture. B3–B4: Immediate postoperative X-rays, revealing noticeable recovery of vertebral height. The injured vertebral body was stabilized using internal fixation. B5–B6: Imaging one year after surgery. The white arrow indicates sustained recovery of vertebral height and stable internal fixation. Group 8s: C1–C2: Preoperative imaging showing an L1 vertebral fracture. C3–C4: Immediate postoperative X-rays showing a significant recovery of vertebral height. Short-segment internal fixation was applied across the injured vertebral body. C5–C6: Imaging one year after surgery. The white arrow shows restored vertebral height and stable internal fixation. These imaging sequences visually demonstrate the effects of the three fixation methods on vertebral height recovery and the stabilization of fractured vertebral bodies before and after surgery. When combined with the quantitative imaging data analysis (Table 5), the comprehensive evaluation of the therapeutic outcomes for the three fixation methods becomes more evident

Angle: 4s group: 15.268 ± 2.838; 6s group: 15.167 ± 2.612; 8s group: 14.878 ± 3.213 ($p = 0.686$). No significant differences were found among the groups ($p > 0.05$). Immediately Postoperative Imaging: Height Ratio of the Anterior Edge: 4s group: 83.72 ± 3.63; 6s group: 84.32 ± 3.035; 8s group: 83.86 ± 3.536 ($p = 0.411$). Compression Ratio of the Anterior Edge: 4s group: 7.113 ± 1.976; 6s group: 7.114 ± 2.025; 8s group: 7.000 ± 2.040 ($p = 0.919$). Cobb Angle: 4s group: 5.423 ± 1.774; 6s group: 5.295 ± 1.655; 8s group: 5.541 ± 1.904 ($p = 0.625$). No statistically significant differences were observed ($p > 0.05$). One Year Postoperative Imaging: Height Ratio of the Anterior Edge: 4s group: 80.21 ± 4.494; 6s group: 80.70 ± 2.985; 8s group: 81.50 ± 3.098 ($p = 0.077$). Compression Ratio of the Anterior Edge: 4s group: 8.268 ± 2.307; 6s group: 8.303 ± 2.428; 8s group: 8.122 ± 2.477 ($p = 0.872$). Cobb Angle: 4s group: 7.394 ± 2.031; 6s group: 7.545 ± 1.904; 8s group: 7.581 ± 1.882 ($p = 0.822$). No significant differences in imaging data were found among the groups one year after surgery ($p > 0.05$), as shown in Table 5.

Discussion

Thoracic and lumbar fractures, typically caused by high-energy trauma such as traffic or industrial accidents, involve damage to the spinal segments between the 10th thoracic vertebra and the 2nd lumbar vertebra [24]. These injuries represent the most common type of spinal fractures, accounting for 90% of all cases [16, 25]. Surgical intervention is the preferred treatment for these fractures as it restores spinal alignment, rebuilds spinal stability, alleviates compression on the spinal cord and nerves, and promotes early postoperative recovery [26–29]. Surgical fixation offers several benefits, including improved fracture reduction, spinal stability, and early mobilization. These advantages reduce complications associated with prolonged immobility, such as those seen in bedridden patients [30–32]. Posterior pedicle screw fixation is considered the standard and most effective surgical method for treating thoracolumbar fractures. However, the optimal length of surgical fixation remains a subject of debate in clinical practice. Short-segment fixation using four screws, which crosses the injured vertebra, is

Table 5 Comparison of imaging data before and after surgery in the three groups

Variable	Follow-up time	4s group	6sgroup	8s group	F	P
Anterior edge height ratio of the injured vertebra	Preoperative	54.479 ± 4.961	54.621 ± 4.733	55.351 ± 4.317	0.764	0.467
	Immediately after surgery	83.72 ± 3.63	84.32 ± 3.035	83.86 ± 3.536	0.893	0.411
	The last follow-up(12mo)	80.21 ± 4.494	80.70 ± 2.985	81.50 ± 3.098#	2.590	0.077
Anterior edge comcompression rate of injured vertebra	Preoperative	42.873 ± 4.125	42.742 ± 4.426	42.595 ± 4.448	0.074	0.929
	Immediately after surgery	7.113 ± 1.976	7.114 ± 2.025	7.000 ± 2.040	0.085	0.919
	The last follow-up(12mo)	8.268 ± 2.307	8.303 ± 2.428	8.122 ± 2.477	0.137	0.872
Cobb angle	Preoperative	15.268 ± 2.838	15.167 ± 2.612	14.878 ± 3.213	0.377	0.686
	Immediately after surgery	5.423 ± 1.774	5.295 ± 1.655	5.541 ± 1.904	0.470	0.625
	The last follow-up(12mo)	7.394 ± 2.031	7.545 ± 1.904	7.581 ± 1.882	0.196	0.822

#Meaningful compared to 4s group; * Meaningful compared to 6s group; mo month

characterized by reduced surgical trauma and is widely utilized [33. Nevertheless, it has the limitation of potentially inadequate long-term stability [32]. Conversely, long-segment fixation using eight screws offers greater stability, a lower rate of fixation failure, and supports early functional rehabilitation. However, this approach requires fixing a greater number of spinal motion segments, thereby reducing postoperative spinal mobility [27]. To address these trade-offs, this study compared the surgical outcomes of three fixation techniques: Short-segment cross-injured vertebra fixation with 4 screws (4s group), Short-segment cross-injured vertebra fixation with 6 screws (6s group), and Long-segment fixation with 8 screws (8s group).

From a clinical perspective, the findings of this study offer valuable guidance for selecting the appropriate surgical fixation method for thoracolumbar type A fractures. Clinicians must consider several factors comprehensively when formulating a surgical plan. For patients with minor fractures, minimal disruption to spinal stability, and a strong need for postoperative spinal mobility, the 4-screw method (short-segment fixation across the injured vertebra) may be the optimal choice. This technique is relatively straightforward, involves shorter operation times, results in less intraoperative blood loss, and allows for faster postoperative recovery. Additionally, early mobilization of the spine can reduce the risk of complications associated with prolonged bed rest, such as lung infections and deep vein thrombosis [34] The 6-screw method (short-segment fixation through the injured vertebra) demonstrates significant advantages in clinical applications. For patients with moderate fractures, this approach provides improved fracture reduction and spinal stability while preserving spinal motor function [35]. Its effectiveness in long-term deformity correction is comparable to the 8-screw method (long-segment fixation), yet it involves less surgical trauma. Consequently, patients often experience smoother postoperative recovery, enabling a quicker return to daily life and work. This approach supports both short- and long-term functional recovery without substantial compromise to spinal stability, while also reducing risks such as adjacent segment degeneration often associated with prolonged fixation. The 8-screw method is best suited for patients with severe fractures, significant spinal instability, or nerve injuries requiring extensive decompression and stabilization. While this technique involves greater surgical trauma and significantly limits postoperative spinal mobility, it remains essential for ensuring proper fracture healing and the reconstruction of spinal stability [36]. In patients with thoracolumbar fractures, achieving precise fracture reduction, effective nerve decompression, and long-term spinal stability is critical to minimizing the risk of further neurological damage and preventing the progression of spinal deformities. Our study demonstrated that operating time, intraoperative blood loss, and postoperative RBC levels in the 4s and 6s groups (short-segment fixation) were significantly better than those in the 8s group (long-segment fixation). These findings are consistent with previous research [24]. The shorter operative time and reduced blood loss in short-segment fixation can be attributed to less extensive soft tissue dissection, smaller incision lengths, and fewer screw placements. Previous studies have seldom compared postoperative laboratory indicators to evaluate the trauma caused by different fixation methods. Our findings revealed that postoperative RBC, hematocrit, and albumin levels in the 6s group were significantly higher than those in the 8s group. However, there was no significant difference between the 6s and 4s groups. These results suggest that the 6s group retains the "minimally invasive" characteristics of the 4s group, resulting in less surgical trauma to patients.

Our results also showed that the height ratio of the anterior edge of the injured vertebra one year postoperatively in the 8s group was significantly higher than that in the 4s group, aligning with earlier studies [6, 37]. However, there were no significant differences between the 8s and 6s groups regarding the height ratio of the anterior edge, compression rate of the injured vertebra, or Cobb angle one year after surgery. This contrasts with previous findings, potentially due to our relatively short follow-up period of only one year. Nonetheless, these results indicate that short-segment fixation with 6 screws provides stability comparable to that of long-segment fixation. Importantly, none of the 277 patients experienced loosening, rupture, or failure of internal fixation during the one-year follow-up. This observation highlights the fact that all three fixation methods provide adequate stability in the short to medium term.

Limitations of this study:①Short Follow-Up Period: The limited follow-up duration of one year is a significant limitation of this study. A follow-up period of this length may not fully capture the long-term differences in the efficacy of the three fixation methods. For instance, complications such as loosening of internal fixation and degeneration of adjacent segments, which may arise during the later stages of spinal fracture healing, are unlikely to be fully observed within a year. Over time, the long-term restriction of the 8-screw method on spinal motion segments could potentially lead to issues such as accelerated intervertebral disc degeneration and facet joint hypertrophy in adjacent segments. These issues could not be thoroughly assessed in the current study. Although the 6-screw and 4-screw methods have demonstrated favorable short-term outcomes, their ability to maintain spinal stability and function over an extended period requires longer follow-up observation.②Single-Center Design: The single-center nature of this study imposes limitations on the generalizability and representativeness of the findings. Single-center studies are prone to patient selection bias and are influenced by the specific medical expertise, technological capabilities, and treatment protocols of the institution. Variations in surgical techniques, postoperative rehabilitation programs, and patient population characteristics across different medical centers could lead to discrepancies in outcomes. For example, certain centers may have unique surgical approaches, preoperative evaluation protocols, or postoperative care practices that impact the results. These differences reduce the external validity of the study.

To address the limitations of the single-center design, future research should adopt a multi-center, prospective, randomized controlled trial approach. By involving medical centers from diverse regions and levels, the study can expand its sample size and ensure the inclusion of patients with varying severity levels, ages, genders, and socio-economic backgrounds, thereby making the sample more representative. During the research design phase, standardized inclusion and exclusion criteria, surgical protocols, postoperative rehabilitation plans, and follow-up procedures should be established. This standardization will help minimize biases arising from inter-center differences. Through multi-center collaboration, more comprehensive data can be collected to validate the reliability of the findings from this study. Additionally, such a design would facilitate the exploration of the optimal application strategies for various fixation methods in different clinical scenarios. Ultimately, this approach would provide more authoritative and widely applicable guidance for the clinical treatment of thoracolumbar type A fractures.

Conclusions

In conclusion, the clinical efficacy of short-segment fixation across the injured vertebra and short-segment fixation through the injured vertebra is comparable in the treatment of thoracolumbar fractures. Short-segment fixation is less invasive than long-segment fixation, resulting in shorter operative times, reduced intraoperative blood loss, and shorter postoperative hospital stays. Moreover, short-segment fixation through the injured vertebra offers long-term deformity correction comparable to that achieved with long-segment fixation.

Abbreviations

LOS	Length of stay
BMI	Body mass index
HB	Hemoglobin
RBC	Red blood cell
ALB	Albumin
HCT	Hematocrit
CRP	C-reactive protein

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Author contributions

Alimujiang Yusufu is the first-author of this paper; Alimujiang Yusufu proposed the research idea and wrote the first draft of the paper; Abudula Abulaiti and Abuduwupuer Haibier is responsible for the statistical analysis of this paper; Junyi Ma collected patient information and data; Yuna Ma is the corresponding author of this paper.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of the Sixth Affiliated Hospital of Xinjiang Medical University with the ethical batch number: LFYLLSC20250108-01; All patients gave informed consent.

Competing interests

The authors declare no competing interests.

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