

A comparison of monoaxial and polyaxial pedicle screws in thoracolumbar fracture

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Research article

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Abstract

Purpose: To evaluate the use of short-segment posterior fixation with monoaxial and polyaxial pedicle screws in thoracolumbar fractures

Methods: All patients who underwent short-segment posterior fixation with monoaxial pedicle screws or polyaxial pedicle screws in the injured vertebra of a thoracolumbar fracture (T12-L2) in our hospital between June 2012 and December 2018 were categorised into two groups: monoaxial pedicle screws group (group A) and polyaxial pedicle screws group (group B). We compared the Thoracolumbar Injury Severity Score (TLISS), American Spinal Injury Association (ASIA) score, the fracture level, Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification, hospital stay, injury-to-operation interval, and associated injuries between the two groups. In addition, the prevertebral height ratio, the injured vertebra Cobb angle, and the injured vertebral endplate centre ratio were measured preoperatively, postoperatively, and at the final follow-up.

Results: There were 63 patients (21 males and 42 females) with an average age of 44.7 years. Compared with group B, the injury vertebral endplate centre ratio significantly increased postoperatively and at the final follow-up ($P < 0.05$) in group A.

Conclusion: Short-segment posterior fixation with monoaxial or polyaxial pedicle screws via the fracture level for thoracolumbar fracture can achieve kyphosis correction, reduce sagittal alignment correction failure, and maintain anterior vertebral height. The insertion of monoaxial pedicle screws at the fracture level after thoracolumbar vertebral fracture has a flick up effect on the central vertebral body of the injured vertebrae, which is beneficial to the recovery of the vertebral endplate.

Introduction

Spine fractures are common, accounting for about 14% of all fractures [1], and the thoracolumbar spine is reportedly the most common site of spinal fractures due to trauma, accounting for 60–70% of spine fractures [2, 3]. Thoracolumbar fractures can cause an unstable spine leading to pain, motion disability, and even full paralysis [4]. Posterior pedicle screw fixation, to maintain the stability of the spine and avoid further nerve damage, has been popular globally [5]. Posterior pedicle screws can be inserted in either the fractured vertebra itself or the adjacent vertebrae. Many orthopaedic specialists believe that it is better to insert pedicle screws at the level of the fracture because the reinforcement of fixation can help to improve kyphosis correction and biomechanical stability. Inserting monoaxial or polyaxial pedicle screws at the level of vertebral fractures, as well as segmental fixation of burst fractures, improves biomechanical stability. [6, 7] In addition, several studies have shown that enhanced fracture-grade screws can improve the biomechanical stability of the construct [8–11], and some authors [7, 12, 13] have also suggested that pedicle screw fixation combined with an intermediate screw in the fractured vertebra improves biomechanical stability with better reduction, less loss of correction, fewer instrument failures, and comparable or better clinical outcomes. However, it has not yet been ascertained whether inserting a

monoaxial or polyaxial pedicle screw at a vertebral fracture yields better clinical results. Our study, therefore, compared the efficacy of inserting a monoaxial or polyaxial pedicle screw at a vertebral fracture, aiming to provide a reference for the clinical options for thoracolumbar fractures.

Materials And Methods

General information

This retrospective study included patients who underwent short-segment posterior fixation with monoaxial or polyaxial pedicle screws in the injured vertebra of a thoracolumbar fracture and removal of the internal fixation in our hospital between June 2012 and December 2018. Of these patients, 42 were male and 21 were female, with an average age of 44.7 years. The patients' thoracolumbar injury classification and severity scale (TLICS) [14] scores were 5–7 points and their [American Spinal Injury Association](#) (ASIA) [15] scores were C–E on first admission. According to the type of pedicle screw insertion at the vertebral fracture, the patients were categorised into two groups: group A had monoaxial pedicle screws, and group B, polyaxial pedicle screws. The fractures were classified according to Arbeitsgemeinschaft für Osteosynthesefragen (AO) [16] Spine Classification.

Inclusion and exclusion criteria

The enrolment criteria were as follows: (1) thoracolumbar single segmental fracture; (2) short-segment posterior fixation with monoaxial or polyaxial pedicle screw via the injured vertebra; (3) patient information is complete, imaging data is complete and fracture healing, pedicle screw removal. Patients with significant osteoporosis, endocrine system disease, vertebral tumour, tuberculosis, ankylosing spondylitis, and other destructive vertebral structural diseases were excluded from the study.

Clinical observation indicators and efficacy evaluation

Perioperative parameters: Injury-to-operation interval (days), associated injury, and hospital stay (days) on first admission.

Imaging parameters X-rays of the ortho and lateral positions of the spine were taken preoperatively, three days postoperatively, and on removal of internal fixation. Measurements taken include the height of the leading edge of the vertebral body adjacent to the injured vertebra and that of the injured vertebra, the height of the centre of the injured endplate and injured vertebra, the Cobb angle, and the vertebral changes for the two internal fixation methods between three days postoperatively and when the internal fixation device was removed. We also assessed whether the internal fixation fractured or loosened.

Measurement and calculation of prevertebral height ratio (Figure 1)

The sum of the heights of the leading edges of the vertebral bodies above and below the injured vertebra was compared with twice the height of the leading edge of the injured vertebra.

Measurement and calculation of injured vertebral endplate centre ratio (Figure 2)

The sum of the heights of the upper and lower endplates of the injured vertebrae was compared with twice the height of the centre of the injured endplate.

Measurement and calculation of kyphosis of the injured vertebrae (Figure 3)

The angle between the upper endplate of the injured vertebra and the extension of the lower endplate of the injured vertebra.

Statistical methods

The statistical software SPSS 20 was used to analyse the data of the monoaxial and polyaxial pedicle screw groups preoperatively, three days postoperatively, and at the removal of internal fixation. The measurement data were expressed as mean \pm standard deviation ($x \pm s$). Data between groups were compared using an independent sample t-test. $P < 0.05$ was considered statistically significant.

Results

General information

There were 33 patients in group A (24 males and nine females), and 30 patients in group B (18 males and 12 females). X^2 test analysis ($P > 0.05$) revealed no significant intergroup differences in terms of. In addition, there were no significant differences in hospital stay, injury-to-operation interval, and associated injuries between the two groups ($P > 0.05$) (Table 1).

AO Classification and Fracture level

Of the 33 patients in group A, there were ten cases of A1 type, two cases of A2 type, and 12 cases of A3 type. There were six cases of B1 type and three cases of B2 type. The fracture sites were T12 in two cases, L1 in 17 cases and L2 in 14 cases. Of the 30 cases in group B, the fractures were classified into six cases of A1 type, four cases of A2 type, nine cases of A3 type, six cases of B1 type, and five cases of B2 type. The fracture sites were zero cases of T12, 21 cases were L1, and nine cases were L2. According to the X^2 test analysis, $p > 0.05$; therefore, there were no statistically significant differences (Table 1).

TLISS Score

In the Thoracolumbar Injury Severity Score (TLISS) group, in group B, 17 people scored five points, nine people scored six points, and seven people scored seven points. In group A, 16 people scored five points, 11 people scored six points, and three people scored seven points. According to the X^2 test analysis, $p > 0.05$; there were no statistically significant differences (Table 1).

ASIA Score

In the ASIA score group, there were seven people evaluated as C, 17 evaluated as D, and nine evaluated as E in group A; and there were three people evaluated as C, 16 evaluated as D, and 11 evaluated as E in group B. According to the X^2 test analysis, $p > 0.05$; therefore, there were no statistically significant differences (Table 1).

Radiographic data

The radiographic data from surgery shows that the prevertebral height ratio and the injured vertebra Cobb angle between the two groups were not significantly different in preoperative, postoperative (three days after surgery), and final follow-up (removal of internal fixation) evaluated by t-test analysis ($P > 0.05$). In addition, the injured vertebral endplate centre ratios between the two groups were not significantly different preoperatively ($P > 0.05$). However, the injured vertebral endplate centre ratio between the two groups were significantly different in the postoperative and final follow-up checks ($P < 0.05$) (Table 2).

Discussion

Research has confirmed the beneficial therapeutic effect of short-segment posterior fixation with pedicle screws in the injured vertebra as treatment for thoracolumbar fractures [6–13]. Biomechanically, the screws at the fracture level function as a push point with an anterior vector, creating a "lordorizing" force that restores the anterior vertebral height and corrects the kyphosis [17]. Some clinical studies have shown that inserting monoaxial or polyaxial pedicle screws at the fracture level could achieve better kyphosis correction, less sagittal alignment correction failure, and better maintenance of anterior vertebral height [7,8,10,12,18]. Short-segment posterior fixation can be achieved by the insertion of either a monoaxial or a polyaxial pedicle screw into the injured vertebra; however, no studies have compared the efficacy of the two options.

Our retrospective study shows that both options markedly improved the outcome of patients postoperatively. This was reflected in considerable improvements whether analysed according to sex, age, fracture injury classification, fracture site, TLISS score, ASIA Score, AO classification, hospital stay, injury-to-operation interval, or associated injury after treatment. However, no statistically significant differences were observed between the two groups ($p > 0.05$). These results support the proposition that inserting either a monoaxial or polyaxial pedicle screw in the injured vertebra is an effective surgical treatment.

In our study, we measured and calculated the prevertebral height ratio, injured vertebral endplate centre ratio, and the kyphosis of the injured vertebrae. As shown in Table 2, the prevertebral height ratio and the kyphosis of the injured vertebrae postoperatively and at the final follow-up were greatly improved. This confirms that inserting a monoaxial or polyaxial pedicle screw in the injured vertebra can correct the deformity through vertebral endplate augmentation with its buttress effect (bending force) as with the rod-sleeve method, which was until recently commonly used in spinal instrumentation [7,19–22]. No statistically significant differences were observed, however, between the two groups. The injured vertebral endplate centre ratios in the postoperative and the final follow-up were greatly improved, and the correction effect of group A was better than that of group B. In addition, significant differences were observed between the two groups ($p < 0.05$). Many reports [17] have proposed that the screw at the fracture level may provide a mass effect that prevents the vertebra from collapsing. It may also help to support the anterior column, which is vital for the stability of the construct. However, it is not clear why there is a better correction effect in group A compared to group B.

Polyaxial pedicle screw heads are vulnerable to fatigue failure; the region between the screw head and shaft has been found to fail first in many biomechanical studies [23–25]. Further, the use of additional intermediate monoaxial pedicle screws may result in a stiffer construct and a reduced level of von Mises stress on the pedicle screws than on the polyaxial pedicle screw models [26]. In addition, the monoaxial screws can slap the collapsed endplate, reset the endplate fracture, maintain the reduction, reduce the degeneration of the intervertebral disc injury, and perhaps better maintain the stability of the spine; thus, reducing the incidence of back pain. Furthermore, the head of the polyaxial pedicle screw is movable and cannot support the injured vertebral body. The monoaxial pedicle screws inserted at the fracture level showed higher stability in flexion and extension than the similarly placed polyaxial pedicle screws [27]. Moreover, in the operation (as shown in Fig. 4), we selected the midpoint of the transverse process on both sides of the injured vertebral body and the intersection of the anterior line of the superior articular process as the needle point. We then placed two locating needles, and kept them at an angle of about 30 degrees to the sagittal plane, the positioning needle, and the cross-section form an angle; the vertebral bodies above and below the injured vertebrae are in the direction of the traditional needle insertion, and the sagittal plane is formed at an angle of about 15 degrees, so that the positioning needle is parallel to the cross-section; The vertebral pedicle screw installed in the manner of needle insertion can support the sling and the role of the vertebral endplate. Thus, our results provided a reference for the treatment of thoracolumbar fractures with severe vertebral endplate damage using invasive intermediate monoaxial pedicle screw fixation.

This study has many limitations. First, the number of patients included in the study was small, and this was a retrospective study. Second, a selection bias may exist because this study included patients referred to our teaching hospitals. Third, it is necessary to discuss several factors including different patient conditions, the variability in bone density, muscle forces, vertebral size, the length and diameter of pedicle screws, and the degree of joint degeneration of the body.

In conclusion, based on our results, short-segment posterior fixation with monoaxial or polyaxial pedicle screws at the fracture level of a thoracolumbar fracture achieved kyphosis correction, reduced sagittal alignment correction failure, and maintained anterior vertebral height. We found short-segment posterior fixation with monoaxial pedicle screws at the fracture level of a thoracolumbar fracture to be better than polyaxial pedicle screws in improving the height of the centre of the injured endplate. After a thoracolumbar vertebral fracture, the insertion of a monoaxial pedicle screws at the fracture level has a flick up effect on the central vertebral body of the injured vertebrae, which is beneficial to the recovery of the vertebral endplate.

Abbreviations

TLISS

Thoracolumbar Injury Severity Score;

ASIA

American Spinal Injury Association;

AO

Arbeitsgemeinschaft für Osteosynthesefragen;

Declarations

Acknowledgements

No acknowledgement.

Authors' contributions

WY and RG made the same contribution in this article, WY and RG performed all the experiments and wrote the manuscript. QL, BX, ZY, XY and CW participated in the collection of experimental data. BZ guided the entire process of the experiment. YL conceived and designed the study. All authors have read and approved the final manuscript.

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Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Ethics approval and consent to participate

Our study has been approved by the Ethics committee of The First Affiliated Hospital of Nanchang University.

Consent for publication

Consent for publication was obtained from all participants.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1 - Patient demographic data

Characteristic	Group A(N=33)	Group B(N=30)	P value
Age(years)	42.3 ±10.0	47.1±12.0	0.089
Female	9	12	0.285
Male	24	18	
TLISS Score			
5	17	16	0.429
6	9	11	
7	7	3	
ASIA Score			
C	7	3	0.429
D	17	16	
E	9	11	
Level			
T12	2	0	0.176
L1	17	21	
L2	14	9	

AO Classification

A1	10	6	0.681
A2	2	4	
A3	12	9	
B1	6	6	
B2	3	5	
Hospital stay(days)	11.5±3.8	13.7±3.9	0.117
Injury-to-operation interval(days)	4.9±2.7	3.5±1.9	0.216

Associated injury

Yes	18	8	0.023
NO	15	22	

Table 2-Radiographic data of surgery

Parameter	Group A	Group B	P value
Prevertebral height ratio(%)*			
Preoperative	1.5±0.4	1.3±0.3	0.063
Postoperative	1.0±0.1	1.0±0.2	0.253
Last follow-up	1.0±0.1	1.1±0.2	0.034
Injury vertebra Cobb angle(°)			
Preoperative	19.0±10.2	18.8±4.0	0.894
Postoperative	9.0±5.2	8.4±2.1	0.533
Last follow-up	8.3±4.5	8.7±2.2	0.670
Injury vertebral endplate center ratio(%)*			

Preoperative	1.6±0.3	1.5±0.2	0.283
Postoperative	1.1±0.2	1.4±0.2	0.001
Last follow-up	1.1±0.2	1.4±0.2	0.001

Prevertebral height ratio(%)* :The sum of the heights of the leading edge of the upper and lower vertebral bodies of the injured vertebra is compared with the height of the leading edge of the injured vertebra.

Injury vertebral endplate center ratio(%)* :The sum of the heights of the upper and lower endplates of the injured vertebrae is compared with the height of the center of the injured endplate.

Figures



Figure 1 measurement and calculation of prevertebral height ratio

Figure 1

The sum of the heights of the leading edges of the vertebral bodies above and below the injured vertebra was compared with twice the height of the leading edge of the injured vertebra $((a+c)/2b)$.

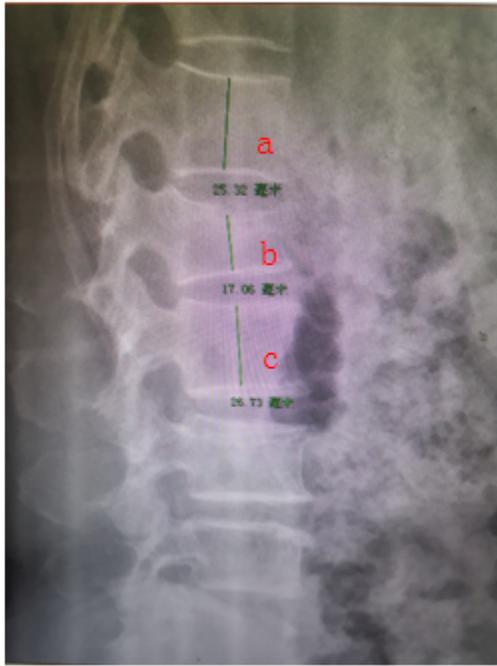


Figure 2 measurement and calculation of injury vertebral endplate center ratio

Figure 2

The sum of the heights of the upper and lower endplates of the injured vertebrae was compared with twice the height of the centre of the injured endplate $((a+c)/2b)$.

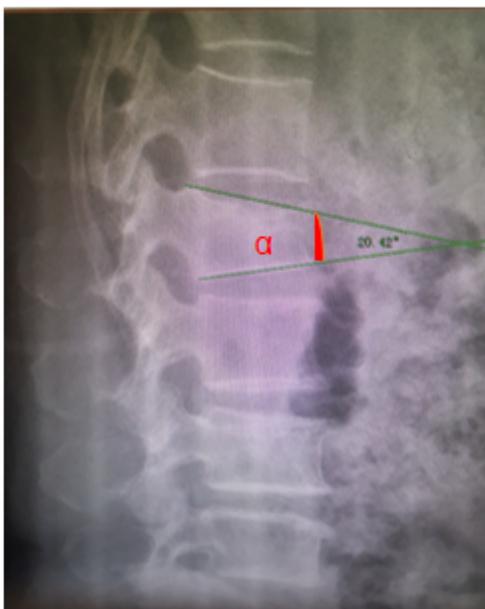


Figure 3 measurement and calculation of kyphosis of injured vertebrae

Figure 3

The angle(α) between the upper endplate of the injured vertebra and the extension of the lower endplate of the injured vertebra.

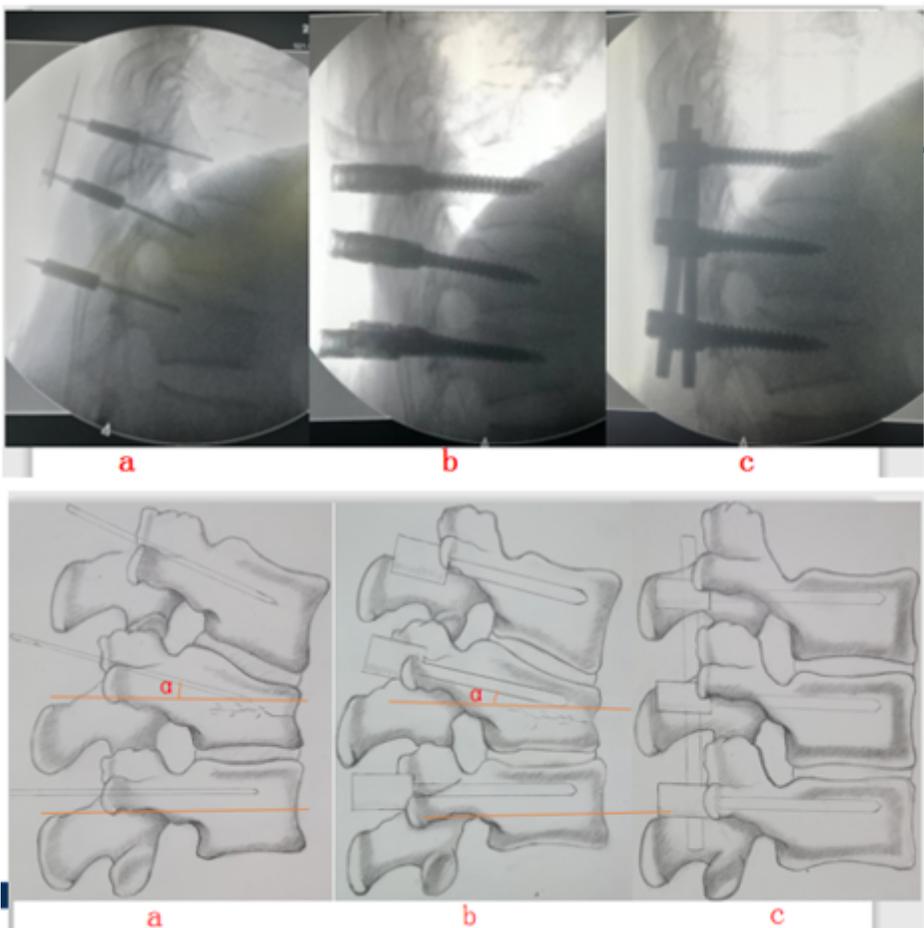


Figure 4

Figure 4

a: We selected the midpoint of the transverse process on both sides of the injured vertebral body and the intersection of the anterior line of the superior articular process as the needle point. We then placed two locating needles, and kept them at an angle of about 30 degrees to the sagittal plane, the positioning needle, and the cross-section form an angle(α); the vertebral bodies above and below the injured vertebrae are in the direction of the traditional needle insertion, and the sagittal plane is formed at an angle of about 15 degrees, so that the positioning needle is parallel to the cross-section. b: The vertebral pedicle screw installed in the manner of needle insertion. c: Use this method to place the monoaxial pedicle screws to restore the center height of the injured vertebral endplate.