Efficacy and Radiographic Analysis of Posterior Mono Axial Pedicle Screw Fixation in Treating Thoracolumbar Burst Fractures

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Abstract

Objective: The purpose of this study was to evaluate the effectiveness of posterior mono axial pedicle screws fixation in the treatment of thoracolumbar burst fractures.

Methods: In the present study we analyzed 50 patients retrospectively who had thoracolumbar burst fractures without a neurological deficit. Patients were divided into 2 groups: mono axial pedicle Screw fixation group (n = 25) and poly axial pedicle Screw fixation group (n = 25). We collected clinical data (visual analog scale score for back pain) and included radiographic measurements. The latter were used to calculate the sagittal plane kyphosis.

Results: For the mono group, the preoperative mean sagittal index (SI) was 0.59 ± 0.12 (range, 0.37–0.77), and the last follow up sagittal index (SI) was 0.76 ± 0.09 (range, 0.56–0.89).

For the poly group, the preoperative sagittal index (SI) was 0.57 ± 0.11 (range, 0.34–0.82),

and the last follow up sagittal index (SI) was 0.65 ± 0.11 (range, 0.36–0.87). For the mono group, the mean postoperative regional kyphosis correction rate was 62.31%, and correction loss was 14.18% in late follow-up. For the poly group, the mean postoperative regional kyphosis correction rate was 52.17%, and correction loss was 33.42% in late follow-up. The mono axial pedicle screw group had good correction rate, and reduce the risks of correction loss. The mean visual analog scale (VAS) scores for back pain improved by 2.4/2.5 and 3.8/4.2 for the mono and poly groups. There was no significant difference between groups.

Conclusions: The mono axial pedicle screw fixation was better for reducing and maintaining anterior vertebral height and regional kyphosis. Therefore, the mono axial pedicle screw is a better optional instrumentation to treat thoracolumbar vertebral fractures.

Introduction

The most common spinal fractures has been reported to be at the thoracolumbar region.¹⁷ Because it is the transition zone between the rigid thoracic kyphosis and more flexible lumbar lordosis.²⁴

Conservative treatment is usually the method of choice if there is little kyphotic deformity, no neurological deficit or no unstable posterior vertebral column.^{4,22,26} In unstable thoracolumbar burst fractures, operative stabilization is preferred.^{12,13,18,27} The main goals of surgery are restoration of spinal stability, correction of deformity, and decompression of the spinal canal with the preservation of neurologic function.^{14,23,33} Anterior or posterior approach, or combined approach are used for the treatment of thoracolumbar burst fractures.^{7,31} But, there is no consensus regarding the best surgical approach. Nevertheless, spine surgeons often prefer the posterior approach because of its easy application, reduction of intraoperative bleeding and low degree of invasiveness.²³ It has become the most used method in the surgical treatment of thoracolumbar burst fractures.^{9,25} Than, transpedicular screw is

popularly used to treat thoracolumbar burst fractures. Many biomechanical studies demonstrate that the designs of screw head play a significant role in the correction of spinal deformity and have different effects on the stiffness in three dimensions (coronal, sagittal, and axial plane).¹⁶

According to biomechanical theory, the mono axial pedicle screw could, more effectively than the poly axial pedicle screws, restore the vertebral height, correct the kyphosis, reduce the postoperative kyphosis loss, and maintain fracture reduction.

However, the question arose whether the mono axial pedicle screw fixation could really achieve vertebral height recovery, improve the kyphosis, reduce postoperative kyphosis loss, and reduce the incidence of internal fixation failure better than the poly axial pedicle screw fixation in clinical practice.

Hence, we decided to compare and analyze the clinical and radiological results after posterior fixation by mono axial pedicle screws and poly axial pedicle screws in thoracolumbar burst fractures.

Methods

Patients

From January 2013 to January 2018, we treated 187 patients surgically in our institution for a variety of different thoracolumbar spine fractures. To obtain retrospective follow up results we selected from these patients a group of patients according to the following inclusion criteria: a burst-compression injury at T12–L1 which involved the middle column but left the posterior column intact ; no neurological deficit ; no pathologic fracture. Based on AO thoracolumbar classification system, all patients were A3 fracture type. Exclusion criteria were pathologic or osteoporotic fracture, or a history of previous back surgery.

We selected 50 patients and divided into 2 groups: mono axial pedicle Screw fixation group (n = 25) and poly axial pedicle screw fixation group (n = 25). The male to female ratio was 1.78:1, with 32 males and 18 females patients. The majority of fractures resulted from falling down. All patients underwent plain X-rays, computed tomography (CT) and magnetic resonance imaging (MRI) before surgery. The most fractured sites were L1 fractures in 32 (64%), T12 in 18 (36%). Follow-up times ranged from 18 to 43 months. The mean age was 49.3 years in the mono group and 52.9 years in the poly group. Surgery of the fracture was done on average 2.9 days after hospital admission. Posterior screw fixation involved 3 levels(fracture level, above and below level of the fracture vertebra) in the both groups. Demographic data are presented in Table 1.

We collected clinical data (visual analog scale score for back pain) and included radiographic measurements. The latter were used to calculate the sagittal plane kyphosis.

The study adhered to the principles of the Declaration of Helsinki with voluntary participation. All experiments were carried out in accordance with relevant guidelines and regulations. Informed consent was obtained from all participants. The data were handled on a group level and personal details were

replaced by identification codes. The research was approved by the Chunchon Sacred Heart Hospital, Hallym University College of Medicine Investigational Review Board (IRB) for the Protection of Human Subjects.

Operative Technique

Patients were positioned prone on the four poster frame in order to reduce the intra-abdominal

Pressure and to create a positional reduction effect on the fracture. A standard posterior midline approach was used in all patients. After we confirmed the fractured vertebra with a fluoroscopy, subperiosteal dissection was applied without damage to the interspinous or supraspinous ligaments. We used 6.5mm diameter titanium mono and poly axial pedicle screws. All screw replacement was confirmed by radiographs. All procedures were same in both groups, except screw type.

In mono group, mono axial pedicle screws were inserted parallel to the superior end plate of the upper and lower adjacent vertebra. Then, intermediate screws were inserted into the pedicles of the fractured vertebrae parallel to the upper endplate of the upper adjacent normal vertebrae. Fracture reduction and indirect decompression of the spinal cord were achieved by applying distraction and producing an appropriate contour in the rod. Details of reduction procedure were as follows: Temporarily tightening of the screw nuts with pre-contoured rods on mono axial pedicle screws which were inserted parallel to the superior end plate formed a 90°–90° screw-rod construct. This led to reduction of the anterior vertebral height (AVH) and segmental kyphosis of the fractured vertebrae. Indirect reduction of the posterior vertebral height (PVH) was performed via ligamentotaxis after connecting rods distraction toward the cranially and caudally in sequence. Final tightening of the whole construct was performed. The length of the spine was restored.

In poly group, poly axial pedicle screw were inserted parallel to the superior end plate of the upper and lower adjacent vertebra. Then, intermediate screws were inserted into the pedicles of the fractured vertebrae parallel to the upper endplate of the upper adjacent normal vertebrae. The rods were fixed and then torque was applied through the rod pusher to bring the vertebra back to the rod. Details of reduction procedure were same in both groups.

Bracing was prescribed for patients during 8 weeks after surgery. Implants removal was performed at 1 to 2 years after surgery when bone healed.

Radiologic Evaluation and Clinical Assessments

Radiographic evaluations were based on anteroposterior (AP) and lateral views, flexion and extension lateral views, and three dimensional computed tomography (CT) scans. Using the ratio of the heights of the anterior and posterior vertebral wall (on lateral views of the injured vertebral body) we calculated the sagittal index (SI) preoperatively, immediately after surgery, and at the final follow up (Fig. 1). Kyphotic deformity was evaluated on lateral views using the Cobb method. Regional kyphosis angle (RKA) between the superior endplate of the vertebra above the apical (injured) vertebra and the inferior endplate

of the apical vertebra below were measured preoperatively, immediately after surgery, and at the final follow up (Fig. 1). RKA does not only stand for the deformity of the fractured vertebral body, but also the destruction of the affected intervertebral disc. Spinal canal encroachment and clearance were calculated before to after surgery on CT scans. The percentage of canal compromise was calculated with the narrowest mid-sagittal diameter of the injured level divided by the mean of the mid-sagittal diameters of adjacent upper and lower vertebra (Fig. 2).^{15,22}

Surgical time, operative blood loss, and perioperative complications were assessed. For clinical outcomes assessment was analyzed using a visual analogue scale (VAS) for back, Oswestry Disability Index (ODI).

Statistical Analysis

The PACS system (π view®, Infinitt, Seoul, Korea) was used by 2 independent observers for the measurement. The intraobserver and interobserver agreement rate and k values were obtained to check errors between 2 observers. For statistical analysis, the SPSS 22.0 was used and the p-value less than 0.05 were considered significant. Continuous variables are presented as means $\pm$ SD. Frequency analysis was used for categorical variables. ANOVA and the Kruskal-Wallis test were used as appropriate for group comparisons.

Results

Radiographic Outcomes

The interobserver agreement rate was 94% (mean k=0.75), and intraobserver agreement rate was 97% (mean k=0.81). The intraobserver and interobserver error analyses showed good agreement.

The radiographic outcomes are summarized in Table 2. For the mono group, the preoperative mean sagittal index (SI) was 0.59 ± 0.12 (range, 0.37–0.77), the postoperative sagittal index (SI) was 0.80 ± 0.09 (range, 0.62–0.98), and the last follow up sagittal index (SI) was 0.76 ± 0.09 (range, 0.56–0.89). For the poly group, the preoperative sagittal index (SI) was 0.57 ± 0.11 (range, 0.34–0.82), the postoperative sagittal index (SI) was 0.73 ± 0.11 (range, 0.46–0.91) and the last follow up sagittal index (SI) was 0.65 ± 0.11 (range, 0.36–0.87). Sagittal index (SI) was significantly improved at the postop and last follow up in mono group and poly group. The mono group was better for reducing and maintaining anterior vertebral height.

For the mono group, the preoperative mean regional kyphosis angle (RKA) was 21.56° and the postoperative mean RKA was 8.13° . The mean correction angle was 13.43° (correction rate 62.31%). The RKA angle decreased from 8.13° to 11.18° (correction loss : 14.18%) in late follow up. For the poly group, the preoperative mean RKA was 23.18° and the postoperative mean sagittal plane kyphosis was 11.09° . The mean correction angle was 12.09° (correction rate 52.17%). The RKA decreased from 11.09° to 18.83° .

(correction loss : 33.42%) in late follow up. The mono axial pedicle screw fixation had better correction rate and reduce the risks of correction loss than the poly-axial pedicle screw fixation (Fig. 3,4).

The mean preoperative canal narrowing is 38.6%, which was recovered 14.8 and 15.1% after surgery and at the last follow-up, in mono group. The mean preoperative canal narrowing is 36.4%, which was recovered 22.3 and 23.7% after surgery and at the last follow-up, in poly group. The mean preoperative canal narrowing was improved in both groups, and a statistical difference was found between both groups ($P < 0.05$). An improvement of spinal canal encroachment at the mono group was better than that found at the poly group.

Bone fusion was obtained at the final follow-up of both groups, and there was no difference in fusion rate.

The incidences of broken screws were 11.3% and 10.4%, respectively, for mono group and poly group, and there were no significant differences ($P > 0.05$).

Clinical Outcomes

The mean Blood loss was 120 mL (range, 50–200 mL) in the mono group and 110 mL (range, 40–180 mL) in the poly group. The mean operative time was 55minutes(range, 35–135 min) in the mono group, 60minutes(range, 40 – 125 min) in the poly group (Table 3). The mean visual analog scale (VAS) scores for back pain improved from 6.4 preoperatively to 2.1 at the last follow up ($P < 0.05$) in the mono group, and from 6.5 preoperatively to 2.2 at the last follow up ($P < 0.05$) in the poly group. There was no significant difference between groups with regard to VAS scores.

Intraoperative complications included one superficial wound infection in mono group. The superficial wound infection was successfully treated successfully using with debridement, primary closure over drains, and antibiotic therapy. There were no other severe complications.

Discussion

The goals of surgical treatment for thoracolumbar burst fractures are to restore vertebral body height, correct angular deformity, decompress neural tissue, allow rapid mobilization and rehabilitation, prevent development of progressive deformity with neurologic deficit, and limit the number of instrumented vertebral motion segments.^{2,3,5,32}

The ideal surgical management remains controversial, and no evidence based guideline for the most optimal surgical approach or instrumentation technique has been developed.^{1,10,11}

Long segment pedicle screw fixation may be stiffer and impart greater forces on adjacent segments compared with short segment fixation, which may affect clinical performance

and long term outcome but at the cost of sacrificing additional motion segments.²⁰ For this reason, short segment posterior fixation (one level above and below the fracture level) has been used more commonly than long segment posterior fixation for the treatment of thoracolumbar burst fractures.^{6,19,23} However, some study showed that short segment posterior fixation alone led to a 9% - 54% incidence of implant failure and rekyphosis at long term follow up, and 50% of the patients with implant failure had moderate to severe pain.²¹ It is important to obtain the best fracture reduction as possible.²⁰ The greater residual kyphotic deformity provides greater anterior vertebral stress on pedicle screws. Thus, the overloading force on the instrument loosens the screw, causing it to break, dislodge, and disconnect, which mostly is seen in short segment posterior fixation.^{20,21,30}

To overcome this situation, some study suggested that pedicle screws be added to the fracture level.²⁸ Because, the stiffness increased an average of 160% when using the additional pedicle screw fixation at the fracture level. Axial testing showed that the six screw construct was 84%stiffer than the four screw construct in flexion and was 38%stiffer than the four screw construct in torsional testing.⁸

The additional pedicle screw fixation at the fracture level can function as a push point with an anterior vector, creating a lordorizing force that restored anterior vertebral height and the segmental kyphosis. Therefore, short segment posterior fixation with pedicle screw fixation at the fracture level provided better anterior vertebral height restoration and kyphosis correction for thoracolumbar burst fractures.¹¹

Many biomechanical studies demonstrate that the designs of screw head play a significant role in the correction of spinal deformity and have different effects on the stiffness in three dimensions (coronal, sagittal, and axial plane).¹⁶ An experimental study has reported by Wang that the mono axial pedicle screw with no motion between screw head and shaft can significantly increase the stiffness in axial direction compared with poly axial pedicle screw, and reduce the risks of correction loss.²⁹ Mono axial pedicle screws can be a better fixation instrumentation for thoracolumbar burst fractures in theory. However, the question arose whether the mono axial pedicle screw fixation could really achieve vertebral height recovery, improve the kyphosis, reduce postoperative kyphosis loss, and reduce the incidence of internal fixation failure better than the poly axial pedicle screw fixation in clinical practice. Hence, we planned this study.

In this study, our results found that there was significant difference in the reduction of anterior vertebral height (sagittal index) and correction of the kyphosis angle (sagittal plane kyphosis) between the mono group and poly group. The mono group was better for reducing and maintaining anterior vertebral height, reducing the kyphosis angle. Because, the mono axial pedicle screw with no motion between screw head and shaft formed a 90°–90° screw-rod construct. But, the poly axial pedicle screw with motion between screw head and shaft could not formed a 90°–90° screw-rod construct. This led to a significant difference in the reduction of anterior vertebral height (Sagittal index) and correction of the kyphosis angle (sagittal plane kyphosis) between the mono group and poly group.

Therefore, Mono screw fixation could provide sufficient immobilization to restore spine stability until the fracture healed, thus obtaining satisfactory reduction and maintenance of the fractured vertebrae height.

This study has some limitations. First, this is a retrospective study. Second, 50 patients is a rather small group for such a clinical study. Third, the short follow up time and not taking into account the adjacent intervertebral space height. therefore, the results may be biased.

Conclusion

The mono axial pedicle screw fixation was better for reducing and maintaining anterior vertebral height, reducing the kyphosis angle. Therefore, Mono axial pedicle screw fixation could provide sufficient immobilization to restore spine stability until the fracture healed, thus obtaining satisfactory reduction and maintenance of the fractured vertebrae height.

Declarations

Funding

No funding was received for this study.

Conflict of interest

The authors declare that they have no conflict of interest.

Availability of data and material

Data of this study are available from the corresponding author upon reasonable request.

Code availability

Not applicable

Ethical approval

The current study was approved by the ethical committee of our hospital.

Consent to participate

Informed consent was obtained from all enrolled patients

Consent for publication

All authors of this manuscript consent to the publication of the manuscript in Neurosurgical Review journal.

Authors' contribution

SS L, JH S and EM S contributed to the study conception and design. SS L, JH S and EM S collected clinical data. SS L, JH S and EM S collected radiological data. EM S performed the statistical analysis and drafted the manuscript. All authors contributed to the interpretation of results, all revised the manuscript critically for important intellectual content, and all approved the final manuscript.

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Tables

Table 1. Summary of demographic profile

Dermographics	All patients	mono group	poly group	P - value
No. of patients	50	25	25	0.755
Age(years)	50.1 ± 13.4	49.3±14.8	52.9±12.6	0.063
Gender(M:F)	1.78:1	1.56:1	2:1	0.323
Follow-up (months) (mean ± SD)	33.3 ± 15.1	27.9±14.6	34.7± 16.7	0.626
Timing from trauma to surgery (day)	2.9±0.8	2.8 ± 0.9	3.1 ± 0.7	0.761
Level of fracture (n (%))				
T12	18(36)	10(40)	8(32)	0.622
L1	32(64)	15(60)	17(68)	0.634

Table 2. Comparisons of radiographic data between the two groups

	mono group	poly group	P - value
Regional kyphosis angle (degrees) (°)			
Preoperation	21.56° ± 8.5 °	23.18° ± 7.6°	0.865
Postoperation	8.13° ± 5.8°	11.09° ± 7.6°	<0.05
Final follow up	11.18° ± 6.4 °	18.83° ± 8.5°	<0.05
p value (pre-final)	<0.05	<0.05	
Sagittal index (SI)			
Preoperation	0.59 ± 0.12	0.57 ± 0.11	0.863
Postoperation	0.80 ± 0.09	0.73 ± 0.11	<0.05
Final follow up	0.76 ± 0.09	0.65 ± 0.11	<0.05
p value (pre-final)	<0.05	<0.05	
Spinal canal encroachment (%)			
Preoperation	38.6±11.4	36.4±17.6	0.412
Postoperation	14.8±9.7	22.3±10.3	<0.05
Final follow up	15.1±10.8	23.7±11.6	<0.05
p value (pre-final)	<0.05	<0.05	

Table 3. comparisons of clinical outcomes between the two groups

	mono group	poly group	P - value
Operation time(min)	55.1±57.6	60.0± 44.4	0.756
Blood loss(ml)	120.3± 82.9	110.6± 69.6	0.471
VAS back score			
Preoperation	6.4± 3.5	6.5 ± 3.3	0.33
Postoperation	2.2± 1.4	2.2 ± 1.2	0.47
Final follow up	2.1 ± 1.6	2.2 ± 1.4	0.83
p value (pre-final)	<0.001	<0.001	

Figures

Figure 1

(A) Sagittal index (SI) was calculated by the ratio of the heights of the anterior and posterior vertebral wall. (B) Regional kyphosis angle (RKA) was measured on lateral radiographs using the Cobb method. RKA between the superior endplate of the vertebra above the fractured vertebra and the inferior endplate of the vertebra below the fractured vertebra were measured.

Figure 2

Spinal canal encroachment and clearance were calculated (A) before to (B) after surgery on CT scans. The percentage of canal compromise was calculated with the narrowest mid-sagittal diameter of the injured level divided by the mean of the mid-sagittal diameters of adjacent upper and lower vertebra.

Figure 3

(A) 58-year-old male patient with L1 burst fracture was treated by mono-axial pedicle screw fixation. (B) Postoperative and (C) Final follow- up imaging show a good correction and no correction loss.

Figure 4

(A) 45-year-old male patient with L1 burst fracture was treated by poly-axial pedicle screw fixation. (B) Postoperative imaging showed a mild correction of anterior body height and kyphosis. (C) Final follow-up imaging showed correction loss.