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Open Muscle-Preserving Pedicle Screw Fixation Versus Conventional Open Posterior Approach in Thoracolumbar Burst Fracture without Neurologic Injury: A Prospective Cohort Study

Urawit Piyapromdee, MD [1], Chanthong Budsayavilaimas, MD [2], Kongtush Choovongkomol, MD [1], Terdpong Tanaviriyachai, MD [1], Weera Sudprasert, MD [1]

[1] *Department of Orthopedic Surgery, Maharat Nakhon Ratchasima Hospital, Nakhon Ratchasima, Thailand*
[2] *Department of Orthopedic Surgery, Banphaeo General Hospital, Samut Sakhon, Thailand*

Purpose: Patients with thoracolumbar spine fractures without neurological deficits often require surgical treatment. Conventional open posterior approach has some disadvantages, including postoperative pain, blood loss, and increased operating time. Minimally invasive approach for open muscle-preserving pedicle screw fixation was proposed to be more beneficial than the conventional approach. This study compared the clinical and perioperative outcomes of thoracolumbar burst fracture fixation using open muscle-preserving and conventional open posterior approaches.

Methods: We performed a prospective cohort study of the open muscle-preserving pedicle screw fixation approach from June 2016 to June 2017 and compared with a historical control of the conventional open posterior approach from May 2015 to May 2016. Postoperative pain score, blood loss, duration of surgery, and clinical outcomes were analyzed.

Results: This study included 23 patients in the muscle-preserving approach group and 27 patients treated with the conventional open posterior approach in a control group. Postoperative visual analog scores were significantly better in the muscle-preserving group (P<0.001). The mean operating time was significantly shorter in the muscle-preserving group (60.4 ± 17.3 vs. 90.9 ± 18.9 min, P<0.001). Moreover, the mean intraoperative blood loss in the muscle-preserving group was also significantly lower (156.96 ± 96.3 vs. 269.26 ± 147.6 mL, P=0.003).

Conclusions: Our results indicate superiority of the open muscle-preserving approach over the conventional open posterior approach for thoracolumbar burst fractures without neurologic injury in terms of postoperative pain score, blood loss, and duration of operation. Therefore, open muscle-preserving approach is an alternative treatment option for thoracolumbar burst fractures.

Keywords: burst fracture, spine surgery, minimally invasive surgery, pedicle screw

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Correspondence to: Urawit Piyapromdee, MD
Department of Orthopedic Surgery, Maharat Nakhon Ratchasima Hospital, Nakhon Ratchasima, Thailand
E-mail: urawit.kr@cpird.in.th, urawit@gmail.com

The thoracolumbar spine is the most common site of spinal damage fracture[1,2]. The rib-bearing thoracic spine and more mobile lumbar spine join at the thoracolumbar junction, causing significant force in this area during injury and motion. Pain, deformity, loss of mobility, and neurological damage are among the complications of ineffective treatments[3-5]. Current treatment

philosophies emphasize avoiding additional neurological damage, achieving sufficient spinal stability and fusion, reestablishing sagittal balance, establishing early rehabilitation, and reintroducing patients to work[6].

Surgical treatment with conventional open posterior spinal instrumentation is suitable for unstable types of injuries because muscle and soft tissue are detached during surgery, possibly causing paraspinal muscle dysfunction and chronic pain[7-9]. Percutaneous pedicle screw fixation is a less invasive technique for thoracolumbar fracture stabilization that results in less perioperative bleeding, lower infection risk, less postoperative discomfort, and shorter duration of hospital stay[10-12]. However, this method includes the use of a cannulated pedicle screw, specialized equipment, increased exposure to radiation, and a steep learning curve[13,14].

The muscle-preserving approach developed by Wiltse[15] splits the paraspinal muscle approach to spinal decompression or fixation[16,17]. This approach can also treat thoracolumbar fractures; however, only few studies have reported clinical outcomes for this approach in comparison with the outcomes for the conventional open approach[18-20].

Therefore, this study aimed to compare the clinical and perioperative results of the open muscle-preserving technique with those of the conventional open posterior approach in thoracolumbar burst fractures without neurological deficits.

METHODS

This study was approved by the Institutional Review Board (number 082/2016). We performed a prospective cohort study of the open muscle-preserving pedicle screw fixation approach from June 2016 to June 2017 and compared with the historical control of the conventional open posterior approach data from May 2015 to May 2016. We evaluated the postoperative pain score, blood loss, operation time, bone reduction quality, and back pain score at the follow-up. Patients aged 18–60 years with acute thoracolumbar burst fractures without neurological deficits were included in the study. The Thoraco-Lumbar Injury Classification and Severity Score (TLICS ≥ 4), indicated surgery. Exclusion criteria were congenital deformity, osteoporotic vertebral fractures, traumatic spondylolisthesis, reluctance or unwillingness, and comorbidities precluding spinal surgery. All the patients underwent comprehensive clinical examination, preoperative supine anteroposterior and lateral radiographs, and computed tomography scans. After obtaining written informed consent, carrying out necessary investigations, and preoperative evaluations, the patients underwent surgery.

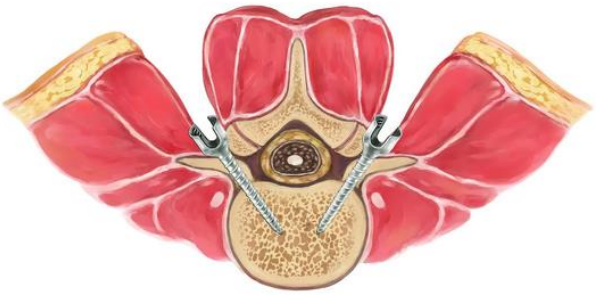

Fig. 1. Cross-sectional anatomy of muscle-preserving approach pedicle screw fixation.

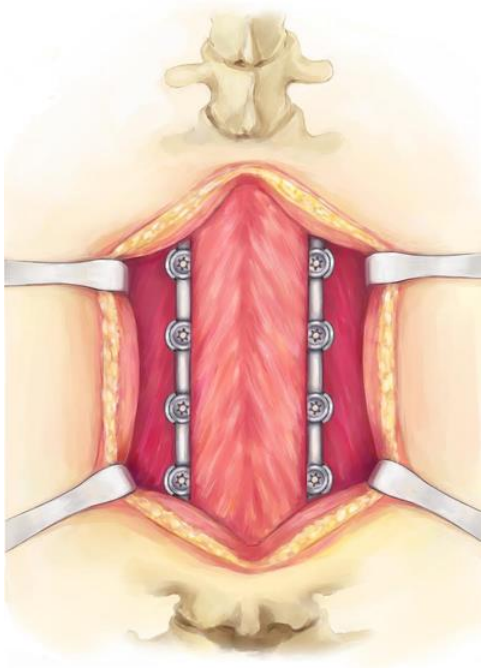

Fig. 2. Muscle-preserving approach with single posterior midline incision.

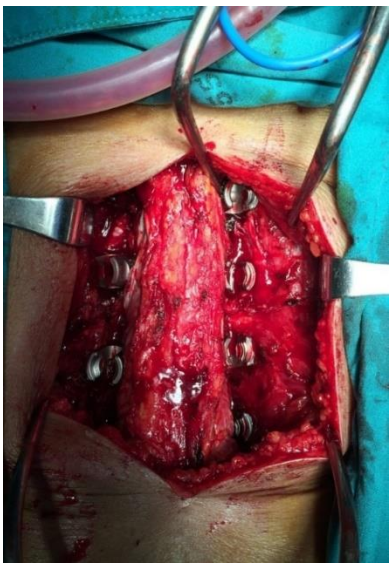

Fig. 3. Intra-operative view of Muscle-preserving approach with single posterior midline incision.

In the muscle-preserving approach group, patients were anesthetized under general anesthesia in a prone position. A single posterior midline incision was made over an appropriate spinal segment. The thoracolumbar fascia was opened, multifidus and longissimus muscles were divided (Fig. 1-3), and lateral regions of the facet joints and transverse processes were revealed. The pedicle screw was inserted at the entry point, which was determined after identifying the intersection of the middle portion of the facet joint and superior border of the transverse process. Screw position was confirmed using fluoroscopy in AP and lateral views. The pre-bent rods were placed over the injured segment using distraction force. Two subfascial drains were placed between the muscles, and the fascia was closed with absorbable sutures. The incision for the screw and rod placement was irrigated and closed.

In the conventional open posterior approach, body positioning, anesthesia, and pedicle screw placement were performed in the same manner as in patients who received the muscle-preserving approach. The paraspinal muscles were detached from the midline using a subperiosteal technique. The wound was then closed using the same technique as that used for the muscle-preserving approach.

The muscle-preserving approach was performed by the first author (U.P.). The conventional open posterior approach was used by the authors (U.P. and W.S.). The same standard pedicle screw system was applied to all patients with no objective arthrodesis (GSS; GS Medical Co., Ltd., Geumcheon-gu, Seoul, Korea). No further bone grafts were used during the surgery. Similar postoperative regimen was used for both groups, including rehabilitation and pain management. Perioperative parameters were documented (surgical time, intraoperative blood loss, drainage volume, and length of hospital stay). Preoperative and postoperative days 1, 2, and 3 were evaluated using the hematocrit levels. Visual analog scores (VAS) were assessed preoperatively, on postoperative days 1 and 2, and before discharge. Complications (screw malposition, infection, and neurological injury) were identified. Thoracolumbar radiographs were assessed preoperatively, postoperatively, and at each follow-up visit. Bone reduction quality was evaluated using the Cobb's angle[21].

We conducted a power analysis to calculate the sample size necessary to detect a significant postoperative VAS score before discharge with a type I error probability of 5% and a 90% probability of avoiding a type II error. The mean of the control group in comparable studies[20] was 2.3 [standard deviation (SD) = 1.5], whereas the mean of the intervention group was 1.0 (SD = 0.8). We used the Power Analysis and Sample Size program to conduct two independent sample t-tests and obtained 18 results in each group. We suggested that each group should enroll at least 22 people to account for a dropout rate of 20 %.

In a case of continuous data with a normal distribution, the mean and SD were provided, while the median and interquartile range were reported for non-normally distributed data. The percentage was reported for categorical data. Statistical analysis was performed using a computer program (STATA version 12.0, College Station, TX.). Suitable statistical procedures were conducted to analyze the differences between groups at a significance level of 0.05.

RESULTS

Twenty-three patients were enrolled in a muscle-preserving approach group and 27 patients treated with the conventional open posterior approach were included in a control group. Patient demographic data are shown in (Table 1).

All patients were fixed using eight pedicle screws. There were significant differences in the operating time (P<0.001), intraoperative blood loss (P=0.003), postoperative drainage volume (P< 0.001), and postoperative length of hospital stay (P=0.03) between the two groups (Table 2).

Table 1 Patients demographic data.

Demographic data	Open muscle-preserving approach (n=23)	Conventional open posterior approach (n=27)	p value
Sex			0.52
Female	9 (39.1%)	13 (48.2%)	
Male	14 (60.9%)	14 (51.8%)	
Median age (IQR)	52 (46-57)	52 (40-58)	0.75
Mean body weight (SD)	57.7 (10.2)	59.6 (9.2)	0.50
Mean height (SD)	161.9 (9.6)	163.7 (6.0)	0.42
Mean BMI (SD)	21.9 (2.2)	22.2 (3.2)	0.69
Median VAS pre-op (IQR)	6 (4-7)	5 (4-6)	0.34
Cause			0.75
Fall from height	15 (65.2%)	18 (66.7%)	
Road traffic accident	6 (26.1%)	8 (29.6%)	
Direct injury	2 (8.7%)	1 (3.7%)	
Level of the fracture			0.7
T12	4 (17.4%)	3 (11.1%)	
L1	10 (43.5%)	12 (44.5%)	
L2	4 (17.4%)	6 (22.2%)	
L3	2 (8.7%)	3 (11.1%)	
T11, T12	1 (4.3%)	0	
T12, L1	1 (4.3%)	1 (3.7%)	
L1, L2	1 (4.3%)	0	
T12, L2	0	2 (7.4%)	
AO type			0.83
A3	16 (69.57%)	18 (66.67%)	
A4	7 (30.43%)	9 (33.33%)	
TLICS			0.07
4	3 (13.0%)	0	
5	20 (87.0%)	25 (92.6%)	
7	0	2 (7.4%)	
Median follow up time (Months) (IQR)	12 (6-24)	28 (9-36)	*0.03
Mean Pre-op Hematocrit level (SD)	37.63 (3.3)	35.6 (4.6)	0.15

IQR: Inter quartile range, BMI: Body mass index

Table 2 Surgical outcomes.

Surgical outcomes	Open muscle-preserving approach (n=23)	Conventional open posterior approach (n=27)	p value
Mean operative time (minute)	60.4 ± 17.3	90.9 ± 18.9	<0.001*
Mean intra-operative blood loss (ml)	156.96 ± 96.3	269.26 ± 147.6	0.003*
Mean total drainage volume (ml)	250.65 ± 96.2	457.4 ± 40.7	<0.001*

*Statistically significant difference

The preoperative VAS scores of the two groups showed no significant differences (P=0.34). A comparison of the VAS scores between the two groups is shown in (Fig. 4). The postoperative VAS score was significantly better in the muscle-preserving surgery group (P<0.001). The median VAS score before discharge in the muscle-preserving group was significantly lower than that in the control group (1 vs. 5, P<0.001).

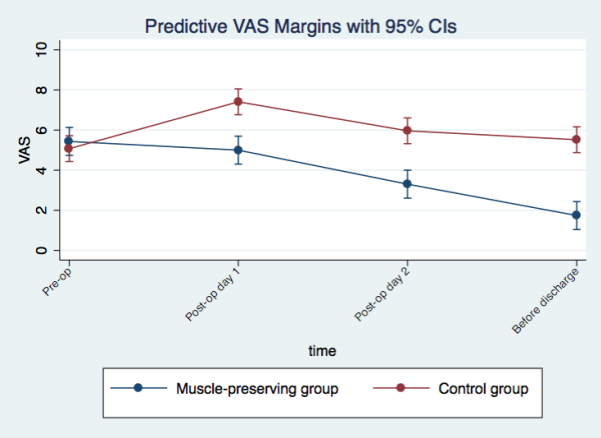

Fig. 4. The comparison of VAS between two groups.

No complications occurred in either of the groups. Four (17.4%) patients in the muscle-preserving group and 10 (37 %) patients in the control group required blood transfusions, but the difference was not statistically significant (P=0.12).

For radiological outcomes, the mean Cobb correction was not significantly different between the two groups, (14.7 ± 8.8° vs.12.8 ± 6.3°, P=0.30). In the muscle-preserving approach group, the median follow-up time was 12 months (IQR 6-24). At the last follow-up visit, the mean Cobb loss was 2.86 ± 3.1°, and 16 (69.6%) patients refused implant removal. Five (23.8%) patients reported mild back pain with a median VAS score of 2.

DISCUSSION

The goals of a thoracolumbar burst fracture without neurological injury treatment are to stabilize the injured spinal segment, promote vertebral healing, restore good sagittal alignment, and minimize short- and long-term complications[22]. The use of pedicle screws as a therapy for these patients has proven to be successful and beneficial, and internal rigid fixation with increased alignment correction and prevention of progressive deformity has been shown to improve treatment outcomes[23-27]. The conventional posterior approach is the most commonly used technique for pedicle screw placement, although it results in paraspinal muscle damage through direct trauma and denervation[9,18,29], which may result in long-term recurrence of low back pain[30].

Minimally invasive surgery is a treatment option for the treatment of these patients. Wiltse' s approach preserves the paraspinal muscle by blunt dissection between the multifidus and longissimus muscles, without disturbing the supraspinal and interspinal ligaments. Furthermore, this technique does not require the use of specialized tools, such as cannulated pedicle screws.

Junhui et al.[18] investigated histological and electrophysiological changes in the multifidus following short-segment pedicle fixation for thoracolumbar fractures, and they found a lower incidence of multifidus atrophy and denervation as well as less fatty infiltration, when compared with the Wiltse's approach.

The present study showed a significantly lower VAS pain score in the muscle-preserving group, which was also reported in the literature[19,20,31]. Furthermore, the operative time and intraoperative blood loss were significantly better than those of the conventional open approach, without complications. On the other hand, the radiological outcomes of both techniques did not demonstrate a statistically significant difference in the results, as demonstrated by the example cases in Fig. 5 and 6.

Our study had some limitations. This was a prospective cohort study with a historical control design, limited sample size, and different follow-up times. The study focused on the perioperative outcomes and no follow-up outcomes in the conventional group. Further study designs are required to confirm this.

However, the findings of this study are therapeutically relevant. The muscle-preserving method is a successful and advantageous treatment for thoracolumbar fractures without neurological

damage because it results in a lower postoperative pain score and less blood loss with a shorter operation length. It is a noninvasive alternative surgery for thoracolumbar fractures without neurological deficits that is safe, does not require specific tools, and is a simple technique to learn.

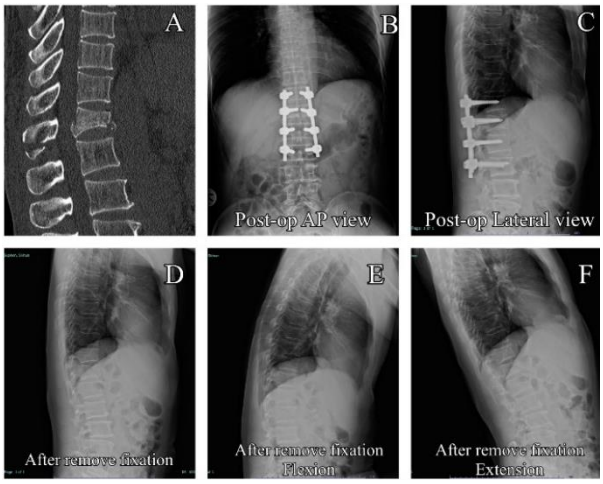

Fig. 5. Example case I: Male 52 years old with fracture L1 that treat with muscle-preserving approach.

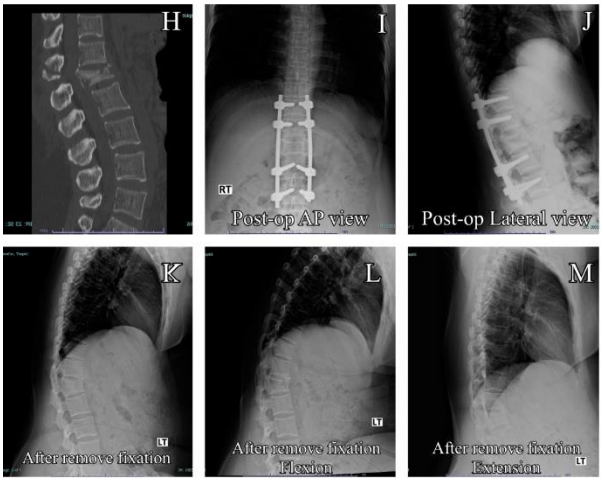

Fig. 6. Example case II: female 36 years old with fracture L1 that treat with conventional approach.

CONCLUSION

In patients with thoracolumbar burst fractures who do not have neurological damage, the open muscle-preserving technique is a reasonable alternative treatment option that can reduce postoperative pain ratings, reduce blood loss, and shorten the duration of time consumed in surgery.

REFERENCES

1. Foley KT, Gupta SK, Justis JR, et al. Percutaneous pedicle screw fixation of the lumbar spine. Neurosurg Focus 2001;10:E10.
2. Holmes JF, Miller PQ, Panacek EA, et al. Epidemiology of thoracolumbar spine injury in blunt trauma. Acad Emerg Med 2001;8:866-72.
3. Gertzbein SD. Scoliosis Research Society. Multicenter spine fracture study. Spine (Phila Pa 1976) 1992;17:528-40.
4. Diaz JJ, Jr., Cullinane DC, Altman DT, et al. Practice management guidelines for the screening of thoracolumbar spine fracture. J Trauma 2007;63:709-18.
5. Denis F. The three column spine and its significance in the classification of acute thoracolumbar spinal injuries. Spine (Phila Pa 1976) 1983;8:817-31.
6. Cahueque M, Cobar A, Zuniga C, et al. Management of burst fractures in the thoracolumbar spine. J Orthop 2016;13:278-81.
7. Kawaguchi Y, Yabuki S, Styf J, et al. Back muscle injury after posterior lumbar spine surgery. Topographic evaluation of intramuscular pressure and blood flow in the porcine back muscle during surgery. Spine (Phila Pa 1976) 1996;21:2683-8.
8. Kawaguchi Y, Matsui H, Tsuji H. Back muscle injury after posterior lumbar spine surgery. A histologic and enzymatic analysis. Spine (Phila Pa 1976) 1996;21:941-4.
9. Sihvonen T, Herno A, Paljarvi L, et al. Local denervation atrophy of paraspinal muscles in postoperative failed back syndrome. Spine (Phila Pa 1976) 1993;18: 575-81.
10. Cox JB, Yang M, Jacob RP, et al. Temporary percutaneous pedicle screw fixation for treatment of thoracolumbar injuries in young

adults. J Neurol Surg A Cent Eur Neurosurg 2013;74:7-11.

11. Court C, Vincent C. Percutaneous fixation of thoracolumbar fractures: current concepts. Orthop Traumatol Surg Res 2012;98:900-9.
12. Kim DY, Lee SH, Chung SK, et al. Comparison of multifidus muscle atrophy and trunk extension muscle strength: percutaneous versus open pedicle screw fixation. Spine (Phila Pa 1976) 2005;30:123-9.
13. Garfin SR, Fardon DF. Emerging technologies in spine surgery. Spine J 2002;2:1-4.
14. Rampersaud YR, Foley KT, Shen AC, et al. Radiation exposure to the spine surgeon during fluoroscopically assisted pedicle screw insertion. Spine (Phila Pa 1976) 2000;25:2637-45.
15. Wiltse LL, Bateman JG, Hutchinson RH, et al. The paraspinal sacrospinalis-splitting approach to the lumbar spine. J Bone Joint Surg Am 1968;50:919-26.
16. Ota M, Neo M, Fujibayashi S, et al. Advantages of the paraspinal muscle splitting approach in comparison with conventional midline approach for s1 pedicle screw placement. Spine (Phila Pa 1976) 2010;35:E452-7.
17. Mehren C, Siepe CJ. Neuroforaminal decompression and intra-/extraforaminal discectomy via a paraspinal muscle-splitting approach. Eur Spine J 2016;25Suppl 2:276-7.
18. Junhui L, Zhengbao P, Wenbin X, et al. Comparison of pedicle fixation by the Wiltse approach and the conventional posterior open approach for thoracolumbar fractures, using MRI, histological and electrophysiological analyses of the multifidus muscle. Eur Spine J 2017;26:1506-14.
19. Meng X, Zeng K, Turghunjan A, et al. [Effectiveness of pedicle screw fixation combined with non-fusion technology for treatment of thoracolumbar fracture through Wiltse paraspinal approach]. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi 2014;28:1106-9.
20. Li H, Yang L, Xie H, et al. Surgical outcomes of mini-open Wiltse approach and conventional open approach in patients with single-segment thoracolumbar fractures without neurologic injury. J Biomed Res 2015;29:76-82.
21. Kuklo TR, Polly DW, Owens BD, et al. Measurement of thoracic and lumbar fracture kyphosis: evaluation of intraobserver, interobserver, and technique variability. Spine (Phila Pa 1976) 2001;26:61-5; discussion 6.
22. Phan K, Rao PJ, Mobbs RJ. Percutaneous versus open pedicle screw fixation for treatment of thoracolumbar fractures: Systematic review and meta-analysis of comparative studies. Clin Neurol Neurosurg 2015;135:85-92.
23. Korovessis P, Repantis T, Petsinis G, et al. Direct reduction of thoracolumbar burst fractures by means of balloon kyphoplasty with calcium phosphate and stabilization with pedicle-screw instrumentation and fusion. Spine (Phila Pa 1976) 2008;33:E100-8.
24. Zou DW. [Treatment of unstable fractures of thoracolumbar spine with neurologic injury using a reduction fixation spinal pedicle screws system]. Zhonghua Wai Ke Za Zhi 1992;30:722-5,78.
25. Carl AL, Tromanhauser SG, Roger DJ. Pedicle screw instrumentation for thoracolumbar burst fractures and fracture-dislocations. Spine (Phila Pa 1976) 1992;17(8 Suppl):S317-24.
26. Esses SI, Botsford DJ, Wright T, et al. Operative treatment of spinal fractures with the AO internal fixator. Spine (Phila Pa 1976) 1991;16(3 Suppl):S146-50.
27. Sasso RC, Cotler HB, Reuben JD. Posterior fixation of thoracic and lumbar spine fractures using DC plates and pedicle screws. Spine (Phila Pa 1976) 1991;16(3 Suppl):S134-9.
28. Zoidl G, Grifka J, Boluki D, et al. Molecular evidence for local denervation of paraspinal muscles in failed-back surgery/postdiscotomy syndrome. Clin Neuropathol 2003;22:71-7.

29. Kawaguchi Y, Matsui H, Tsuji H. Back muscle injury after posterior lumbar spine surgery. Part 2: Histologic and histochemical analyses in humans. Spine (Phila Pa 1976) 1994;19:2598-602.

30. MacDonald D, Moseley GL, Hodges PW. Why do some patients keep hurting their back? Evidence of ongoing back muscle dysfunction during remission from recurrent back pain. Pain 2009;142:183-8.

31. Fan Y, Zhang J, He X, et al. A comparison of the mini-open wiltse approach with pedicle screw fixation and the percutaneous pedicle screw fixation for neurologically intact thoracolumbar fractures. Med Sci Monit 2017;23:5515-21.