

Original Article

The Wiltse approach plus injured vertebral screw fixation for thoracolumbar fractures

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Abstract: Objective: This study aims to investigate the efficacy of the Wiltse approach plus injured vertebral screw fixation (W-VSF) for thoracolumbar fractures (TCF) without nerve injury. Methods: Forty-eight patients with TCF were retrospectively examined. Half of these patients were treated with W-VSF, and the remaining half were treated with a traditional paraspinal muscle peeling approach plus injured vertebral screw fixation (PMP-VSF). The operative time, intraoperative blood loss, postoperative ambulation time, preoperative and postoperative back pain improvement, and changes in vertebral height were compared between the groups. Results: The operative time, intraoperative blood loss, and postoperative ambulation time exhibited significant ($P < 0.05$) improvements in the W-VSF group compared to those in the PMP-VSF group. There was no significant difference in preoperative visual analog scale (VAS) scores between the groups ($P > 0.05$); however, VAS scores on postoperative days 1 and 3 and weeks 1 and 2 were significantly lower in the W-VSF group ($P < 0.05$). There was no significant difference in VAS scores at month 6 ($P > 0.05$). Vertebral height restoration rates between the groups showed no significant difference ($P > 0.05$). Conclusions: Both methods can obtain good reduction of vertebral fractures. However, W-VSF exhibits shorter operative times, less trauma, and faster postoperative recovery.

Keywords: Wiltse approach, vertebral screw fixation, thoracolumbar fracture, paraspinal approach, visual analogue scale

Introduction

Thoracolumbar fractures (TCF) without nerve injury are common in clinical practice [1, 2], and surgical treatment remains the gold standard, with substantially greater efficacy than nonsurgical treatment. One study has shown that the majority of patients receiving surgical treatment are able to return to work, while 25% of patients receiving nonsurgical treatment are unable to return to work, and 17% develop late nerve damage, as well as persistent low back pain [3]. Therefore, surgery is the mainstay of TCF treatment [4, 5]. Posterior vertebral pedicle screw fixation is the primary surgical treatment for this type of fracture, with less trauma and favorable reduction and fixation of the fractured vertebra [6].

Despite the fact that posteromedial paraspinal muscle peeling is the traditional approach for vertebral screw fixation, extensive stripping

and stretching of the paraspinal muscles is required. The consequence of such extensive manipulation is substantial bleeding, and potentially even paraspinal ischemic necrosis and muscular denervation in severe cases, which are followed by complications such as flat back deformity and intractable low back pain [7-9]. As early as 1968, Wiltse proposed the technique of trans-multifidus and longissimus gap posterolateral lumbar fusion plus pedicle screw fixation without spinal decompression [8]. This trans-paraspinal muscular gap approach did not require peeling of the paraspinal muscles, and had advantages in minimizing trauma and intraoperative blood loss, and improving the speed of postoperative recovery [1].

Among the fixation methods for TCF, trans-injured vertebral short-segment 4-pedicle screw fixation has traditionally been the technique of choice for many surgeons. However,

with increasing clinical use, it was found that this type of fixation had certain shortcomings, such as poor reduction of the fractured vertebrae, height loss of the injured vertebrae after weight-bearing, kyphosis, internal fixation loosening, and screw breakage [10]. Studies showed that trans-injured vertebral short-segment 6-pedicle screw fixation could increase the stability of internal fixation, improve the reduction of the injured vertebrae, correct kyphosis, and significantly reduce vertebral height loss, internal fixation loosening, screw breakage, and other complications [11, 12].

The Wiltse approach minimizes trauma and facilitates rapid postoperative recovery, while trans-injured vertebral short-segment pedicle screw fixation is appealing with respect to strength; therefore, the combination of these methods for treating TCF could enable early ambulation and good reduction of vertebral fractures. In this study, TCF patients treated with the paraspinal muscle peeling approach plus injured vertebral screw fixation (PMP-VSF) were established as a control group, in order to retrospectively study the efficacy of the Wiltse surgical approach, and to provide a reference for clinical application.

Materials and methods

General information

The inclusion criteria were as follows: (1) presence of TCF (T11-L2), (2) traumatic origin, (3) thoracolumbar injury classification and severity score greater than 4, and (4) neurological American Spinal Injury Association classification grade E. The exclusion criteria were: (1) incomplete information or follow-up, (2) pathological vertebral fracture, (3) nerve injury and need for laminectomy for decompression, or (4) inability to tolerate surgery.

Patients treated with the Wiltse approach plus injured vertebral screw fixation (W-VSF) were defined as the experimental group, while those treated with PMP-VSF were defined as the control group. The experimental group included 24 patients, of which 12 were male and 12 were female, with a mean age of 48.1 ± 8.0 years; the control group included 24 patients, of which 19 were male and 5 were female, with a mean age of 46.7 ± 13.1 years. This study was conducted in accordance with the Declaration of

Helsinki, and with approval from the Ethics Committee of Soochow University. Written informed consent was obtained from all participants. Causes of injury in the experimental group included traffic accidents in 2, falls from a height in 7, simple falls in 5, and being struck by a heavy weight in 2. The causes of injury in the control group included traffic accidents in 3, falls from a height in 11, simple falls in 9, and being struck by a heavy weight in 1. When classifying fractures according to the Denis method, the experimental group included 9 simple compression fractures and 15 burst fractures, while the control group included 10 simple compression fractures and 14 burst fractures. Injury sites in the experimental group were the T11 in 2, T12 in 4, L1 in 14, and L2 in 4, while those in the control group were T11 in 1, T12 in 3, L1 in 14, and L2 in 6.

Surgical methods

Under general anesthesia, the patient was placed in the prone position, with radiographic positioning and marking of the fractured vertebral pedicle. A 10-12 cm median incision was made with the marking at the center, followed by incision of the skin and subcutaneous tissues in turn. In the experimental group, a 1.5-2 cm incision was made along both sides of the spinous process, the lumbodorsal fascia was excised, the gap between the multifidus and longissimus was isolated, the facet joints and transverse processes were identified, and the protruding elements were slightly peeled using an electric knife. Subsequently, a cortical bone opening was made at the thoracic transverse root and the vertex of the lumbar "A" crest, guided by palpation; the positioning pin was inserted, and 6 screws were implanted for fixation when a satisfactory position was obtained. The control group underwent a traditional midline approach, as follows: the skin was incised, subcutaneous tissue and lumbodorsal fascia were excised, the supraspinal ligament was preserved, the paraspinal muscles were peeled along both sides of the spinous process and from the posterior aspect of the thoracolumbar vertebra, both sides of the lamina and articular process were exposed, and 6 screws were placed for fixation.

The reduction and fixation methods were the same in both groups: uniaxial pedicle screws were driven into the upper and lower normal

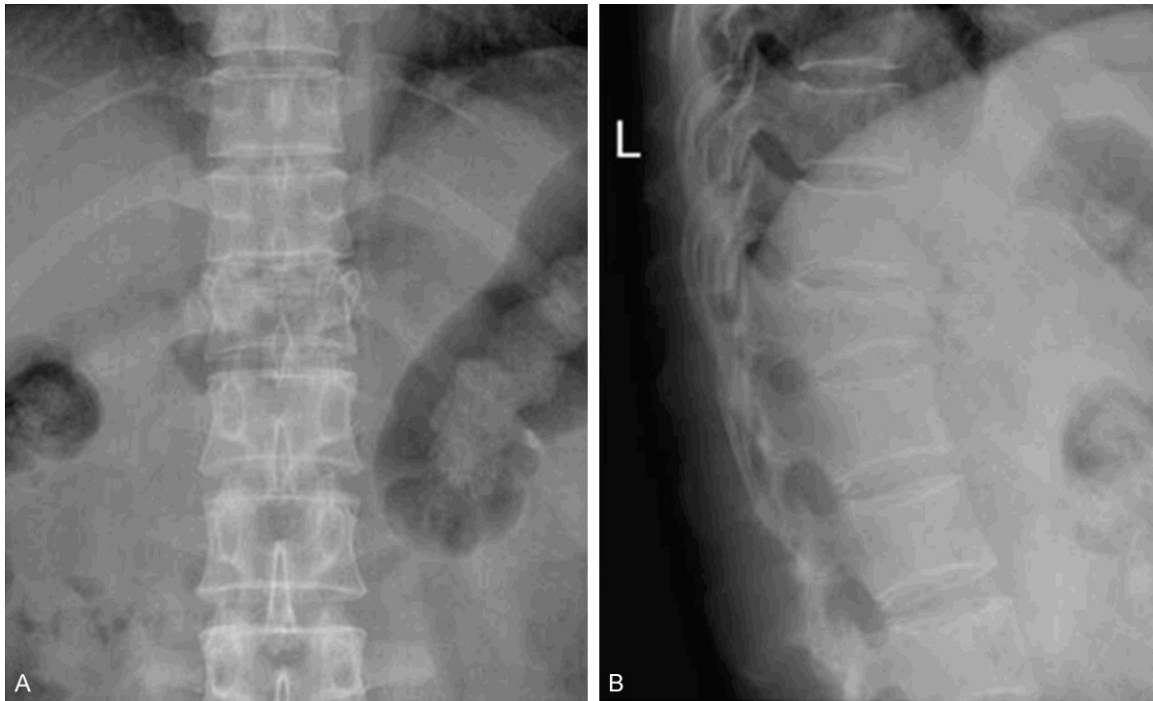


Figure 1. Male, 50 years old, admitted for falling down caused back pain for 1 d, diagnosed as T12 vertebral fracture. Preoperative normal and lateral X-ray, displaying T12 vertebral fracture.

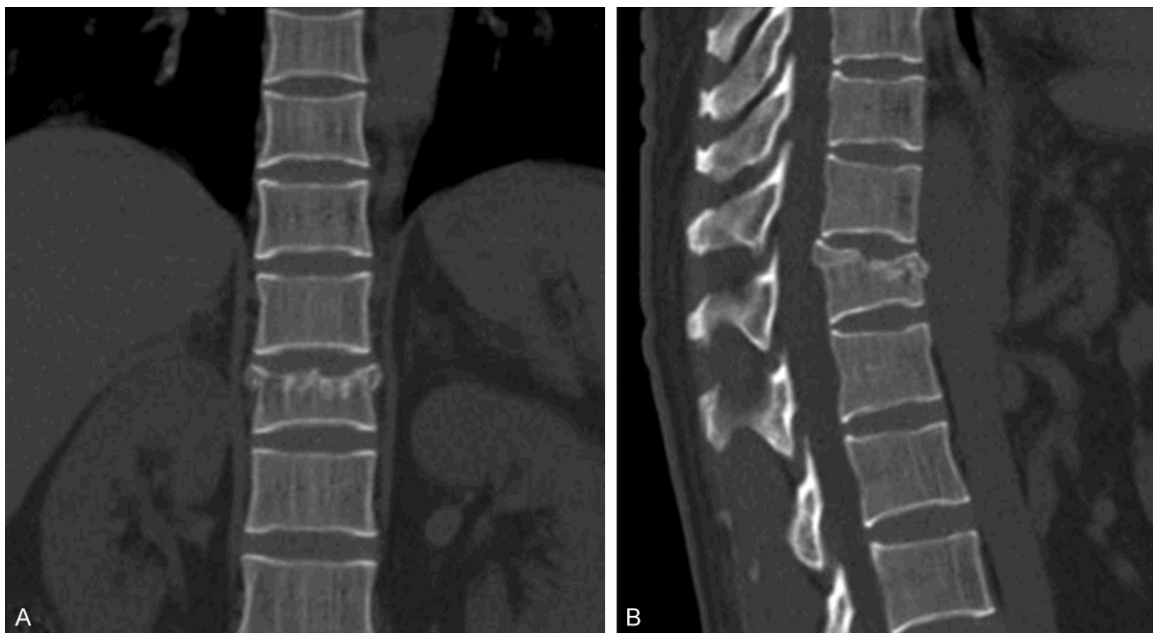


Figure 2. Male, 50 years old, admitted for falling down caused back pain for 1 d, diagnosed as T12 vertebral fracture. Preoperative CT coronal and sagittal reconstruction, displaying T12 vertebral fracture.

vertebrae (Changzhou Kanghui Medical Innovation Co., Changzhou, China), and universal pedicle screws were driven into the fractured vertebra (Changzhou Kanghui), with a shorter

screw selected. Subsequently, the pre-bent connecting rod was implanted and the pedicle screws were tightened; first, tightening was performed at the injured vertebra, followed by

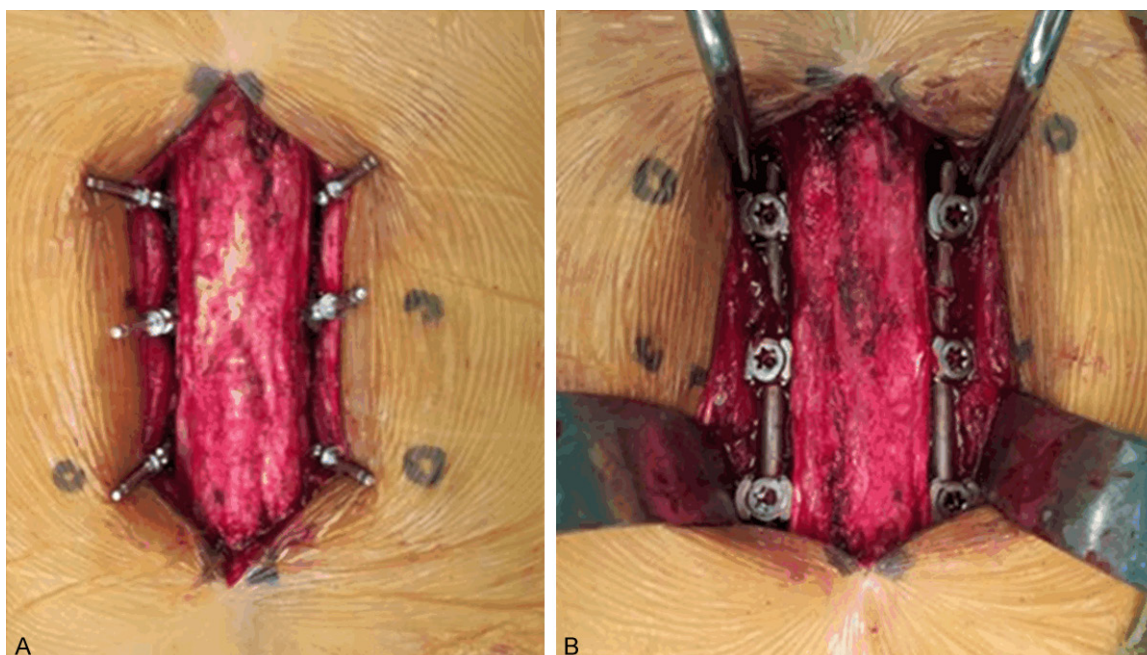


Figure 3. Male, 50 years old, admitted for falling down caused back pain for 1 d, diagnosed as T12 vertebral fracture. Intraoperative implantation of positioning pin and screws via Wiltse approach, no significant bleeding appeared.

tightening at the lower normal vertebra, and then by tightening at the upper normal vertebra. Using this technique ensures that the fractured vertebra can be pressed forward by vertical stress, to correct kyphosis and to reduce the height of the injured vertebra. Radiography was performed for intraoperative assessment; for example, if the restoration of median column height was poor, moderate distraction was performed between the fractured and normal vertebrae.

Postoperative treatments

Both groups received routine prophylactic antibiotics for 2 days. The experimental group ambulated with a thoracolumbar brace 3-5 days later, and the control group ambulated with a thoracolumbar brace 1-2 weeks later.

Efficacy evaluation

The operative time, intraoperative blood loss, postoperative ambulation time, preoperative and postoperative (at days 1 and 3, weeks 1 and 2, and month 6) back pain improvement, and changes of vertebral height at different time points were compared between groups. Incisional complications, internal fixation loosening, and breakage were also recorded.

The intraoperative bleeding volume was determined using the following equation: intraoperative bleeding volume = $\frac{[(\text{preoperative hemoglobin} - \text{postoperative hemoglobin}) / \text{preoperative hemoglobin}] \times 100\%}{\text{preoperative hemoglobin}}$. The visual analogue scale (VAS) was used to evaluate back pain; VAS scores ranged from 0 to 10 points, with 0 points taken to indicate a complete lack of pain, while 10 points indicated unbearable pain. The anterior injured vertebral height was determined using the following equation: anterior injured vertebral height = $\frac{(\text{anterior injured vertebral height} / \text{mean of upper and lower anterior vertebral heights}) \times 100\%}{\text{mean of upper and lower anterior vertebral heights}}$.

Statistical analysis

Statistical analysis was performed using SPSS 17.0 statistical software (SPSS Inc., Chicago, Ill., USA). Categorical variables were analyzed using the chi-square test, and continuous data were analyzed using t-tests. *P*-values < 0.05 were considered statistically significant.

Results

Surgical outcomes

The operative time, intraoperative blood loss, and postoperative ambulation time of the

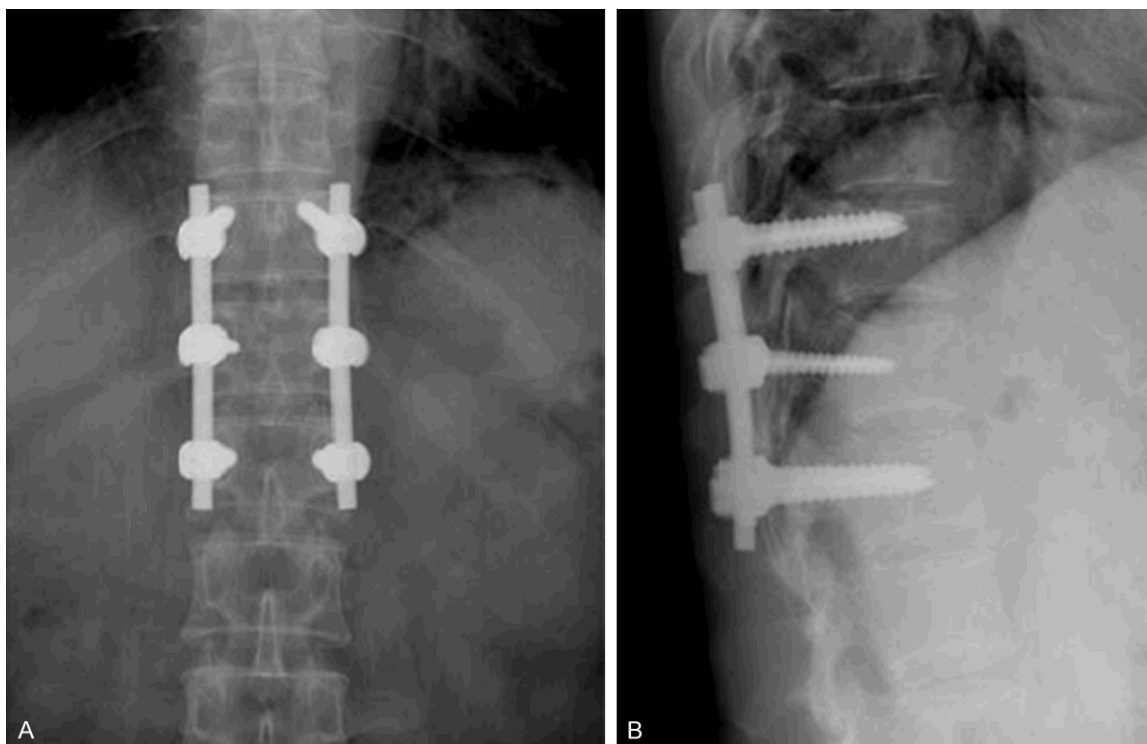


Figure 4. Male, 50 years old, admitted for falling down caused back pain for 1 d, diagnosed as T12 vertebral fracture. Postoperative normal and lateral X-ray, displaying satisfactory restoration of vertebral height, and the spinal alignment was normal.

experimental group were 56.5 ± 10.6 min, $10.6 \pm 5.0\%$, and 3.4 ± 1.5 days, respectively; all such values differed significantly from those in the control group (74.5 ± 15.6 min, $17.1 \pm 7.5\%$, and 6.4 ± 5.5 days, respectively; $P < 0.05$). Follow-up durations of the experimental group and the control group were 12.1 ± 6.5 months and 13.1 ± 4.7 months, respectively. Neither group exhibited any cases of wound complication, screw loosening, or breakage.

Imaging evaluation

The anterior injured vertebral height of the experimental group was restored from $43.3 \pm 6.8\%$ (mean value before surgery) to $98.1 \pm 4.0\%$ (mean value before postoperative ambulation) ($P < 0.01$). At follow-up, the vertebral height in the experimental group was $97.7 \pm 3.9\%$, with no significant difference to that observed prior to postoperative ambulation ($P > 0.05$). Similarly, the anterior injured vertebral height of the control group was restored from $47.3 \pm 5.8\%$ (mean value before surgery) to $97.9 \pm 3.8\%$ (mean value before postoperative ambulation) ($P < 0.01$). At follow-up, the verte-

bral height in the control group was $97.9 \pm 4.6\%$, with no significant difference to that observed prior to postoperative ambulation ($P > 0.05$). Vertebral height restoration rates between the groups prior to postoperative ambulation and at follow-up showed no significant differences. The values for typical cases are shown in **Figures 1-5**.

Clinical efficacy assessment

The VAS scores of the experimental group before surgery, and on postoperative days 1 and 3, weeks 1 and 2, and at month 6 were 6.2 ± 2.7 , 2.5 ± 3.1 , 1.7 ± 2.1 , 0.6 ± 0.4 , and 0.0 ± 0.0 , respectively, while those of the control group were 6.1 ± 2.9 , 5.8 ± 4.1 , 4.7 ± 3.1 , 2.6 ± 0.7 , and 0.5 ± 0.3 , respectively. There was no significant difference between the groups before surgery ($P > 0.05$); however, VAS scores from the experimental group were significantly lower than those from the control group on postoperative days 1 and 3 and weeks 1 and 2 ($P < 0.05$). No significant difference was noted at postoperative month 6 ($P > 0.05$).

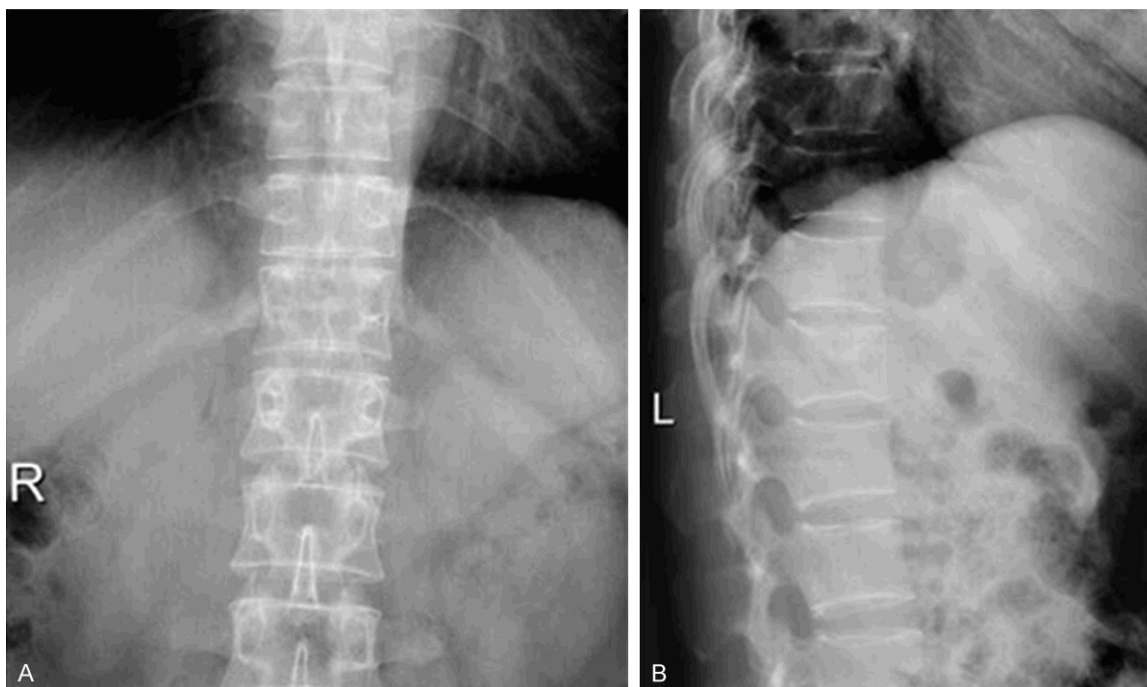


Figure 5. Male, 50 years old, admitted for falling down caused back pain for 1 d, diagnosed as T12 vertebral fracture. Removed the internal fixation on postoperative Month 12, and reviewed normal and lateral X-ray 3 months later, displaying no obvious collapse of vertebral height, and the spinal alignment was normal.

Discussion

Surgical approach

The traditional posteromedial approach to treating TCF has a number of shortcomings. This approach requires complete separation of the paraspinal muscles from the spinous processes and their attachment points on the lamina, and continuous stretching of the paraspinal muscles to reveal the location for insertion of the pedicle screws and internal fixation. This extensive muscle stripping could easily damage the posteromedial branches of the spinal nerves and the descending posterior lumbar artery branches. Indeed, such damage, when accompanied by postoperative muscle and soft tissue edema, could result in denervation atrophy and ischemic necrotic atrophy of the paraspinal muscles. Despite the fact that healing would eventually occur with the lamina via scar tissue formation, this would damage dynamically stable structures of the spine, affect the strength of the trunk muscles, and may result in postoperative flat back deformity and intractable pain [8, 9].

Conversely, the Wiltse approach to treating TCF has advantages. Gaps exist between the mul-

tifidus paraspinal muscles and adjacent muscles, and blunt dissection of muscle bundles through these gaps and splitting of surfaces has the potential to reduce damage to the paraspinal muscles. Wiltse et al. [8] used these gaps to reach the facet processes and to perform lumbar pedicle screw fixation, the product of which was effective fixation with less trauma than that observed in the traditional approach. This technique has since been named the Wiltse approach, and has been used for the surgical treatment of TCF in a number of studies [1, 13]. In this study, patients treated with the Wiltse approach had significantly better outcomes with respect to postoperative back pain, ambulation time, operative time, and intraoperative bleeding, when compared to those treated with the traditional surgical approach. This validates the advantages of the Wiltse approach, specifically in minimizing trauma and improving the speed of postoperative recovery. Importantly, the Wiltse approach uses natural gaps between the paraspinal muscles, and primary operative procedures are performed at the avascular interface. Consequently, the Wiltse approach minimizes damage to the blood supply and innervation of the paraspinal muscles, and protects the normal

physiological functions of these muscles; therefore, patients are able to perform postoperative exercise and begin ambulation much earlier, which may aid in shortening hospitalization and reducing postoperative back pain.

The surgical approach and technique required to successfully use the Wiltse technique warrants discussion. Before skin disinfection, we performed routine radiography to determine the position of the injured vertebral pedicle, and marked it on the body surface, such that the incision would not deviate upwards or downwards. When cutting the skin and subcutaneous tissues, the lumbodorsal fascia should be opened 1.5-2 cm away from the midline, and the surgeon should first use a finger to feel for the facet process, before precisely identifying the muscular gaps. After limited separation with forceps, blunt dissection should be performed along the natural muscular interface to the facet processes, taking care that the dissection is not performed intramuscularly to ensure that intraoperative blood loss is minimized. Although this approach reduces the dissection of the paraspinal muscles, it creates a relatively smaller operating space, and the surrounding anatomic landmarks are less obvious than those in the traditional approach. The consequence of these limitations is an increased reliance on screw technology, surgical skill, and experience. When exposing the pedicle screw insertion points, it was believed that this could result in outward angulation; the transverse process could be mistaken for the facet process, thus damaging smaller blood vessels and increasing bleeding. Therefore, exposure should be performed from the inside to the outside of the posterior vertebral pedicle process, which should ensure that smaller blood vessels are not damaged. Furthermore, the Wiltse approach does not expose the lamina and spinous process, resulting in greater difficulty in cases with a large cross-sectional area. Special hardware and transconnecting rod implantation can increase the operative time and damage structures of the posterior column and spinal lamina, resulting in postoperative low back pain; therefore, we selected U-shaped screws, and fixation was performed without a transconnecting rod. Consequently, the surgical approach used was simple, practical, and minimized damage to the structures of the posterior column. To estimate the volume of intraoperative blood loss, the decrease in hemoglo-

bin between preoperative and postoperative measurements was used, the product of which is a result that more accurately reflects perioperative bleeding, has a greater overall accuracy, and is more objective.

Fixation methods for vertebral pedicle screws

As identified in the literature, there are a number of limitations to 4-pedicle screw fixation. The short-segment pedicle screw fixation system for treating TCF has advantages in being able to reduce and fix the injured vertebral spine, and facilitates maximal preservation of the spinal motor functions. Transvertebral 4-pedicle screw fixation has, classically, been the mainstay of vertebral fixation. However, with increased case reporting, it became evident that traditional transvertebral 4-pedicle screw fixation is associated with a number of complications, including screw-rod breakage, screw loosening, height collapse of the injured vertebral spine, and kyphosis [11, 14]. Further studies [15, 16] have shown that 4-pedicle screw fixation can produce suspension and parallelogram effects, and is associated with increased screw-rod stress load. Suspension effects occur because the anterior edges of the superior and inferior adjacent vertebral spines tend to be close, while the median vertebral spine tends to shift backwards, producing kyphosis and increasing the risk of internal fixation failure. Furthermore, a parallelogram effect (i.e. lateral instability) occurs with 4-pedicle fixation, whereby antirotation is limited; consequently, the environment for repair of vertebrae, ligaments, and intervertebral discs is compromised, especially in the context of vertebral fracture and dislocation. Finally, it has been noted that 4-pedicle fixation is associated with a greater longitudinal distance between screws of the upper and lower vertebrae. Increasing longitudinal distance is likely to increase screw-rod stress load, the force from which would be conducted through the pedicle screw internal fixation system, rather than via the vertebrae. Indeed, this redistribution of forces onto the vertebral pedicle screw could easily result in fixation breakage, dislocation, and late reduction loss. Therefore, 4-pedicle fixation is likely to be associated with an increased rate of internal fixation impairment.

Conversely, 6-pedicle fixation addresses and solves many of these concerns. A number of

authors previously advocated trans-injured vertebral pedicle screw internal fixation, and gradually introduced this technique clinically. The result was a significant reduction in the rate of aforementioned complications [11, 15]. Trans-injured vertebral 6-pedicle screw fixation may enable the restoration of 3-column continuity and effectively reduce stress on the anteromedial column, the consequence of which would be an improvement in vertebral stability, reduction in anteromedial column load, and a decrease in the rate of recurrent vertebral collapse [17]. Trans-injured vertebral fixation also shortens the distance between screws, thereby avoiding the overconcentration of stress on the internal fixation device, reducing the stress load on the screw-rod system, and increasing biomechanical stability [18]. Compared with traditional 4-pedicle screw fixation, the anti-torsion, anti-bending, and axial loading capacity characteristics of this fixation system are significantly improved. Consequently, lateral instability is avoided, fixation fracture and loosening are prevented, and interspinous space collapse is prevented [18]. Our data showed that the height of the vertebral body was largely restored, and that no loss of vertebral height, loosening, or fracture of internal fixation was observed between postoperative week 1 and final follow-up. This validates the ability of trans-injured vertebral consecutive fixation to effectively reduce the rates of reduction loss, kyphosis, screw breakage, and other complications.

Some comments are warranted on the implantation of vertebral screws. Not all injured vertebral spines are suitable for pedicle screws. Indeed, we believe that vertebral pedicle screw fixation should only be performed when no fracture is apparent in the injured vertebral spine, or at least when no significant shift is noted when such a fracture is present. Some authors [19] believe that a vertebra with excessive height loss should not undergo pedicle screwing, as the screws may penetrate the vertebral body. However, based on assessments of vertebral disintegration by preoperative computed tomography, pedicle screws with appropriate lengths can be selected, and C-arm fluoroscopy may be used for intraoperative pin guidance. Furthermore, when screws are angled slightly towards the unfractured vertebral body, it is possible to avoid screw penetration.

A number of authors have suggested that vertebral screw length should be consistent with normal vertebral screws, as it was thought that long screws implanted into the injured vertebral body would directly sledge the reduction of fractured vertebrae. However, a long vertebral screw would push the bone block of the anterior column forward, thereby separating and projecting the vertebral body; if the implanted screw is required to have sufficient traction strength, the bones around the screw channel must be intact [20]. Indeed, in fracture reduction, the vertebral screw is the reduction point preventing vertebral kyphosis, and a shorter vertebral screw can facilitate satisfactory reduction of the fractured vertebral body, provided the screw extends at least one-third of the vertebral body [21]. The pedicle screws chosen were shorter than normal vertebral screws to avoid exceeding the fracture line, and the penetration point was angled slightly towards the caudal end to avoid the fractured anteromedial vertebral column. The results of this study have shown that short-segment vertebral screw fixation can not only achieve desired reduction, fixation, and deformity correction, but also avoids fouling the fractured vertebral segments, thus improving the capacity for healing. When treating the injured vertebral spine, a single, universal screw type was used, while a single fixed screw was used for the upper and lower vertebrae. Therefore, our selection may facilitate convenient rod installation, but is unlikely to affect vertebral reduction. When performing reduction, the connecting rod was pre-bent, and the vertebral screws were tightened first, which ensured that the vertebral pedicle was pushed forwards to act as the reduction site, thus preventing vertebral kyphosis. Subsequently, tightening of the screws on the lower and upper vertebrae followed. Because the rod was pre-bent, tightening the screws resulted in “automatic distraction”, such that the damaged anteromedial column would be stretched to correct vertebral kyphosis; when the reduction was unsatisfactory, the cephalic vertebral pedicle screw could be moderately distracted to further restore vertebral height.

Summary

The Wiltse approach enables the opening of muscle gaps without damage to the paraspinal

muscles, retains the integrity of the posterior ligament complex, and significantly reduces surgical trauma and bleeding, when compared with traditional surgery. Consequently, the Wiltse approach is ideal with respect to limiting invasiveness. As the technique did not require special technical equipment, and was relatively easy to master with experience in open screwing, there is potential for wider applicability of this technique in clinical practice. Vertebral pedicle screw fixation facilitates good fracture reduction and firm fixation. This study has shown that the Wiltse approach for treating TCF avoids nerve injury, and could facilitate an earlier return to ambulation after surgery, thereby aiding in the reduction of hospitalization time and postoperative back pain. Limitations of this study included the small number of cases and the use of data from a single center.

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Disclosure of conflict of interest

None.

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