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RESEARCH

Clinical application of a modified wiltse approach in middle and lower thoracic vertebrae: a case-control study of thoracic fracture patients

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Abstract

Background The Wiltse approach has been extensively employed in thoracolumbar surgeries due to its minimal muscle damage. However, in the middle and lower thoracic spine, the conventional Wiltse approach necessitates the severance of the latissimus dorsi and trapezius muscles, potentially leading to muscular injury. Consequently, we propose a modified Wiltse approach for the middle and lower thoracic vertebrae, which may further mitigate muscular damage.

Methods From May 2018 to April 2022, 60 patients with spinal fractures in the middle and lower thoracic vertebrae (T5-12) were enrolled in this study. Thirty patients underwent surgery using the modified Wiltse approach (Group A), while the remaining 30 patients received traditional posterior surgery (Group B). The observation indices included operation time, intraoperative blood loss, incision length, number of C-arm exposures, postoperative drainage, postoperative ambulation time, discharge time, as well as preoperative and postoperative Cobb's angle, percentage of anterior vertebral body height (PAVBH), visual analog scale (VAS) Score, and Oswestry disability index (ODI).

Results Compared to the traditional posterior approach, the modified Wiltse approach demonstrated significant advantages in operation time, intraoperative blood loss, length of incision, postoperative ambulation time, postoperative drainage, and discharge time, as well as postoperative VAS and ODI scores. No significant differences were observed between the two groups in terms of number of C-arm exposures, postoperative Cobb's angle, or postoperative PAVBH.

Conclusion We propose a modification of the Wiltse approach for the middle and lower thoracic vertebral regions, which may further minimize muscular damage and facilitate the recovery of patients who have undergone surgery in the middle and lower thoracic vertebrae.

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Keywords Modified Wiltse approach, Middle and lower thoracic vertebrae, Thoracic fracture, Muscular damage, Postoperative recovery

In 1968, Dr. Wiltse pioneered a novel approach involving the separation of muscles between the multifidus and longissimus, preserving the integrity of the posterior osseous structure and ligamentous complex [1, 2]. This technique enables surgeons to accurately access the intervertebral foramen, transverse process, and other surgical sites while minimizing paravertebral muscle dissection and traction [3, 4]. Compared to the traditional posterior incision, the Wiltse approach reduces complications such as extensive paravertebral muscle stripping, which can lead to postoperative scar formation, muscle denervation, and chronic back pain [5, 6]. Consequently, the Wiltse approach has gained widespread acceptance in thoracolumbar surgery [5, 7, 8].

Although initially developed for lumbar surgery [2], the Wiltse approach has become a standard surgical technique in thoracic procedures [9, 10]. However, the posterior muscular anatomy of the thoracic spine differs from that of the lumbar region. In the middle and lower thoracic spine, the latissimus dorsi and trapezius muscles cover the plane between the spinalis thoracis and longissimus. Employing the conventional Wiltse approach necessitates severing these muscles, potentially resulting in muscular damage and blood loss. The advent of percutaneous pedicle screw fixation (PPSF) provides an alternative for thoracolumbar surgery [11, 12]. Nevertheless, recent studies have demonstrated the superiority of the Wiltse approach with pedicle screw fixation over PPSF in terms of radiation exposure, facet joint violation, vertebral height restoration, kyphosis correction, hidden blood loss, and learning curve for patients with thoracolumbar fractures [9, 13, 14].

Consequently, we sought to modify the Wiltse approach for the middle and lower thoracic spine after carefully examining the posterior approach anatomy and apply this modified Wiltse paraspinal approach to the surgical treatment of middle and lower thoracic vertebral fractures, aiming to further minimize local muscle damage.

Materials and methods

Participants

From May 2018 to April 2022, 60 patients with spinal fractures in the middle and lower thoracic vertebrae (T5-12) were enrolled in this study. Patients were randomly assigned to two groups in a 1:1 ratio using a computer-generated randomization table: the modified Wiltse paraspinal approach group and the traditional posterior surgical group. Before surgery, the surgeon provided patients and their families with a detailed explanation of the advantages and disadvantages of conservative and surgical treatment.

The inclusion criteria were as follows: (1) vertebral fracture in T5-12 confirmed by imaging; (2) fresh fractures with an injury time < 2 weeks; (3) accepted surgical treatment through the modified Wiltse paraspinal approach or traditional posterior approach combined with pedicle screw internal fixation. The exclusion criteria were as follows: (1) pathological fracture caused by tumor or infection; (2) MRI showing obvious spinal cord compression or spinal nerve injury; (3) combined with more severe multiple injuries or other spinal fractures; (4) combined with serious heart, lung, kidney, brain, or other organ diseases; and (5) mental illness precluding cooperation with treatment.

This study was approved by the ethics committee of Weihai Central Hospital of Qingdao University, and all patients provided written informed consent upon admission. Group A consisted of 30 patients who underwent surgery through the modified Wiltse paraspinal approach, while group B underwent pedicle screw fixation through the traditional posterior approach. A single senior surgeon performed the operations for each group separately.

Modified wiltse paraspinal approach surgery

Patients in Group A underwent surgery using the modified Wiltse paraspinal approach under general anesthesia in the prone position. The fracture site was confirmed radiographically, and a posterior midline incision was made. The tendinous portions of the latissimus dorsi and trapezius muscles were incised using an electric knife adjacent to the spinous processes bilaterally. The incised muscles were retracted laterally, exposing the deep erector spinae muscles, which were bluntly separated approximately 2 cm from the midline. The erector spinae, pectoral spinae, thoracic semispinalis, and multifidus muscles were retracted medially to expose the transverse processes (Fig. 1). The point for the pedicle screw insertion was decided according to the superior and inferior border of the transverse process, and the outer edge of the vertebral plat, while the coronal and sagittal angulations were determined as usual. Pedicle screws were inserted into the fractured vertebra and the adjacent vertebrae above and below the fracture level (Fig. 2). Two drains (diameter: 5 mm) were placed on both sides of the incision, and were removed about 1–2 days after surgery.

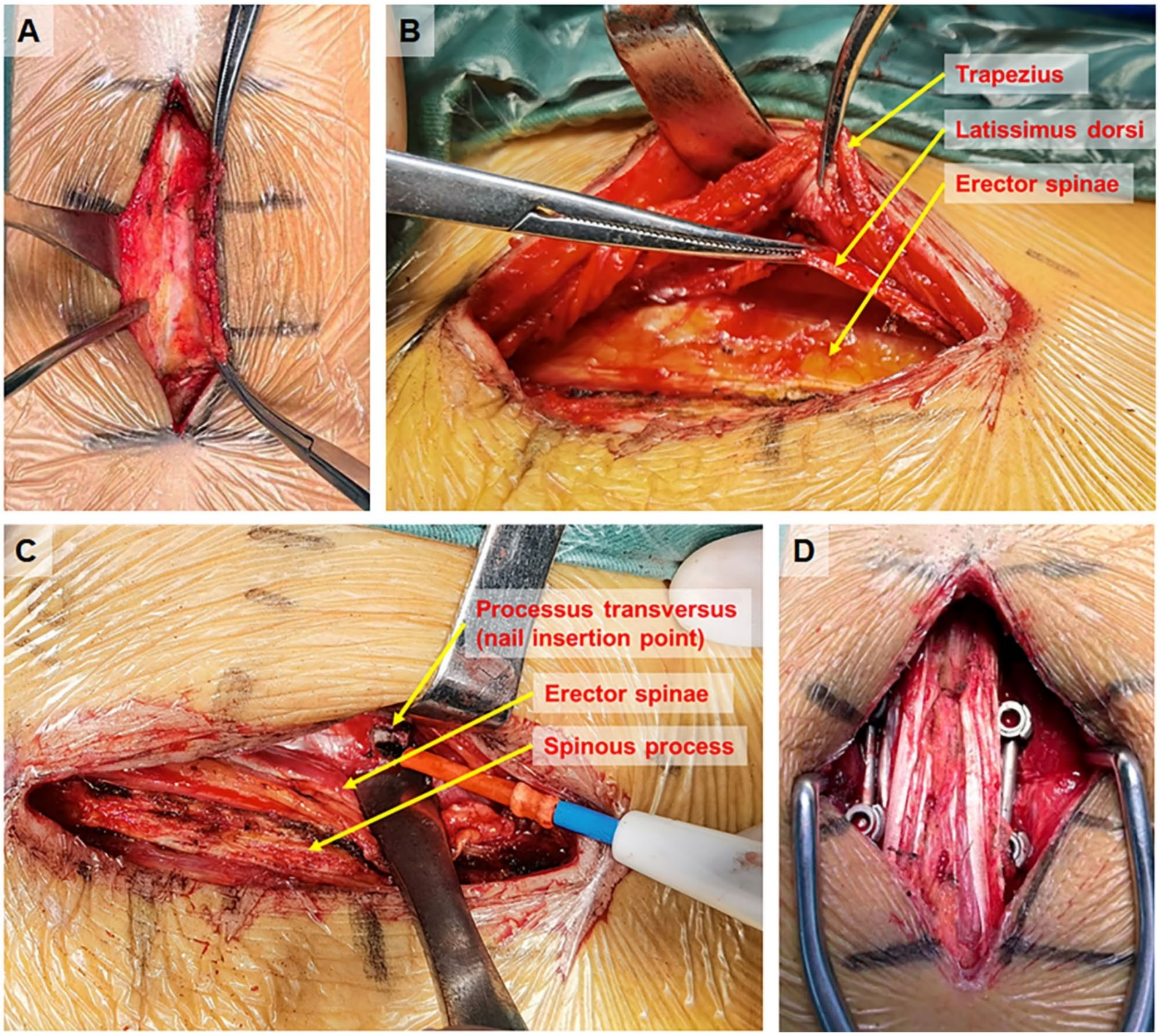

Fig. 1 Detailed illustration of the modified Wiltse approach for the middle and lower thoracic vertebral regions. (**A**) Exposing of trapezius through a posterior midline incision. (**B**) the latissimus dorsi and trapezius muscles were incised adjacent to the spinous processes bilaterally, to expose the deep erector spinae muscles. (**C**) Erector spinae muscles were retracted medially to expose the transverse processes. (**D**) Pedicle screws were then inserted into the vertebrae

Traditional posterior approach surgery

Group B patients were treated using the traditional posterior surgical approach under general anesthesia in the prone position. After radiographic confirmation of the fracture site, a midline incision was made. The paraspinal muscles were elevated bilaterally from the spinous processes to expose the interproximal joints and transverse processes. Pedicle screws were then inserted into the fractured vertebra and the adjacent vertebrae, as determined by the surgeon.

Observation index

Baseline characteristics, including age, sex, body mass index (BMI), number of fractured segments, and fracture location, were recorded to assess group comparability. Perioperative parameters, such as operation time, intraoperative blood loss, incision length, number of intraoperative C-arm exposures, postoperative drainage, time to ambulation, and discharge time, were evaluated to assess surgical trauma and postoperative recovery. The intraoperative blood loss was calculated by measuring the volume in the suction apparatus, and the volume of saline that used to wash the incision intraoperatively was excluded. Cobb's angle, percentage of anterior vertebral

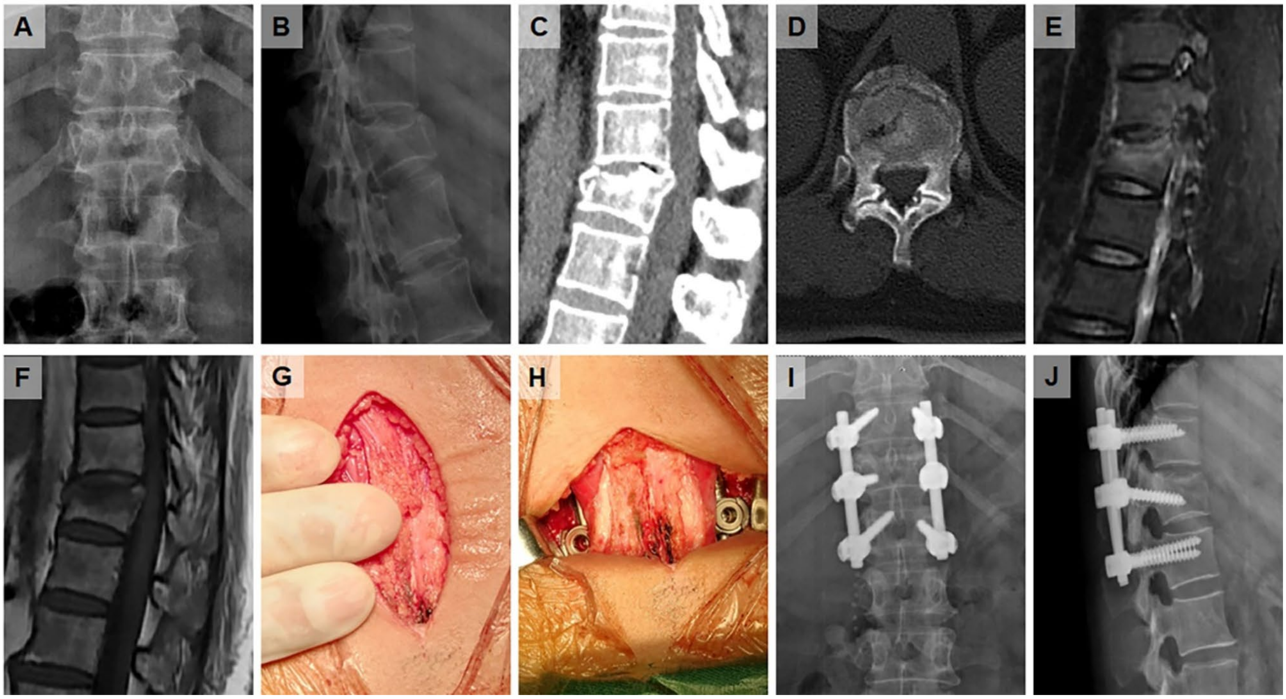

Fig. 2 Case presentation of a 50-year-old male patient who suffered a T11 fracture due to a fall from height and underwent surgery via the modified Wiltse approach. (**A**, **B**) Preoperative X-ray radiograph of the thoracic spine; (**C**, **D**) Preoperative sagittal CT scan of the fractured thoracic vertebra; (**E**, **F**) Preoperative MRI scan confirming the thoracic vertebral fracture and excluding nerve injury; (**G**, **H**) Intraoperative anatomy of the modified Wiltse approach; (**I**, **J**) Postoperative X-ray radiograph of the thoracic spine

body height (PAVBH), visual analog scale (VAS) pain scores, and Oswestry disability index (ODI) were used to evaluate the efficacy of fracture-level screw incorporation. Cobb's angle and PAVBH were measured radiographically preoperatively, immediately postoperatively (within three days of surgery), and at 3 months and 1 year postoperatively. VAS score, and ODI score were obtained through questionnaires administered preoperatively and at 1 week, 3 months, and 1 year postoperatively. A single research assistant independently collected all the data.

Statistical analysis

Statistical analyses were performed using SPSS version 27.0 (SPSS Inc., Chicago, IL, USA). Continuous data were expressed as mean ± Standard Deviation, while categorical data were presented as frequencies and compared using the chi-square or Fisher's exact test. The Shapiro-Wilk test was performed to confirm the normal distribution of the data. Normally distributed factors were compared by using independent t-test (welch-t-test for factor with unequal variances), while nonnormally distributed factors were compared by using Wilcoxon test. Repeated measures ANOVA test was performed to compare postoperative Cobb's angle, PAVBH, VAS score, and ODI score between the two groups. A p-value less than 0.05 was considered statistically significant.

Results

General population information

Group A included 20 males and 10 females with a mean age of 54.83 ± 14.47 years (range: 31–80 years) and a mean BMI of 23.99 ± 3.82 (range: 18.07–30.80). Group B consisted of 20 males and 10 females with a mean age of 52.17 ± 13.17 years (range: 30–79 years) and a mean BMI of 22.89 ± 3.78 (range: 17.23–30.47). In Group A, 25 patients had single-segment fractures, while the remaining patients had two-segment fractures. In Group B, 26 patients had single-segment fractures, and the others had two-segment fractures. Seven patients in Group A and six patients in Group B had fractures in the middle thoracic vertebrae (T5-8), while the remaining fractures occurred in the lower thoracic vertebrae (T9-12). Table 1 summarizes the demographic information for all 60 patients. There were no significant differences between the two groups in terms of age, gender, BMI, number of fractured segments, or fracture location ($p > 0.05$).

Perioperative parameters of the two groups

Significant differences were observed in operation time, intraoperative blood loss, postoperative drainage, and discharge time between the two groups (Table 2). The mean operation time for group A was significantly shorter than group B (108.90 ± 26.94 vs. 123.60 ± 23.86 min). The length of incision was also

Table 1 Patients' baseline data

Characteristics	Group A	Group B	*P* value
No. of cases	30	30	
Age (years)	54.8 ± 14.5	52.2 ± 13.2	0.4584
Sex (male / female)	20 / 10	18 / 12	0.5921
BMI	24.0 ± 3.8	22.9 ± 3.8	0.3632
No. of fractured segments (1 segment / 2 segments)	23 / 7	22 / 8	0.7656
Site of fracture (middle thoracic / lower thoracic)	23 / 7	25 / 5	0.5186

BMI: body mass index

Table 2 Perioperative data of the patients

Characteristics	Group A	Group B	*P* value
Operation time (min)	108.9 ± 26.9	123.6 ± 23.9	**0.0291***
Intraoperative blood loss (ml)	64.2 ± 38.7	120.7 ± 42.6	**< 0.0001***
Length of incision (cm)	10.6 ± 2.9	11.6 ± 2.3	**0.0473***
No. of C-arm exposures	4.0 ± 1.1	4.3 ± 1.2	0.2359
Postoperative drainage (ml)	45.7 ± 23.5	77.2 ± 18.1	**< 0.0001***
Postoperative ambulation time (day)	3.0 ± 1.0	3.4 ± 0.7	**0.0337***
Discharge time (day)	12.0 ± 1.4	13.6 ± 1.6	**0.0002***

* means *P* value < 0.05

shorter in group A (10.57 ± 2.86 cm) compared to in group B (11.62 ± 2.34 cm). Furthermore, group A demonstrated notably lower intraoperative blood loss (64.17 ± 38.73 ml) and postoperative drainage (45.67 ± 23.52 ml) compared to group B (120.67 ± 42.64 ml and 77.17 ± 18.08 ml, respectively). Additionally, patients in group A experienced reduced postoperative ambulation time (2.97 ± 1.03 days) and discharge time (12.03 ± 1.35 days) compared to those in group B (3.40 ± 0.67 days and 13.63 ± 1.63 days, respectively). The number of C-arm exposures did not exhibit any clear differences between the groups. No intraoperative vascular or nerve injuries were reported in any of the patients.

Clinical outcomes

No significant differences in VAS, ODI, Cobb's angle, or PAVBH were observed between the two groups prior to surgery. However, all these parameters showed significant improvements after surgery in both groups ($P < 0.05$). Notably, patients in group A experienced better VAS and ODI scores compared to those in group B, particularly at one week and three months post-surgery ($P < 0.05$, Table 3). Although the immediate postoperative Cobb's angle and PAVBH did not exhibit clear differences between the groups, the values for group A were slightly better than those for group B at one year after surgery, albeit without statistical significance (Table 3).

Discussion

Spinal fractures, primarily caused by trauma, osteoporosis, or tumors, are among the most prevalent orthopedic conditions [15, 16]. Due to their anatomical structure and biomechanical properties, thoracic and lumbar vertebrae are particularly susceptible to fractures [9, 17]. Conservative management of thoracolumbar fractures necessitates extended bed rest, potentially leading to severe kyphotic deformities and even secondary spinal nerve injuries [18]. Moreover, patients undergoing conservative treatment often experience a reduced quality of life and incur high nursing costs. The pedicle screw system facilitates faster recovery following internal fixation, allowing patients to promptly resume their daily activities [19].

Conventional posterior surgical approaches involve extensive paraspinal muscle stripping from the spinous processes and vertebral plate and retracting the muscles laterally to expose the screw markers. This technique is associated with lengthy incisions, significant trauma, and excessive bleeding. Furthermore, the paraspinal muscles are susceptible to ischemic necrosis and denervation, potentially resulting in chronic back pain, back muscle weakness, and other complications [20, 21].

To minimize paraspinal muscle damage during posterior surgery, Wiltse et al. [2] introduced an approach through the multifidus muscle and the longest muscle space for treating thoracolumbar vertebral fractures. This technique employs a shorter incision compared to conventional methods, significantly reducing intraoperative blood loss. As the pedicle screw is inserted through the normal muscle space, there is no need to detach muscle tissue attachments from the spinous and mastoid processes, preserving the posterior spinal nerve branches. Consequently, the incidence of chronic low back pain and lumbar dorsal muscle weakness is greatly diminished [22, 23]. The Wiltse approach has gained widespread acceptance in thoracolumbar surgery, including fracture management and degenerative conditions [1, 5, 13, 18, 23].

Table 3 Clinical outcomes

Characteristics	Group A	Group B	*P* value
Cobb's angle (degree)			
Preoperative	19.7 ± 6.9	18.4 ± 6.8	0.4661
Immediate postoperative	11.4 ± 3.8	12.0 ± 4.2	0.1511
3 months after surgery	12.2 ± 3.8	13.1 ± 4.8	0.1019
1 year after surgery	12.8 ± 4.0	13.8 ± 5.0	0.0863
PAVBH (%)			
Preoperative	66.6 ± 13.4	67.7 ± 11.7	0.7956
Immediate postoperative	85.6 ± 11.6	85.1 ± 10.9	0.5392
3 months after surgery	84.6 ± 11.3	82.5 ± 12.2	0.3032
1 year after surgery	83.7 ± 11.3	80.2 ± 13.1	0.1526
VAS score			
Preoperative	7.7 ± 0.8	7.7 ± 1.0	0.8639
1 week after surgery	2.3 ± 0.8	3.0 ± 0.9	**0.0216***
3 months after surgery	1.8 ± 0.9	2.4 ± 0.8	**0.0208***
1 year after surgery	0.9 ± 0.8	1.2 ± 1.0	0.0658
ODI score			
Preoperative	37.7 ± 8.2	36.9 ± 8.1	0.7342
1 week after surgery	21.9 ± 6.3	25.5 ± 6.6	**0.0148***
3 months after surgery	12.3 ± 3.9	15.5 ± 5.7	**0.0273***
1 year after surgery	9.2 ± 3.4	12.3 ± 4.8	**0.0379***

PAVBH: percentage of anterior vertebral body height; VAS: visual analog scale; ODI: Oswestry disability index. * means P value < 0.05

Advances in minimally invasive spinal surgery have introduced new surgical options for thoracolumbar fractures. Numerous studies have demonstrated that PPSF is a superior choice for treating neurologically intact thoracolumbar fractures [24, 25]. Compared to traditional approaches, PPSF offers advantages such as reduced blood loss, shorter operative times, enhanced soft tissue preservation, briefer postoperative hospital stays, and more rapid functional recovery [24–26]. However, recent investigations have revealed that PPSF may also cause deep soft tissue injuries during percutaneous pedicle screw placement and connecting rod insertion, leading to increased postoperative drainage [14]. Zhang et al. [14] reported that the Wiltse approach exhibited benefits in radiation exposure, vertebral height restoration, kyphosis correction, and learning curve compared to PPSF in patients with multi-segmental thoracolumbar fractures. A meta-analysis comparing PPSF and the Wiltse approach further confirmed that the Wiltse approach has a shorter learning curve, reduces facet joint violation, operative time, hospitalization costs, and radiation exposure, while providing better improvement in postoperative vertebral body angle and percentage of vertebral body height for thoracolumbar fracture treatment [14]. Therefore, the Wiltse approach may be the preferred choice for thoracolumbar fracture surgery.

Originally developed for lumbar surgery, the Wiltse approach involves cutting the latissimus dorsi muscle layers approximately 2 cm lateral to the paraspinous process and bluntly dissecting the multifidus muscle to expose the nail insertion point. However, in the thoracic spine, the lateral muscle layers, including the trapezius, latissimus dorsi, and inferior posterior serratus, are thicker than in the lumbar region. The conventional Wiltse approach in the thoracic vertebral region requires cutting through these muscle layers, potentially increasing hemorrhage, causing muscle disruption, and diminishing muscle function. This may explain the relatively limited research on the Wiltse approach in thoracic vertebrae.

In this context, we attempted to modify the Wiltse approach and apply it to the treatment of middle and lower thoracic vertebral fractures. Regarding the surgical level and anatomical structure of the middle and lower thoracic vertebrae, the skin and subcutaneous tissues were incised longitudinally along the midline, and the sides were separated to reveal the deep dorsal fascia. Beneath the fascia lies the trapezius muscle, which originates from the posterior occipital protuberance and inserts into the spinous process of T12. Deep in the trapezius muscle is the latissimus dorsi muscle, which is distributed in the spinous processes of the lower six thoracic vertebrae, all lumbar vertebrae, and the iliac crest. The inferior posterior serratus muscle is situated deeper than the latissimus dorsi and spans from the spinous process of T11 to L2, with thickened fascia near its spinal attachment. Deeper than the inferior posterior serratus (at the T11 and T12 levels) and the latissimus dorsi are the spinal muscles (thoracic semispinalis and thoracic spinalis) and the longissimus muscle. The multifidus muscles lie deep in the spinal muscles, and the thoracic longus and shortus ileus are located even deeper.

We modified the Wiltse approach by considering the anatomical features and making a posterior median incision. The tendinous portions of the trapezius and latissimus dorsi on both sides of the spinous process were incised (including the tendinous portions of the serratus posterioris inferior at T11 and T12), and then retracted laterally to expose the spinous process and longissimus muscle. The spinal muscles and longissimus were then separated to reveal the transverse process and the point of nail insertion. This modified Wiltse approach was applied in thoracic fracture surgery and compared to the traditional posterior approach. The results demonstrated that the modified Wiltse approach had significant advantages in operation time, intraoperative blood loss, postoperative drainage, length of incision, postoperative ambulation time, discharge time, and postoperative VAS and ODI scores. These findings suggest that patients who underwent the modified Wiltse approach may have experienced relatively limited muscular damage and exhibited better recovery compared to the other group.

The modified Wiltse approach not only preserves the advantages of the conventional Wiltse approach, such as shorter operation time, no need to detach muscle attachments from the spinous and transverse processes, reduced bleeding, shorter hospitalization, and fewer complications [27], but also minimizes damage to the trapezius and latissimus dorsi muscles. However, due to the smaller size of thoracic pedicle screws, the increased difficulty of placement compared to lumbar screws, and the less distinct anatomical landmarks compared to the traditional procedure, experienced surgeons should perform this technique to avoid the risk of spinal cord injury.

This modified transmuscular interspace approach improves upon the traditional Wiltse approach by further reducing muscle damage in the middle and lower thoracic vertebrae. As expected, our study comparing this modified Wiltse approach to the traditional posterior approach found the modified Wiltse approach to be superior. In future studies, we plan to compare this modified Wiltse approach to the conventional Wiltse approach, or PPSF surgery, to assess the advantages and disadvantages of this surgical technique compared to other methods. Furthermore, we believe that this surgical approach can be applied not only in thoracic fracture surgery but also in other thoracic operations. We intend to further explore the potential application of this modified Wiltse approach in the surgical treatment of thoracic metastases.

In conclusion, we propose a modification of the Wiltse approach for the middle and lower thoracic vertebral regions, which may further reduce muscular damage compared to the conventional Wiltse approach. Our comparison of this modified Wiltse approach to the traditional posterior approach in thoracic fracture surgery revealed advantages in operation time, intraoperative blood loss, postoperative drainage, length of incision, postoperative ambulation time, discharge time, and postoperative VAS and ODI scores. We believe that this modified Wiltse approach may be further utilized in other thoracic surgeries.

Abbreviations

BMI	Body mass index
PAVBH	Percentage of anterior vertebral body height
VAS	Visual analog scale
ODI	Oswestry disability index
PPSF	Percutaneous pedicle screw fixation

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No.

Author contributions
T.W. and J.T. conceptualized and designed the study. S.S., Q.G., Q.M., J.T. performed the surgical procedures. S.S. and H.C. collected clinical data. Z.W. and J.S. conducted the statistical analysis. T.W. and Z.W. drafted the initial manuscript, and J.T. revised it. All authors have read and approved the final submitted manuscript.

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Data availability
Full access to all raw data and materials throughout the study is available from the corresponding authors (Jun Tao, tjspine@gmail.com, or Ting Wang, wangt_boneleven@163.com).

Declarations

Ethics approval
This study was reviewed and approved by the Medical Ethics Committee of Weihai Central Hospital of Qingdao University. Written informed consent was obtained from all patients or their legal guardians.

Consent for publication
The data collected in this study were obtained with written informed consent from all participants.

Competing interests
The authors declare no competing interests.

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