CLINICAL ARTICLE

The Clinical Effect of Manual Reduction Combined with Internal Fixation Through Wiltse Paraspinal Approach in the Treatment of Thoracolumbar Fracture

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Objective: To evaluate the clinical outcome of manual reduction combined with pedicle fixation through Wiltse paraspinal approach (WPA) in the treatment of thoracolumbar fractures.

Methods: From May 2017 to May 2019, 48 thoracolumbar fractures patients without neurological symptoms were enrolled in this study. Forty-eight patients were randomly divided into two groups based on the different surgical treatment. Group 1 was manual reduction combined with pedicle screw fixation through Wiltse paraspinal approach treatment group. Group 2 was pedicle screw fixation through traditional posterior approach treatment group. The operation time (OT), intraoperative blood loss (BL), postoperative drainage (PD), time of brace (TB) and the cobb angle recovery of the injured kyphosis in the prone position were obtained and compared between the two groups, respectively. Comparison of cobb angle changes, serum creatine kinase (CK) level, pain visual analogue score (VAS), Oswestry disability index (ODI), and multifidus cross-sectional (MCS) area changes were achieved between the two groups, respectively.

Results: Forty-eight patients were enrolled in this study and each group had 24 patients. There was no significant difference between the two groups in patient's age, height, weight, and body mass index (BMI). There were 20 males and four females in group 1. The mean age, height, weight, and BMI of patients were 61.99 ± 11.00 years (range, 42–75 years), 175.21 ± 4.49 cm, 76.71 ± 4.87 kg, and 24.98 ± 1.03 kg/m^2 in group 1, respectively. Group 2 had 18 males and six females, and the mean age, height, weight, and BMI of patients were 57.95 ± 9.22 years (range, 44–77 years), 176.37 ± 4.56 cm, 77.42 ± 4.61 kg, and 24.87 ± 1.10 kg/m^2 in group 2, respectively. The mean bleeding volume of group 1 was significantly less than group 2 (64.13 ± 9.77 ml and 152.13 ± 10.73 ml, respectively) ($P < 0.05$). The mean operation time, postoperative drainage, and time of brace were 62.95 ± 9.80 min, 66.25 ± 12.75 ml, and 3.62 ± 0.97 days in group 1, respectively, and they were significantly better than those of group 2 (69.29 ± 6.82min, 162.96 ± 14.55ml and 7.88 ± 1.94 days, respectively) ($P < 0.05$). The mean multifidus cross-sectional area was significantly smaller than per-operation after surgery in two groups ($P < 0.05$). The mean creatine kinase of group 1 was 403.13 ± 39.78 U/L and 292.12 ± 45.81 U/L at 1 and 3 days after surgery, respectively, which was significantly smaller than those in group 2 (654.25 ± 53.13 U/L and 467.67 ± 44.25 U/L, respectively) ($P < 0.05$). The Oswestry disability index of group 1 were significantly better than those in group 2 especially at 1 month and final follow-up after

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surgery ($P < 0.05$). Moreover, group 1 also had better outcomes in postoperative Cobb angle change than those in group 2, with significant difference on intra-operation, 1 day and 1 month post-operation ($P < 0.05$).

Conclusion: In short, this operation is suitable for thoracolumbar fractures without neurologic symptoms. Preoperative manual reduction had advantages of restoring the height of injured vertebrae. Wiltse intermuscular approach can reduce intraoperative blood loss, shorten operation time, and reduce paraspinal muscle damage. Using the traditional posterior approach, it is easy for surgeons to grasp this technique and it should be recommended as conforming with the minimally invasive approach of recent years.

Key words: Internal fixation; Manual reduction; Paravertebral space; Thoracolumbar fracture

Introduction

The thoracolumbar junction is the significant part that supports the main weight of an individual, which can be divided into two parts: the thoracic spine (T10-T12) and the lumbar spine (L1-L2)[1]. It is also the most common region of thoracolumbar fractures (TF) due to it being the stress concentration point of whole body[2]. Significant blunt trauma such as motor vehicle accidents or falling from a height are the main reasons for TF, which range from non-complex to highly complex resulting in different prognoses depending on the severity of injury. Recent studies showed that the number of motor vehicles in China would increase up to nearly 360 mn in the first half of 2020[3]. Moreover, the construction industry is constantly developing because of the rapidly growing economic and social development, which indirectly result in high incidence of TF because of falling accidents[4]. Interestingly, it makes sense that males have a higher risk of TF than females because of these reasons. And nearly 70% of patients who suffer vertebral fractures do so because of a series of accidents occurring in the lumbar and thoracic spine[5].

Types of TF include compression fracture, burst fracture, posterior column fracture, chance fracture, thoracic spine fracture-dislocations, translation-rotation injuries, and transverse process fracture[6]. But there is still no consensus of classification of TF. In order to make the right choice for patients with TF, various classifications attempted to provide effective guidance for clinic including the AO Spine classification of thoracolumbar injuries, proposed by Müller *et al.*, thoracolumbar injury classification and severity score (TLICS) presented by Vaccaro *et al.*, and Denis classification or McAfee classification[7]. The first two classifications are commonly used in current clinical applications but there are differences between them. The simplification and universalization of classifying spinal injuries and improvement of the reliability of diagnosis are the main goal of the AO Spine classification of thoracolumbar injuries system[7]. However, thoracolumbar injury classification and severity score (TLICS) system aims to make the right treatment choice for patients with TF based on not only the morphologic image but also incorporating clinical features[5].

The common clinical symptoms of TF mainly consist of acute and severe radioactive back pain, swelling at the fracture site, and limited movement of spine. In addition, impairment to the nerve root and spinal cord, because of compression from fracture fragments, will inevitably cause loss of sensory or motor function in lower limbs[6]. In some severe cases, patients may suffer complete paralysis of lower extremities, incontinence, etc. Aiming to improve TF patients' recovery speed and quality of life, surgery seems to be an optimal choice to help them reduce bedridden time, especially for elder patients who could not suffer the variety of complications including deep vein thrombosis, hypostatic pneumonia, and pressure sores, etc[8]. Surgery can provide the patients with immediate stability of spine, early ambulation, early independence from braces, and correction of deformity. However, it is still controversial about whether surgery should be managed in TF patients without neurological deficit[5].

As for the surgical options, including instrument fixation from anterior or posterior approach, posterior pedicle screws fixation, combined with fully autogenous or allogeneic bone graft, has become the common and effective choice to provide rigid fixation for patients who require surgery[9]. In addition, posterior pedicle screw fixation also uses short or long lengths of the fixed segment based on the case and surgeon opinion. But the traditional pedicle screw fixation still has some disadvantages, such as extensive stripping of the paraspinal muscles or continuous traction of the paraspinal muscles resulting in significant postoperative muscle atrophy and scars[1]. These adverse factors can cause postoperative intractable low back pain and activity limitation, which directly result in the badly postoperative life quality of patients. As early as 1959, Watkins first described the paraspinal approach for spinal fusion as the treatment for lumbosacral spondylolisthesis[10]. In 1968, Wiltse *et al.* proposed the modified trans-muscular paraspinal approach and it is also interestingly popularized by their series of studies[11]. Until now, various research arose into many aspects of Wiltse paraspinal approach, and its advantages are clear: this approach does not need to intraoperatively strip the paraspinal muscles, leading to less trauma, less intraoperative bleeding, and quicker recovery[12,13]. Manual reduction is becoming popular for treatment of various fractures or as rehabilitation medicine in recent years[14]. Moreover, some studies indicate that the manual reduction seems to be quite

a useful treatment for TF, as it can help restore the height of the fractured vertebral body[15]. To the best of our knowledge, there are few studies about pedicle screw fixation using the Wiltse paraspinal approach combined with manual reduction for the treatment of TF. Therefore, we propose this surgical technique as the treatment of TF.

The aims of this study were: (i) to investigate pedicle screw fixation through Wiltse paraspinal approach combined with manual reduction; (ii) to study the anatomy of paraspinal muscle of thoracolumbar; and (iii) to evaluate the short-term clinical outcome of this treatment compared to the traditional surgical approach in terms of bleeding volume (BV), operation time (OT), protection of paraspinal muscle, and Cobb angle changes, etc.

Materials and methods

Participants

From May 2017 to May 2019, 48 patients with TF were enrolled in this study and they were randomly divided into two groups.

The inclusion criteria were as follows: (i) TF (T11 to L2) patients with clear history of trauma but without neurological symptoms; (ii) accepted the surgical treatment through Wiltse paraspinal approach combined with manual reduction or pedicle screw internal fixation through traditional posterior approach; (iii) MRI showed no spinal cord compression or neurological symptoms.

The exclusion criteria were as follows: (i) TF with pathological factors; (ii) TF treated by conservative treatment; (ii) MRI showed obvious spinal cord compression; (iv) combined with more serious multiple injuries or patients could not tolerate surgery because of other serious diseases.

This study was approved by the ethics committee of Qingdao University Hospital, and all patients signed the ethical informed consent after admission.

Interventions

The 48 patients with TF were divided into two groups based on the different surgical treatment. Group 1 was manual reduction combined with pedicle screw fixation through Wiltse paraspinal approach while group 2 was pedicle screw fixation through traditional posterior approach. We treated 24 patients with TF who underwent manual reduction combined with internal fixation through Wiltse paraspinal approach in this period of time. There were 20 males and four females, with an average age of 60.88 years (range, 42 to 75 years). In group 1, six patients had T11 fracture, seven patients had T12 fracture, six patients had L1 fracture, and five patients had L2 fracture. There are 24 patients who underwent the traditional posterior internal fixation in group 2 including 18 males and six females, with an average age of 57.96 years (range, 44 to 77 years). In group 2, six patients had T11 fracture, six patients had T12 fracture, seven patients had L1 fracture, and five patients had L2 fracture.

Surgical Technique of Manual Reduction Combined with Wiltse Paraspinal Approach

The patient lied in the prone position after general anesthesia. The position of the injured vertebral body was fluoroscopically located and the height of the injured vertebral body was observed from the body surface. Appropriate amounts of padding were inserted under the patient to achieve a position where the chest and waist were hanging in the air. Then the manual reduction was performed. One assistant put his hands under the patient's armpits while another pulled the patient's legs and continued traction was performed for about 2 to 5 minutes. The chief surgeon placed both hands on the surface of the patient's injured vertebral body and pressed down with appropriate strength (Fig. 7). Intraoperative fluoroscopy was performed after the manual reduction to evaluate the recovery of fracture vertebral height and physiological curvature of thoracolumbar. The skin was routinely disinfected and sterile drapes were placed onto the area of incision. An 8~10 cm long longitudinal surgical incision was made on the midline of the back. Multifidus and longisis muscle space were separated after incising the skin, subcutaneous and low back fascia layer by layer. The exposure of the junction between the transverse process and the vertebral body or the "her-bone" ridge of the lumbar spine was achieved, and pedicle screw was inserted after satisfied fluoroscopy with positioning needles. Then the pre-curved longitudinal rod link was placed appropriately. The fluoroscopy was performed not only to confirm the position of pedicle screw but also to evaluate the height of injured vertebrae, the correction of kyphosis, and the physiological curvature recovery of the thoracolumbar spine. Finally, the incision was washed and drainage tube was placed in the bilateral muscle space before suture, layer by layer.

Surgical Technique of Traditional Posterior Approach

After general anesthesia, the patient was in the prone position followed by the intraoperative fluoroscopy of injured thoracolumbar vertebra. The skin was routinely disinfected and sterile drapes were placed onto the area of incision. An 8-10-cm-long skin incision was made on the midline of the thoracolumbar section followed by the incision of subcutaneous fascia, layer by layer. The complete detachment of paravertebral muscles was performed and the pedicle screws were inserted. Intraoperative fluoroscopy was also necessary to ensure the good position of pedicle screws. Then, the longitudinal rod was bent and placed appropriately. Finally, the incision was washed, and drainage tube was placed on both sides of the spinous process before suture, layer by layer.

After Surgery

Antibiotics were prophylactically used regularly for 24 hours to prevent from incision infection. The drainage tube was removed 24 to 48 hours after surgery. Stitches were postoperatively removed after approximately 10–14 days. All patients were encouraged to move their legs to prevent

thrombus of lower extremity veins and develop the muscles strength of their legs in bed.

Comparison

The enrolled patients with TF were all treated in surgery but with different treatment. The manual reduction was conducted before the screw fixation through the Wiltse paraspinal approach in group 1. However, the patients in group 2 merely underwent the pedicle screw fixation through traditional posterior approach.

Outcomes

The operation time (OT), bleeding volume (BV), postoperative drainage (PD), and time of brace (TB) were compared between the two groups. The different times of the Cobb angle (CA) recovery of injured kyphosis were obtained for both groups, including pre-operation after manual reduction or prone position, 1 day, 1 month and 3 months after surgery. In both groups, the patient's serum creatine kinase (CK) changes were also monitored at pre-operation, 1 day, 3 days, and 5 days after surgery. The multifidus cross-sectional (MCS) area of the two groups was evaluated from MRI after surgery. We also studied the basic details of patients in both groups, including age, height, weight, body mass index (BMI), and sex.

Visual Analog Scale

The visual analog scale (VAS) is a scale used to determine the pain intensity experienced by individuals. It consists of a line, approximately 10–15 cm in length, with the left side signifying no pain with a smiling face image and the right side signifying the worst pain ever with a frowning face image. The VAS is used to assist individuals to determine pain levels when they may not be accustomed to rating their pain on other types of scales. The patient can point to or mark a spot on the line where they feel indicates their current level of pain and we can score the point of the patient's pain level. The VAS score was obtained at pre-operation, 1 week, 1 month, and 3 months after surgery between the two groups.

Oswestry Disability Index

The Oswestry Disability Index is a questionnaire, which is an extremely important tool that researchers use to measure a patient's permanent functional disability. The test is considered the "gold standard" of low back functional outcome tools. For each section the total possible score is 5. If the first statement is marked, the section score = 0; if the last statement is marked, the section score = 5. If all 10 sections are completed, the score can be calculated. The ODI score was obtained pre-operation and at 1 month and 3 months after surgery.

Statistical Analysis

All the data are presented as mean ± standard deviation (SD). Statistical significance was determined by unpaired t-test using the SPSS 22.0 pro-gram (SPSS Inc., Chicago, IL, USA) with $P < 0.05$ being statistically significant.

Results

General Information

The basic details of all patients were obtained before surgery. Forty-eight patients were enrolled in this study and each group had 24 patients. There was no significant difference between the two groups in patient's age, height, weight, and BMI. There were 20 males and four females in group 1. The mean age, height, weight, and BMI of patients were 61.99 ± 11.00 years (range, 42–75 years), 175.21 ± 4.49 cm, 76.71 ± 4.87 kg, and 24.98 ± 1.03 kg/m^2 in group 1, respectively. Group 2 had 18 males and six females, and the mean age, height, weight, and BMI of patients were 57.95 ± 9.22 years (range, 44–77 years), 176.37 ± 4.56 cm, 77.42 ± 4.61 kg, and 24.87 ± 1.10 kg/m^2, respectively (Table 1).

The Bleeding Volume, Operation Time, Postoperative Drainage, and Time of Brace of Two Groups

There were significant difference in bleeding volume (BV), operation time (OT), postoperative drainage (PD), and time of brace (TB) between the two groups ($P < 0.05$) (Fig. 1). In

TABLE 1 The characteristics of two group (mean ± SD)

Parameters	Group 1	Group 2	*t* value	*P* value
Age (years)	61.99 ± 11.00	57.95 ± 9.22	1.01	0.31
Height (cm)	175.21 ± 4.49	176.37 ± 4.56	0.89	0.38
Weight (kg)	76.71 ± 4.87	77.42 ± 4.61	0.47	0.64
BMI (kg/m^2)	24.98 ± 1.03	24.87 ± 1.10	0.36	0.72
Sex	20 male (83%)	18 male (75%)		0.72
	4 female (17%)	6 female (25%)		
BV (ml)	64.13 ± 9.77	152.13 ± 10.73	29.70	$P < 0.05$
OT (min)	62.95 ± 9.80	69.29 ± 6.82	2.60	$P < 0.05$
PD (ml)	66.25 ± 12.75	162.96 ± 14.55	24.49	$P < 0.05$
TB (day)	3.62 ± 0.97	7.88 ± 1.94	9.60	$P < 0.05$

BV, Bleeding volume; OT, Operation time; PD, Postoperative drainage; TB, Time of brace.

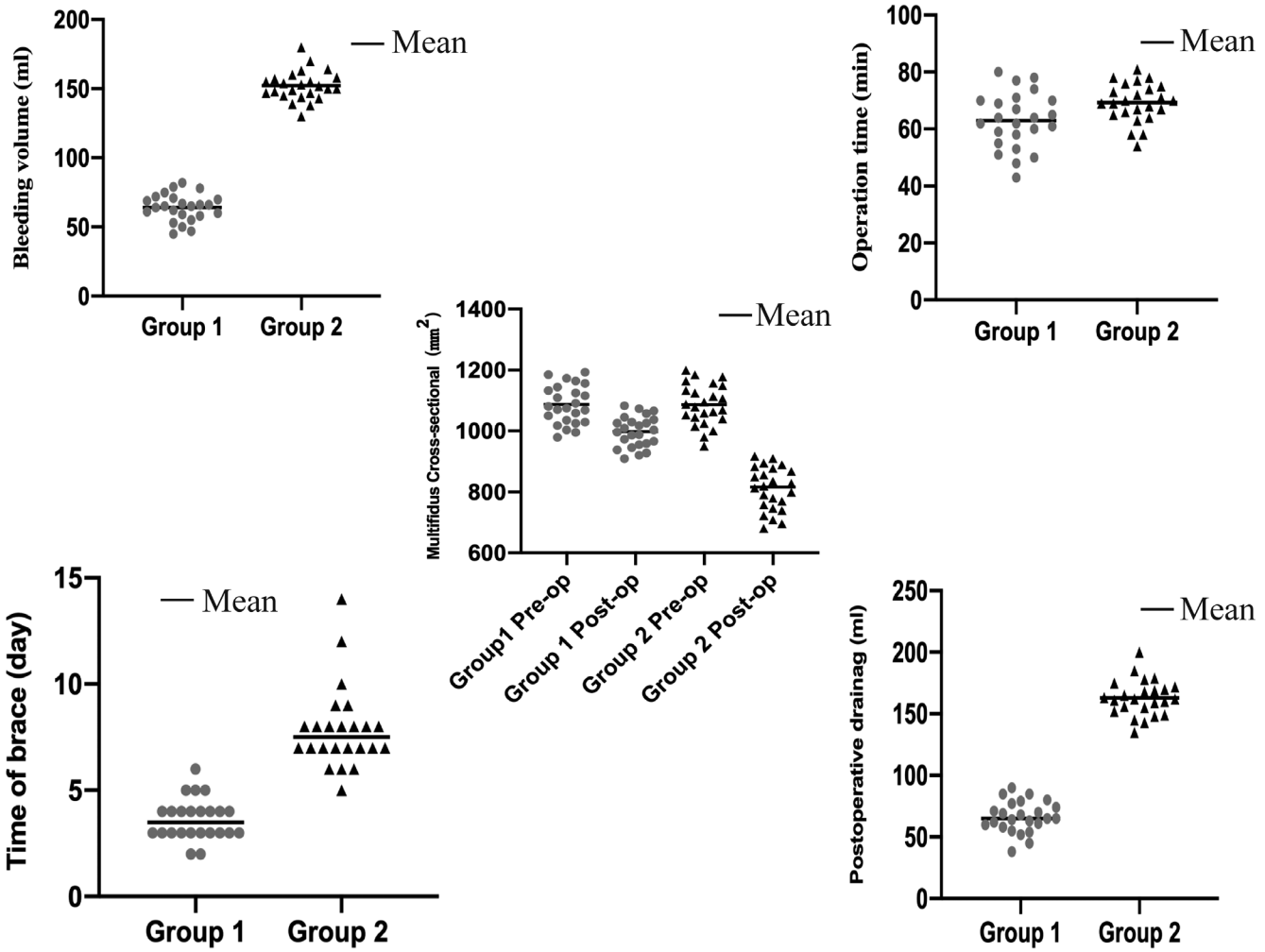

Fig 1 The patients in group 1 had lower BV (top left), TB (bottom left), OT (top right), and PD (bottom right) than those in group 2. The MCS (middle) in group 1 were higher than those in group 2 after surgery. Graphs showed that there were significant difference in terms of BV, TB, MCS, OT, PD between the two groups.

detail, the mean BV of group 1 was significantly less than group 2 (64.13 ± 9.77 ml and 152.13 ± 10.73 ml, respectively) ($P < 0.05$). The mean OT, PD, and TB were 62.95 ± 9.80 min, 66.25 ± 12.75 ml, and 3.62 ± 0.97 days in group 1, respectively, which was significantly better than those of group 2 (69.29 ± 6.82 min, 162.96 ± 14.55 ml and 7.88 ± 1.94 days, respectively) ($P < 0.05$).(Table 1).

The Changes of Multifidus Cross-sectional Area and Creatine Kinase

The mean multifidus cross-sectional area changes (MCS) were significantly smaller than pre-operation after surgery in the two groups ($P < 0.05$). The mean creatine kinase (CK) of group 1 was 403.13 ± 39.78 U/L and 292.12 ± 45.81 U/L at 1 and 3 days after surgery, respectively, which was significantly smaller than in group 2 (654.25 ± 53.13 U/L and 467.67 ± 44.25 U/L, respectively) ($P < 0.05$) (Fig. 2).

The Changes of Visual Analog Score, Oswestry Disability Index, and Cobb Angle

The preoperative visual analog score (VAS) and Oswestry disability index (ODI) of the two groups were significantly better after surgery ($P < 0.05$) (Fig. 2). In addition, the ODI of group 1 were significantly better than those in group 2 especially on 1 month after surgery and final follow-up ($P < 0.05$). Moreover, group 1 also had better outcomes in postoperative Cobb angle (CA) changes than those in group 2, with significant difference on intra-operation, 1 day and 1 month post-operation ($P < 0.05$). Three typical cases were shown in Figs 3–5.

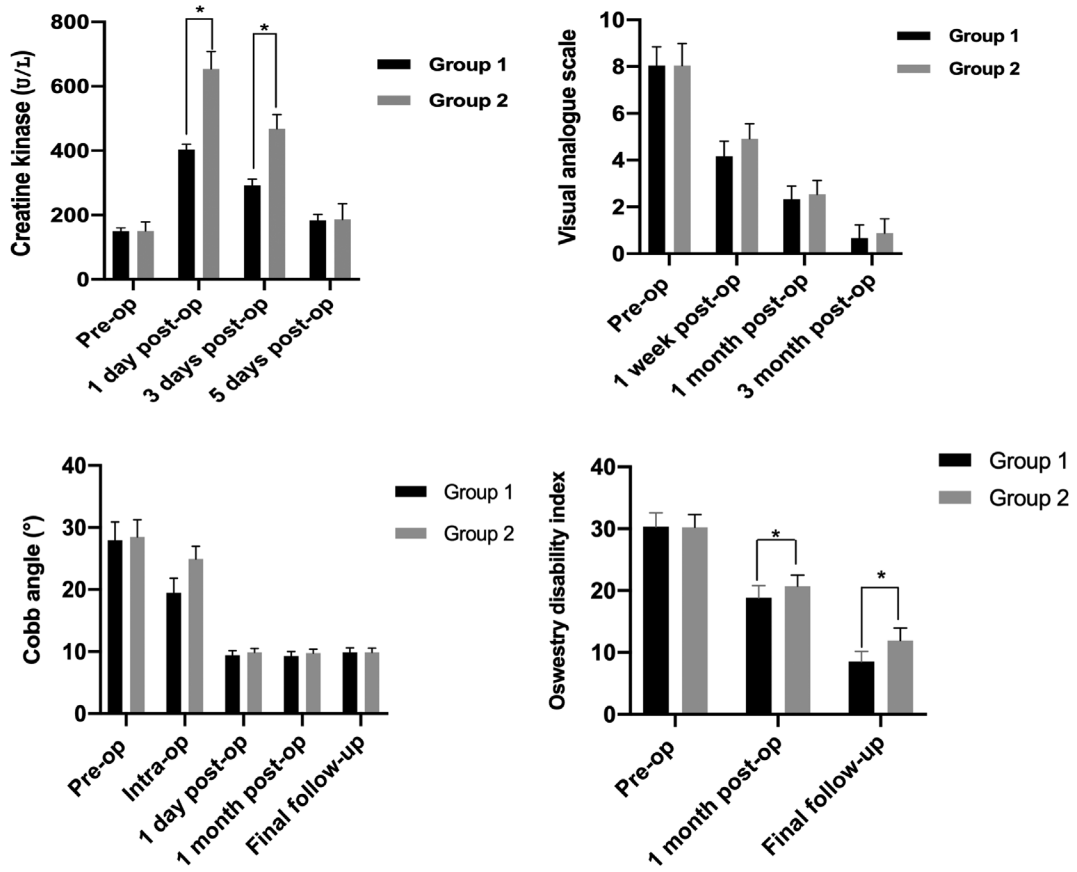

Fig 2 The graphs showed the comparison of CK (top left), CA (bottom left), VAS (top right), ODI (bottom right) between the two groups. The patients in group 1 had better clinical outcomes relatively in terms of VAS, ODI, CA, and CK than those in group 2. There was significant difference in postoperative terms of CK and ODI after surgery (* = $P < 0.05$).

Discussion

Anatomy of Paraspinal Muscle for Pedicle Screw Insertion

The paraspinal approach was firstly recommended for extremely lateral lumbar disc herniation by Wiltse *et al.*[16]. A profound understanding of anatomy of the thoracolumbar spine is important for mastering this surgical technique (Fig. 6) The muscles surrounding the thoracolumbar spine normally consists of anterior and posterior muscles group. The anterior muscles group mainly includes psoas major, psoas minor, and quadratus lumborum. The multifidus, erector spinae, semispinalis, musculi rotatores, and intertransverse mainly compose the posterior muscles group[17]. The erector spinalis is also known as musculus sacrospinalis including lliocostal muscles, longus muscles, and spinous muscles[18]. In addition, the paravertebral muscles are tightly enclosed by muscular fasciae but the degeneration of paravertebral muscles will inevitably arise because of prolonged mechanical muscle pulling, athletic injury, surgical disruption, and aging. Especially for the thoracolumbar spine, the paravertebral muscles play a crucial part in maintaining the stability of the spine. The thoracolumbar spine is the transition section between thoracic and lumbar spine, so the high similarities are presented in the anatomical features from thoracolumbar to lumbar[19]. In order to accurately insert the pedicle, we must find and separate the muscle space of the medial multifidus muscle and the lateral longissimus, which can help us expose the articular process pedicle[20].

The Advantages of Manual Reduction

The thoracolumbar segment is the high stress–strain region of three-dimensional degree of freedom and instantaneous motion for spine, leading to a high incidence of spinal injury. Studies have shown that TF account for 90% of the overall spine fractures[9]. For TF without neurological symptoms, surgical treatment has the advantages of correcting deformities, restoring and maintaining spinal stability, and promoting rehabilitation[21]. Interestingly, studies showed that prone position traction can simultaneously stretch the posterior longitudinal ligament, reduce the compression of adjacent vertebral bodies, promote the recovery of the entire vertebral body height, and correct kyphotic deformity with appropriate pressure[22]. Some scholars have also proposed that prone

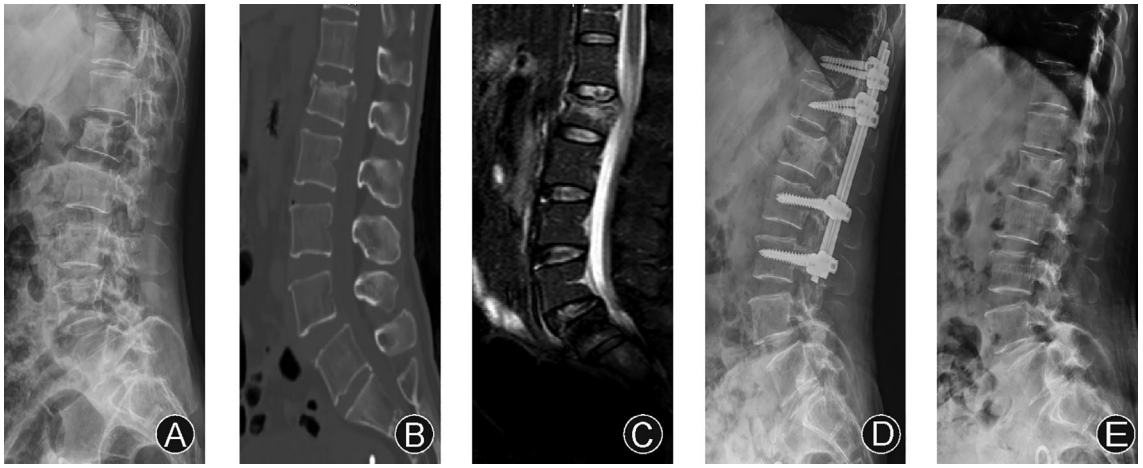

Fig 3 Typical case one. A 55-year-old female patient suffered L1 compression fracture because of accidental fall. She took the surgery by MR combined with pedicle fixation through WPA. (A) The lateral X-rays showing the wedge shape of L1. (B) Sagittal CT showing the fracture on L1, especially on the upside of L1. (C) Sagittal MRI T2-weighted image showing the hypointense on L1 and indicated the L1 fracture. (D) The postoperative lateral X-rays showing the restored height of L1 vertebra. (E) The follow-up lateral X-ray also showing the satisfactory height recovery of L1 vertebra after the remove of screws-rods fixation.

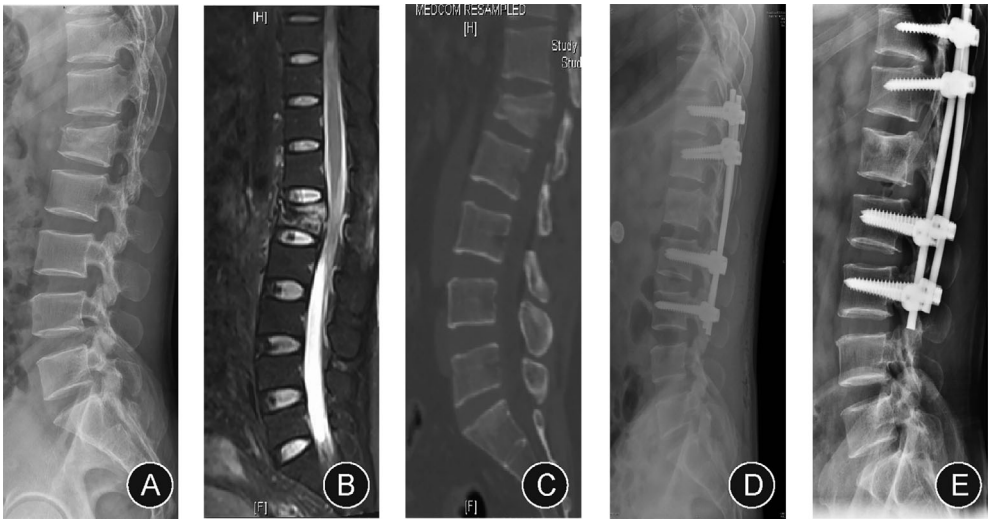

Fig 4 Typical case two. A 45-year-old male patient suffered back pain because of car accident. He underwent the surgery by the MR combined with pedicle fixation through WPA. (A) The lateral X-rays showing the wedge shape of L1, especially on the front L1 vertebra. (B) Sagittal MRI T2-weighted image showing the hypointense on L1 and spinal cord compression from L1. (C) Sagittal CT showing the fracture on L1, especially on the front L1 vertebra. (D,E) The postoperative and follow-up lateral X-rays showing the satisfactory restored height of L1 vertebra.

position traction can lose tissue hinge structure around the injured vertebrae to restore vertebrae height[15,22] (Fig. 7). The anterior and posterior spinal longitudinal ligament of the cases that we enrolled were intact and there was no obvious damage to the injured vertebrae and adjacent intervertebral discs. Therefore, we believed that the prone position traction could stretch the surrounding muscles and lose tissues through the elasticity of the anterior and posterior longitudinal ligaments. At the same time, the injured bone structure can be recovered and restore the physiological curvature of the thoracic and waist. The results showed that manual reduction could help patients recover the height of the injured vertebrae and correct kyphosis.

The Surgical Treatment for Thoracolumbar Fractures

The traditional posterior fixation is a routine surgical procedure for the treatment of TF, thoracolumbar instability, and degenerative scoliosis[1]. But it also has a variety of surgical risks including increased blood loss, high infection rates, postoperative paraspinal muscle injury, and prolonged operation time[23]. Studies have shown that extensive stripping of the paraspinal muscles will cause avascular necrosis resulting in trunk muscle strength decrease, spinal instability and severe postoperative back pain[20]. To effectively avoid the above problems, the pedicle fixation through the paraspinal muscle approach arose for the treatment of TF. Through the paraspinal muscles, there is a natural muscle gap between

Fig 5 Typical case three. A 40-year-old male patient undergoing the surgery by MR combined with pedicle fixation through WPA. (A) The lateral X-rays showing the obvious wedge shape of T12. (B) Sagittal MRI T2-weighted image showing the hypointense on T12. (C) Sagittal CT showing the compression fracture of T12, mainly on the front T12 vertebra. (D) The postoperative lateral X-rays showing the satisfactory restored anterior height of T12.

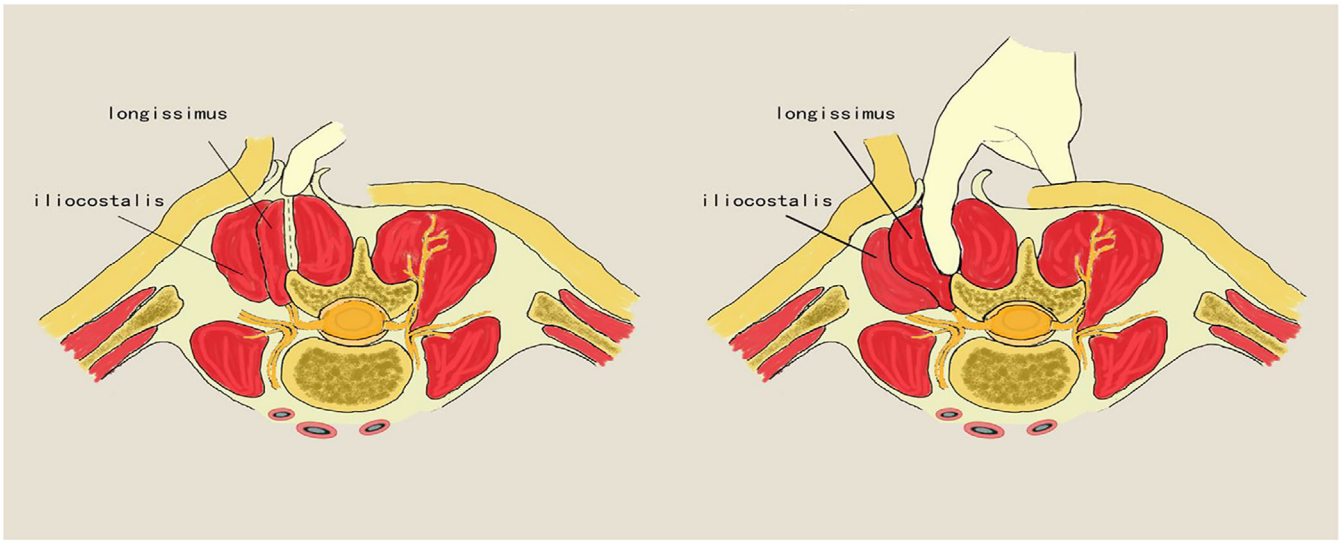

Fig 6 The anatomy of muscles of Wiltse paraspinal approach (WPA).

the thoracolumbar multifidus and the longissimus muscle, which can expose the pedicle entry point after blunt separation[24]. Initially, Wiltse *et al.* proposed the lateral paraspinal muscle approach to treat extreme lateral lumbar disc herniation[16]. But it has obvious advantages to reduce the incidence of recurrent low back pain and accelerate the recovery of TF patients after surgery. The Wiltse paraspinal surgical approach can effectively reduce paraspinal muscle damage resulting in quick back muscle function recovery and maintain the integrity of the posterior longitudinal ligament complex which plays a significant role in maintaining the stability of spine[12,13]. The results showed that the Wiltse paraspinal approach significantly reduced postoperative low back pain within a short period of time after surgery. Vialle *et al.* believed that the traditional approach continuously stretched the paraspinal muscles resulting in the insufficient blood supply of paraspinal muscles and it directly leads to the decrease of muscle activity[20,25]. We believed that the Wiltse intermuscular approach preserved the integrity and activity of the soft tissue and muscle complex around the injured vertebrae. Some scholars have suggested that muscle damage increases the serum concentration of CK that is usually used to assess muscle damage in the early postoperative period[26]. And postoperative serum CK usually reaches the highest level on the first day after surgery and gradually normalizes with prolonged postoperative time. The results of our study showed that the postoperative serum creatine kinase level in Wiltse paraspinal muscle approach group was significantly lower than that of the traditional posterior fixation group at 1 and 3 days after surgery and the

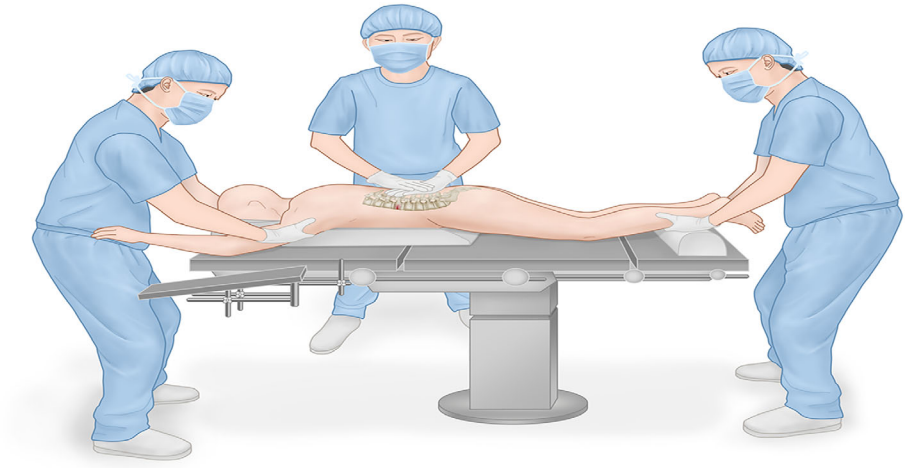

Fig 7 The schematic diagram of manual reduction and reverse traction. One surgeon put his hands on the fracture part of patient's back while another two assistants achieved the reverse traction by holding on patient's hands and legs.

postoperative serum creatine kinase level of the two groups gradually returned to normal at 5 days after surgery. The results showed that the paraspinal muscles approach had less damage to the paraspinal muscles and promoted the recovery of patients. Our results showed that the BV and PD of the intermuscular approach were significantly less than the traditional approach. He *et al.* mentioned that lumbar spine surgery was one of the main causes of paraspinal muscle atrophy[27]. Through the follow-up MRI, we found that the paravertebral muscle of traditional posterior fixation group was more atrophic and the fat infiltration range was larger than that of the intermuscular approach group. Some scholars believed that the atrophy and fat infiltration of the multifidus muscle delayed muscle activation, control, and coordination functions ultimately resulting in the instability of the spine[27]. The instability of the spine after surgery was believed to be the main reason of recurrent postoperative low back pain. Considering that the multifidus muscle itself has more split surfaces, we can reduce the damage of the multifidus muscle with blunt separation which can avoid the obvious atrophy of the paraspinal muscles and fat infiltration. Although the traditional fixation is a relatively classical treatment, some scholars have proposed that this fixation method had several disadvantages including screw loosening, high collapse of the injured vertebrae, and broken rods and screws. Therefore, we used the long-stage fixation across the injured vertebrae to reduce the suspension effect and parallelogram effect.

There were a few limitations to this study. The number of cases is small due to the specific criteria including TF without neurologic symptoms. This study lacked the evaluation of abundant paraspinal muscle tissue. In addition, some postoperative patients were lost during follow-up.

Conclusion

In short, this operation is suitable for TF without neurological symptoms. Preoperative manual reduction had advantages of restoring the height of injured vertebrae. Wiltse intermuscular approach can reduce intraoperative BV, shorten OT, and reduce paraspinal muscle damage. With the basis of traditional posterior approach, it is easy to grasp this technique for surgeons and promotion should be recommended in conforming with minimally invasive approaches of recent years.

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