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ORIGINAL

STUDY ON THE EFFICACY OF PERCUTANEOUS PEDICLE SCREW FIXATION AND TRANSMUSCULAR INTERSTITIAL PEDICLE SCREW FIXATION WHEN TREATING THORACOLUMBAR FRACTURES

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ABSTRACT

Objective: To evaluate the efficacy of percutaneous pedicle screw fixation and intermuscular pedicle screw fixation in the treatment of thoracolumbar fractures. **Methods:** The clinical data of 72 patients with thoracolumbar fracture from March 2020 to March 2021 were analyzed retrospectively. According to the mode of treatment, they were divided into percutaneous pedicle screw fixation group (percutaneous pedicle screw fixation group) and transmuscular interstitial pedicle screw fixation group (transmuscular space fixation group), with 36 cases in each group. The sagittal index of injured vertebra, Cobb angle, perioperative parameters, serum index, degree of multiple laceration, visual analogue score (VAS) and oswestry disability index (ODI) score were compared before and after treatment. **Results:** The sagittal plane index of injured vertebral body at 3 days, 3 months and 12 months after treatment was higher than that before treatment, and the Cobb angle was lower than that before treatment. The incision length and intraoperative blood loss in the percutaneous group were lower than those in the intermuscular space group, while the operation time and the number of intraoperative fluoroscopy in the percutaneous group were significantly higher than those in the intermuscular space group ($P < 0.05$). After 3 days of treatment, the levels of creatine kinase (CK) and lactate dehydrogenase (LDH) in the intermuscular space permeation group were significantly lower than those in the percutaneous permeation group. After 12 months of treatment, the fat infiltration rate in the Intermuscular space group was lower than that in the percutaneous group ($P < 0.05$). Compared with

those before treatment, VAS score and ODI score decreased significantly at 1 week, 3 months and 12 months after treatment. **Conclusion:** Percutaneous puncture has the advantages of less trauma and short operation time, but it also has the risk of increasing radiation exposure. The intermuscular space pedicle screw fixation group had less fat infiltration.

KEY WORDS: Percutaneous; Pedicle screw fixation; Intermuscular; Thoracolumbar fracture; Curative effect.

INTRODUCTION

Thoracolumbar vertebral fracture is an obvious spinal injury and severe thoracolumbar fracture often leads to nerve injury (Shao et al., 2022). The reason is that the broken bone or intervertebral disc tissue enters the spinal canal, spinal canal invasion and vertebral body compression cause damage and spinal cord nerve in order to restore the injured nerve function. Timely surgical treatment is of great significance to reduce the injury of nerve function and to the prognosis.

Previous studies have found that percutaneous pedicle screw fixation is an effective surgical method for the treatment of thoracolumbar fractures, which is technically mature, safe and effective. Traditional open pedicle screw fixation is a mature method (Y. Wen et al., 2022). Some scholars have found that percutaneous pedicle screw fixation has some disadvantages, such as strong invasiveness, long incision, long operation time and so on, which can lead to injury of posterior branch of spinal nerve and paraspinal muscle radiculopathy (Laurita et al., 2022). In recent years, the surgical methods of percutaneous pedicle screw fixation and intermuscular interstitial pedicle screw fixation came into being and their curative effect has been confirmed by clinical research (Tu, Yan, Hao, Cao, & Jiang, 2022). Therefore, it is more and more widely adopted in clinic.

Previous studies have found that percutaneous pedicle screw fixation does not require extensive dissection of paraspinal muscles. Paraspinal muscles remain on the spinous process, avoiding prolonged muscle stretching, reducing damage to the blood supply of paraspinal muscles and cortical nerves, and making them less likely to cause extensive fibrosis of paraspinal muscles (Lu, Chen, Hu, & Sun, 2022). There will be no numbness and atrophy of paraspinal muscles, and the incidence of postoperative complications of spinal internal fixation is lower (Hirahata et al., 2022).

It also has the advantages of less trauma, less operative blood loss and faster postoperative recovery (Malit Jr, Alawad, & Naufal, 2017; Shi, Shen, Chen, Zhou, & Dai, 2022). It is found that common pedicle screw fixation through intermuscular space is developed on the basis of

traditional pedicle screw fixation and percutaneous pedicle screw fixation, which combines traditional internal fixation with minimally invasive percutaneous fixation. Intermuscular space approach pedicle internal fixation is generally performed under direct vision, because the operator can observe the operation in real time, so the operation is safe for patients (Wen, Jiang, Zhou, Teng, & Zhao, 2022; Wu et al., 2022).

The intermuscular space approach is adopted to reduce iatrogenic trauma and medical costs to a greater extent (Dong et al., 2022). This study will compare the effects of percutaneous pedicle screw fixation and trans muscular space approach pedicle screw fixation and analyze their advantages and disadvantages (de Lourdes Chauffaille, 2017).

1 PATIENTS AND METHODS

1.1 General information

72 patients with thoracolumbar fracture were hospitalized from Mar. 2020 to Mar. 2021. According to the mode of treatment, the patients were classified into percutaneous pedicle screw fixation group (percutaneous group) and trans muscular interstitial pedicle screw fixation group (trans muscular space group). There were 36 patients in each group. In the percutaneous group, there were 21 males and 15 females whose ages ranged from 26 to 62 years (mean age =50.72±5.29). The fracture locations of the percutaneous group included 5 cases of T10, 4 cases of T11, 9 cases of T12, 14 cases of L1 and 4 cases of L2. There were 20 males and 16 females in the intermuscular gap group, whose age was 27 to 60 years old (mean age =51.04 ±5.35). the fracture locations of the intermuscular gap group consisted of 4 cases of T 10, 5 cases of T 11, 10 cases of T 12, 13 cases of L1 and 4 cases of L2. This study was permitted by the Medical Ethics Association of our hospital and all patients noticed informed consent.

Selection criteria: 1) the cases who could tolerate general anesthesia; 2) preoperative routine examination of thoracolumbar X-ray CT, MRI and other imaging data, diagnosed as single segment fresh vertebral fracture; 3) surgical treatment within 1 week after fracture occurred; 4) traumatic vertebral fracture with injury time less than one week.

Exclusion criteria: 1) patients with severe osteoporosis; 2) patients with pathological fracture. 3) multi-segmental thoracolumbar fractures; 4) patients who did not reach the follow-up time point, patients who lost follow-up, or patients whose case data were not collected completely.

1.2 Treatment methods

All the patients were examined by X-ray, CT, MRI and so on before

operation. Enhancements of the preoperative routine examination, the patient's physical signs were in line with the operative conditions, routine infusion of antibiotics 30 minutes before the operation. Percutaneous pedicle screw fixation: general anesthesia was given; the prone position was taken and the abdomen was suspended. Under the C-arm X-ray, the location of the injured segment of the thoracolumbar spine was determined according to the fluoroscopy.

The injured vertebrae, adjacent upper and lower vertebrae and bilateral pedicles were located on the patient's skin. The surface projection of the upper and lower vertebral pedicle of the fracture was marked with metal standard square grid, routine disinfection, longitudinal incision, about 1.5cm, incision of skin, subcutaneous and deep fascia, separation from the space between the multifidus muscle and the longest muscle to the articular process and transverse process. Under the guidance of X-ray fluoroscopy of the shaped arm, the needle tip was placed at the outer edge of the pedicle projection in all vertebrae (i.e.,10:00 on the left and 2 o'clock on the right) with an introversion of 10°-15°.

After puncturing the vertebral body parallel to the endplate, the puncture needle enters the bone 2 cm and fluoroscopy confirms that the tip of the puncture needle has not breached the medial cortex of the pedicle projection. Lateral fluoroscopy confirms that the puncture needle is parallel to the internal plate and the puncture is continued to 1.0 cm anterior to the posterior border of the vertebral body. Pull out the inner core, place the guide wire, remove the puncture needle, place the expansion tube and protective cannula, hollow wire to expand the screw path, then screw the pedicle screw into the vertebral body through the guide wire, and remove the guide wire.

The fluoroscopy of the C-arm X-ray machine confirmed that the screw position was good. The rod was installed and placed the nut in turn, the stretcher was applied to open and reset. The nut was fixed after the reduction was satisfactory and the wound can be closed subcutaneously with absorbable line. The internal fixation system was purchased from Shanghai Sanyou Company.

After operation, antibiotics were routinely injected intravenously to prevent infection, dressing was changed every other day and the drainage was closely observed. After 48-72 hours, it was removed. On the first day after operation, brace could be worn to get out of bed for proper activities to reduce postoperative complications and assist patients to recover. The anterior and lateral radiographs of the whole spine, thoracic vertebrae and lumbar vertebrae were taken on the 3rd day after operation. If there was no abnormality, if the patient had no special discomfort after 1-2 days of observation, he could be followed up outside the hospital. Routine follow-up was performed at 7 days, 3

months, 6 months and 12 months after discharge.

1.3 Observation index

1.3.1 Comparison of sagittal plane index of injured vertebrae

The patients were examined by X-ray, CT 3D reconstruction and MRI before treatment and X-ray and CT 3D reconstruction after treatment. The sagittal plane index (VSI) of injured vertebrae was calculated by measuring the height of anterior and posterior edge of injured vertebrae before treatment and 3 days, 3 months and 12 months after operation.

The height of the anterior edge of VSI= injured vertebral body/the height of the posterior edge of injured vertebral body. If the posterior edge of the vertebral body is also compressed, the average height of the posterior edge of the adjacent upper and lower vertebral body is taken as the posterior edge height of the injured vertebra.

1.3.2 Comparison of Cobb angle

The patients were examined by X-ray, CT 3D reconstruction and MRI before treatment, and X-ray and CT 3D reconstruction after treatment. The sagittal plane kyphosis Cobb angle of the patients was measured by positive and lateral X-ray films before treatment and 3 days, 3 months and 12 months after operation. The Cobb angle of injured vertebrae was measured. The vertical line of the extension line was made on the upper endplate of the injured vertebra and the vertical line of the lower vertebral body of the injured vertebra was made. The angle of intersection of the vertical lines was Cobb angle.

1.3.3 Comparison of perioperative parameters

The perioperative parameters such as incision length, operation time, intraoperative blood loss and fluoroscopy times were recorded.

1.3.4 Comparison of serum indexes before and after operation

The levels of creatine kinase (CK) and lactate dehydrogenase (LDH) were compared before and 3 days after treatment.

1.3.5 Comparison of the injury degree of polypide muscle before and after operation

The net cross-sectional area of cleft muscle and the percentage of fat infiltration were compared before treatment and 12 months after treatment.

1.3.6 Comparison of VAS score before and after operation

Visual analogue score (VAS) was adopted to evaluate the pain degree of

the two groups before treatment, 1 week after treatment, 3 months after treatment and 12 months after treatment (M. Zhang et al., 2022).

1.3.7 Comparison of ODI score before and after operation

Oswestry disability index (ODI) was adopted to evaluate the dysfunction (Linhart et al., 2022).

1.4 Statistical analysis

All the data were analyzed by SPSS26.0 statistical program. The measured data were presented by mean ±standard deviation ($\bar{x}$±s). The independent sample t-test was adopted for comparison. The counting data were presented as a percentage and the comparison was made by χ2 test. P<0.05 indicated that the difference exhibited statistically significant.

2 RESULTS

2.1 The sagittal plane index of injured vertebrae

There exhibited no significant difference in the sagittal index of injured vertebrae before treatment, 3 days after treatment, 3 months after treatment and 12 months after treatment (P>0.05). The sagittal index of injured vertebrae in both groups was higher compared to before treatment at 3 days, 3 months and 12 months after treatment (P<0.05). All the data results are indicated in Table 1.

Table 1 comparison of sagittal plane index of injured vertebrae ($\bar{x}$±s)

Group	N	Before treatment	3 days after treatment	3 months after treatment	12 months after treatment
Percutaneous group	36	0.61±0.18	0.87±0.17#	0.97±0.17#	0.96±0.29#
Intermuscular space group	36	0.57±0.23	0.89±0.19#	0.94±0.15#	0.91±0.27#
t		0.822	0.471	0.794	0.757
P		0.414	0.639	0.430	0.452

Note: # is compared with that before treatment, P<0.05.

2.2 The Cobb angle

There exhibited no significant difference in Cobb angle before treatment, 3 days after treatment, 3 months after treatment and 12 months after treatment (P>0.05).

However, the Cobb angle was lower compared to before treatment at 3 days, 3 months and 12 months after treatment (P<0.05). All the data are indicated in Table 2.

Table 2 comparison of Cobb angle ($\bar{x}$±s)

Group	N	Before treatment	3 days after treatment	3 months after treatment	12 months after treatment
Percutaneous group	36	18.21±2.83	8.14±1.81#	7.51±1.17#	7.93±1.59#
Intermuscular space group	36	18.75±2.59	8.28±1.92#	7.64±1.19#	8.01±1.72#
t		0.845	0.318	0.467	0.205
P		0.401	0.751	0.642	0.838

Note: # is compared with that before treatment, P<0.05.

2.3 The perioperative parameters

The incision length and intraoperative blood loss in the percutaneous group were lower compared to the trans muscular space group, while the operation time and the number of intraoperative fluoroscopy in the percutaneous group were remarkably higher compared to the trans muscular space group (P<0.05). All the data results are indicated in Table 3.

Table 3 comparison of perioperative parameters ($\bar{x}$±s)

Group	N	Notch length(cm)	Operation time(min)	Intraoperative bleeding(mL)	Perspective (times)
Percutaneous group	36	2.21±0.52	120.18±9.89	28.19±3.26	8.23±2.15
Intermuscular space group	36	8.16±1.13	72.62±4.37	132.38±24.27	3.54±1.16
t		28.700	25.837	25.528	11.519
P		0.000	0.000	0.000	0.000

2.4 The serum indexes before and after operation

There exhibited no significant difference in the levels of CK and LDH before treatment(P>0.05). But the levels of CK and LDH in the Intermuscular space group were lower compared to the percutaneous group 3 days after treatment (P<0.05). All the data are indicated in Table 4.

Table 4 comparison of serum indexes before and after operation ($\bar{x}$±s)

Group	N	CK(U/L)		LDH(U/L)	
		Before treatment	3 days after treatment	Before treatment	3 days after treatment
Percutaneous group	36	126.72±50.19	296.43±57.68	224.25±26.71	306.74±62.18
Intermuscular space group	36	118.95±32.44	265.42±46.39	215.39±24.83	271.58±59.64
t		0.780	2.525	1.458	2.449
P		0.438	0.014	0.149	0.017

2.5 The injury degree of polyfida muscle before and after operation

There exhibited no significant difference in the net cross-sectional area and the percentage of fat infiltration before treatment (P>0.05). At 12 months after treatment, there exhibited no significant difference in the net cross-sectional area of poly-cleft muscle between the Intermuscular space group and the percutaneous group (P>0.05), but the percentage of fat infiltration was remarkably lower compared to the percutaneous group (P<0.05). All the data are indicated in Table 5.

Table 5 comparison of the injury degree of polypide muscle before and after operation ($\bar{x}$±s)

Group	N	Net cross-sectional area of cleft muscle（mm^2）		Percentage of fat infiltration（%）	
		Before treatment	12 months after treatment	Before treatment	12 months after treatment
Percutaneous group	36	362.95±91.44	333.92±89.73	21.49±4.93	38.45±7.41
Intermuscular space group	36	398.76±89.28	369.57±87.52	20.57±5.14	31.84±5.56
t		1.681	1.706	0.775	4.281
P		0.097	0.092	0.441	<0.01

2.6 Comparison of VAS score before and after operation

There exhibited no significant difference in VAS score before treatment, 1 week after treatment, 3 months after treatment and 12 months after treatment (P>0.05). However, compared with those before treatment, it was found that the VAS scores of the two groups decreased remarkably at 1 week, 3 months and 12 months after treatment (P<0.05). All the data results are indicated in Figure 1.

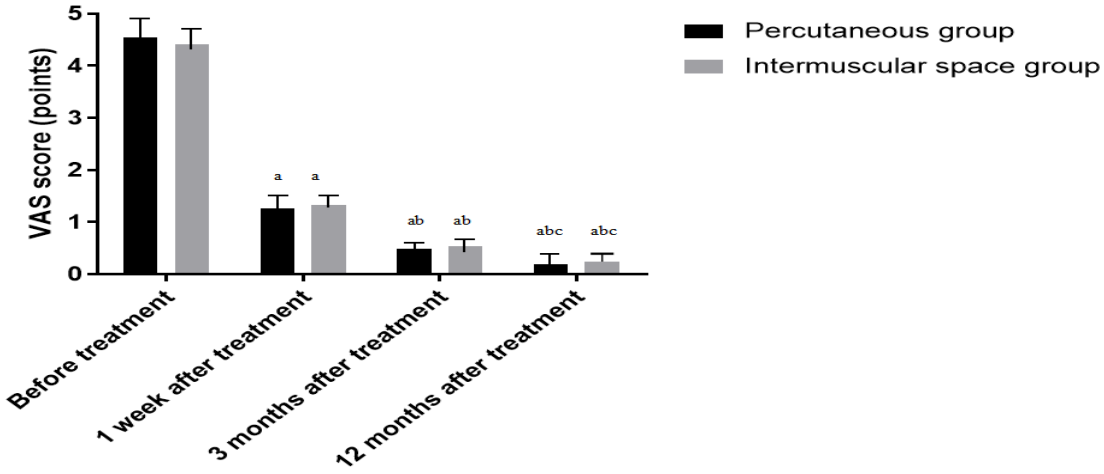

Figure 1. Comparison of VAS score before and after operation There exhibited no significant difference in VAS score before treatment, 1 week after treatment, 3 months after treatment and 12 months after treatment (P>0.05). However, compared with those before treatment, it was found that the VAS scores of the two groups decreased remarkably at 1 week, 3 months and 12 months after treatment (P<0.05).

2.7 Comparison of ODI score before and after operation

There exhibited no significant difference in ODI score before treatment, 1 week after treatment, 3 months after treatment and 12 months after treatment (P>0.05). However, compared with those before treatment, it was found that the ODI scores of the two groups decreased remarkably at 1 week, 3 months and 12 months after treatment (P<0.05). All the data results are indicated in Figure 2.

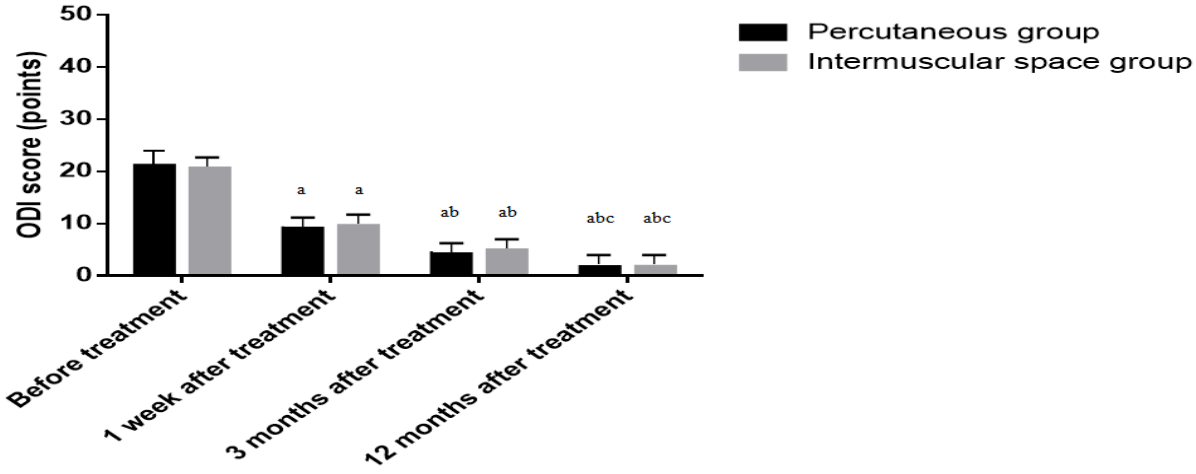

Figure 2.Comparison of ODI score before and after operation

There exhibited no significant difference in ODI score before treatment, 1 week after treatment, 3 months after treatment and 12 months after treatment (P>0.05). However, compared with those before treatment, it was found that the ODI scores of the two groups decreased remarkably at 1 week, 3 months

and 12 months after treatment (P<0.05).

3 DISCUSSION

Relevant data has displayed that spinal fracture is a relatively common fracture, accounting for about 6% of systemic fractures. The most obvious spinal fracture is thoracolumbar fracture, which is mainly determined by its special anatomical structure. Its predilection site is the combination of the physiological curvature of the thoracic vertebrae and the physiological curvature of the lumbar spine, which may have something to do with the greater range of motion here (Hamdan, Mahmoud, Tammam, & El-Khateeb, 2021). The surgical method of lumbar posterior open pedicle screw operation for the treatment of thoracolumbar fracture has been relatively mature in clinic. The biggest advantage is that the posterior anatomy is simple, the visual field is clear and it is convenient for distraction and reduction of injured vertebrae (Aigner et al., 2021; Kim, 2021; R.-J. Zhang et al., 2022). However, the destruction of surrounding soft tissue and long-term traction caused muscle atrophy and fibrosis due to loss of nerve innervation and ischemic necrosis. And the destruction of the surrounding soft tissue has also become an obstacle to early functional activity (Cook et al., 2021; Li et al., 2021; Ruf et al., 2021). The clinical application of minimally invasive pedicle screw fixation confirms that minimally invasive surgery can first avoid most arterial vessels and ensure the least bleeding during operation. Compared with traditional surgery, the introduction of minimally invasive surgery reduces the dissociation and injury of muscle and fascia around the vertebral body, which not only promotes the prognosis and recovery time of patients, but also reduces the pain feeling of patients after operation and increases compliance (Noriega et al., 2021; Sasagawa, Takagi, Hayashi, & Nanpo, 2021). The pedicle screw technique can provide safe and effective stable fixation for the three columns of the spine, better correction of fracture deformities and faster recovery of patients. Therefore, it can avoid complications caused by conservative treatment or unreliable pedicle screw fixation for a long time, so it is widely adopted in clinic (Yao et al., 2022).

The paraspinal muscle space approach can reduce the injury of paraspinal muscle, which has been applied in clinic and achieved good therapeutic effect (Lin et al., 2021; Sezer & Sezer, 2021). Wiltse approach can effectively avoid extensive peeling of paraspinal muscles, electric burn and long-term mechanical compression of automatic retractor. In the case of complete sarcolemmal coverage, as long as strictly along the intermuscular approach, muscle injury can be effectively avoided (Yan et al., 2021). The Wiltse approach is in the space between the longissimus and the bifida muscle at 2-3.0cm beside the posterior midline, which the number of blood vessels is the least. The vertebral body reduction and pedicle screw fixation during the operation are exactly the same as the posterior median approach, which can effectively

restore the height of the vertebral body. In addition, this operation shortens the time of operation and greatly reduces the probability of postoperative low back pain. Percutaneous pedicle screw fixation is a treatment guided by guide wire through muscle approach. In actual operation, only four small incisions of about 1.5 cm are made longitudinally on the skin of the injured segment of low back. Percutaneous pedicle screws and connecting rods were placed under X-ray fluoroscopy. The vertebral body was reduced and fixed by predetermined screw angle and distraction system. This operation has the advantages of small injury of paraspinal muscles and ligaments, complete preservation of posterior column structure, less blood loss during operation, low postoperative infection rate, less postoperative pain and so on. With the help of surgical fluoroscopy navigation, the entry angle of pedicle screws can be calculated and the angle between two pedicle screws can be determined to reach 15-20 degrees, so as to ensure that the degree of correction can reach 30 degrees and prevent the fixation rod from bending due to uneven force (York, Shah, Pragga, & Toscani, 2022).

The main causes of low back pain in patients with thoracolumbar vertebral fracture after operation are as follows: (1) the decline of multifid muscle function and injury and contraction are the close factors of low back pain. In the posterior spinal surgery, it is necessary to extensively peel off the multifissure muscle, resulting in damage to the posterior branch of the lumbar artery and the posterior medial branch of the spinal nerve, resulting in denervated muscle atrophy and chronic low back pain after operation. Additionally, pulling for a long time can easily lead to excessive ischemia of paraspinal muscles, ischemic necrosis of muscles, uneven stress on both sides of the spine, destruction of normal physiological characteristics, vasospasm of low back muscles and reduction of local oxygen supply over time. Thus, producing inflammatory substances, the emergence of low back pain symptoms; (2) when the posterior medial spinal nerve branch is stimulated, it will produce low back pain. In the course of operation, in order to ensure the accuracy of the nail position, it is often necessary to extensively peel off and pull the muscles on both sides and electrocoagulation to stop bleeding, so that the upper and lower facet joints and transverse processes of the corresponding segments are completely exposed. It is very easy to damage the posterior branch of the spinal nerve in the corresponding segment. In the meantime, muscle traction and electrocoagulation hemostasis will cause compression of the bony fiber canal passing through the posterior branch of the spinal nerve, irritation of the posterior branch of the spinal nerve and low back pain after operation; (3) The lesion of vertebral facet joint is an important factor of low back pain. The facet joint of thoracolumbar vertebrae is composed of synovium, fibrous capsule, articular space and cartilage, which is controlled by superior 1-2 segments and nerve fibers of the same segment. During the posterior lumbar surgery, it will cause damage to the midline structure of the corresponding segment of the spine, resulting in a decrease in the stability of the spine. Moreover, a large

number of stripped muscles will form a large number of scars and local cord-like induration, which will reduce the movement coordination of muscles on both sides of the spine, cause stress changes in the posterior column of the spine to make secondary changes in the facet joints of the spine. Fracture will inevitably cause damage to the surrounding local soft tissue, and its severity is directly related to the recovery of fracture and the preservation of motor function in the later stage. It is one of the important indicators to judge the degree of fracture and prognosis. The degree of damage and even necrosis can be reflected by serum CK, which is mainly distributed in skeletal muscle and myocardium. Serum CK is an important enzyme in human body, in which skeletal muscle is the most abundant, accounting for 96% of the whole-body content. It is the catalyst for the reaction of ATP with creatine. In myocardial injury and severe muscle injury, CK will increase greatly and accordingly. Soft tissue injury can also increase the probability of wound infection, aggravate tissue injury and even muscle necrosis. Serum CK is regarded as an indication of tissue debridement and curative effect evaluation index. Creatine phosphokinase in normal serum mainly enters the blood through the cell membrane of skeletal muscle and cardiomyocytes with a normal value of less than 100 units per liter of blood. Therefore, the level of serum CK in patients in this study effectively reflected the postoperative soft tissue injury. The muscle cell membrane is damaged, which promotes the release of CK from the cells and into the blood circulation.

In this study, the injury degree of paraspinal muscles was evaluated by a series of direct or indirect methods, such as perioperative parameters, serum indexes and the degree of multiple muscle injury. The curative effect of fracture was evaluated by sagittal index, Cobb angle, VAS score and ODI score before and after fracture operation. The results showed that the sagittal index of injured vertebrae after treatment was higher than that before treatment, and the Cobb angle was lower than that before treatment. The incision length and intraoperative blood loss in the percutaneous group were lower compared to the trans muscular space group, while the operation time and the number of intraoperative fluoroscopies in the percutaneous group were remarkably higher compared to the trans muscular space group. Three days after treatment, the levels of CK and LDH in the Intermuscular space group were lower compared to the percutaneous group. In 12 months after treatment, the percentage of fat infiltration in the Intermuscular space group was lower compared to the percutaneous group.

Conclusively, when treating thoracolumbar fractures with percutaneous pedicle screw fixation and transmuscular pedicle screw fixation, the sagittal index and Cobb angle of the injured vertebrae were well recovered. The postoperative ODI and VAS scores were remarkably lower than those before operation. The percutaneous cases had less trauma and intraoperative blood loss, but operation time and fluoroscopy times were increased. Three days after

treatment, the levels of CK, LDH and the percentage of fat infiltration in the Intermuscular space group were lower compared to the percutaneous group. The two groups have definite curative effect when treating thoracolumbar fracture. It has a certain guiding significance for the treatment of clinical thoracolumbar vertebral fracture.There are some limitations in this study. First, the sample size of this study is not large and it is a single-center study, so bias is inevitable. In future research, we will carry out multi-center, large-sample prospective studies, or more valuable conclusions can be drawn.

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