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Original Article

The effect of intervertebral disc injury on the percutaneous pedicle screw fixation in the operative treatment of thoracolumbar fractures

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Abstract: Objective: This study aimed to explore the effect of intervertebral disc injury on the percutaneous pedicle screw fixation in treating thoracolumbar fractures. Methods: A total of 100 patients received percutaneous pedicle screw fixation for the treatment of thoracolumbar fractures in our hospital were selected and divided into experimental group (intervertebral disc injury, 56 cases) and control group (non-intervertebral disc injury, 44 cases) based on the presence of intervertebral disc injury. A retrospective analysis of the X-ray and MRI results among patients at preoperative stage, 2 months and 12 months after operation, and 6 months after removal was performed. The vertebral wedged angle (VWA), the sagittal plane kyphosis (SPK), proximal intervertebral disc angle (PIA), Sagittal index (SI), and classification of intervertebral disc degeneration were compared and analyzed between the two groups. Results: No significant difference was found in VWA in patients at preoperative stage, 2 months and 12 months after operation, and 6 months after removal between the two groups ($P > 0.05$); The SPK, PIA, and SI in the experimental group at preoperative stage, 12 months after operation, and 6 months after removal were significantly higher than those in the control group ($P < 0.05$); the grading of intervertebral disc degeneration in the experimental group at 12 months after operation and 6 months after removal significantly increased compared with that in the control group ($P < 0.05$); No significant difference was found in adverse reaction between the two groups ($P > 0.05$). Conclusion: Obvious kyphosis was noted in patients underwent percutaneous pedicle screw fixation. The incidence rates and severity of kyphosis in patients with intervertebral disc injury were much higher than those without intervertebral disc injury. The reasons behind this could be related to the degeneration of intervertebral disc from the injury.

Keywords: Intervertebral disc injury, thoracolumbar fracture, clinical treatment, percutaneous pedicle screw fixation, therapeutic effect, impact

Introduction

The spine, also known as the vertebral column, is a column of 26 vertebrae and 1 coccygeal vertebra connected by ligaments, joints, and intervertebral discs [1]. The functions of spine include support for the trunk, protection of the internal organs and spinal cord, and movement. There is a vertical spinal canal that runs top to bottom through the spinal column, which contains the spinal cord. With the continuous development of industrial construction and transportation, the incidence rates of varied spinal cord injuries have increased significantly. Thoracolumbar fracture is a common type of spinal fractures and accounts for 10%-20% of spinal trauma. Fractures at thoracic segment T1 to T2 are the most common [2]. Studies indicated that the spinal stability in patients was often compromised after the thoracolumbar fractures, which led to high disability rate and serious impact on the quality of lives in patients. Therefore, operative treatment was recommended in clinical practice to improve the stability of the fractured vertebrae and restore the daily activates of the patients to the maximum extent [3].

Percutaneous pedicle screw fixation is one of the common minimally invasive operative treatments for thoracolumbar fractures. This treatment could effectively improve the loss of

height and angle of sagittal deformity in the spinal fracture as well as alleviate the vertebral injury in the thoracolumbar fracture. In recent years, increased studies have shown that intervertebral disc injury could have significant impact on the prognosis of the patients with thoracolumbar fractures [4]. High incidence rates of delayed kyphosis were also found in some of the patients with thoracolumbar fractures. A follow-up of 219 patients with thoracolumbar fractures indicated compromised spinal stability and significant loss of disc height in patients after surgeries. Some other studies have indicated that patients with thoracolumbar burst fractures often had disc height loss. These patients were often found to have poor spinal angle correction during the follow-up [5, 6].

Currently, clinical studies of thoracolumbar fractures are mainly focused on the treatment of the fracture and improvement of clinical symptoms, but there were few studies on the correction of intervertebral disc injury, and the effect of disc injury on the function of the vertebrae [7]. This study aimed to analyze the effect of intervertebral disc injury on the percutaneous pedicle screw fixation in treating thoracolumbar fractures and provide the reference for improving the prognosis of patients with thoracolumbar fractures through comparative study.

Materials and methods

General data

A total of 100 patients with thoracolumbar fracture, who received operative treatment in out hospital from January 2017 to December 2018, were selected. Retrospective analysis was performed. The patients were divided into the experimental group (intervertebral disc injury, 56 cases) and the control group (no disc injury, 44 cases).

Inclusion criteria: (1) Patients were diagnosed with thoracolumbar fractures by radiographic imaging; (2) age ≤ 55 years old; (3) patients were conscious and could cooperate with the study; (4) approval from the hospital ethics committee for the process and methods; (5) the patients or family members signed informed consent.

Exclusion criteria: (1) Patients with mental illness; (2) ≥ 50% occupation of the spinal canal and neurological impairment; (3) Patients with longitudinal ligamentous complex; (4) Patients treated with bone grafting or intervertebral disc fusion during surgery; (5) patients with systemic disease or acute/chronic infection; (6) history of pharmacotherapy for thoracolumbar or paravertebral fractures; (7) Patients with nonunion fracture or pathologic fracture.

Exclusion criteria: (1) Patients who were lost to follow-up during the study; (2) patients who voluntarily quitted during the study; (3) death cases during the study; (4) patients with screw or rod breakage during the study, which led to reoperation.

Intervention method

Percutaneous pedicle screw fixation was performed on patients from both groups with surgeons from the team of spine surgery in our hospital. The patients were informed with the surgical plan and risk before the operation and signed the operative informed consent. The patient was intubated and put under general anesthesia. The patient was placed in a supine position. Median incision was made at the site of vertebral fracture, and the pedicel screws were placed in the neighboring vertebras to achieve reduction of the fracture. Then, the pedicle screw was fixed to the connecting rods. The wound was cleansed with the surgical drain, and the incision was stitched. The patient was closely monitored for 24 hours after surgery and treated with routine antibiotics to prevent infection. Urine output and drainage were recorded. Patients were assisted to walk 2 weeks after surgery. The implant for internal fixation was removed 12 months after surgery.

Assessment parameters and evaluation standards

Classification of intervertebral disc injury: Sander's classification of intervertebral disc lesions was adopted to evaluate the disc injuries in the patients. Grade 0 indicated no signal or morphological changes on both T1W1 and T2W2, and no disc injury; grade 1 indicated no change in signal on T2W1 and increased signal intensity on T2W1, and disc edema; grade 2 depicted hyperintense appearance on T1W1 and mild signal on T2W1 with hyperintense appearance of the surrounding of the lesion, which indicated annular tear of the disc with hemorrhage;

Grade 3 depicted hyperintense appearance on T1W1, and intense signal on T2W1 with hyperintense appearance of the surrounding of the lesion, which indicates disc invasion into the endplate, leading to tearing of the vertebral body. In this study, grade 0 was considered as no disc injury, and grade 1-3 was considered as disc injury [8, 9].

Angle changes in vertebral fractures: The vertebral wedged angle (VWA), the sagittal plane kyphosis (SPK), proximal intervertebral disc angle (PIA), and Sagittal index (SI) in patients at preoperative stage, 2 months after operation, 12 months after operation, and 6 months after removal were recorded, in which VWA depicted the angle between the upper endplate and lower endplate of the vertebra, SPK was the angle between the anterior superior endplate and anterior endplate of the upper adjacent vertebra; PIA depicted the angle of the upper adjacent disc, and SI depicted the proportion of PIA in the sagittal plane kyphosis.

Comparison in the adverse reaction rates after the surgery: The adverse reactions such as wound infections, rejection of the implant for internal fixation, loosening of internal fixation, and etc. between the two groups were summarized, and the difference between the two groups were compared.

Statistical methods

The collected data were inputted into Excel 2019. The SPSS 22.0 statistical software was used to perform statistical analysis. The counting data were represented as n%, and the difference in groups was analyzed with chi-square test. The measurement data were expressed as $x \pm s$. The difference between two groups was analyzed with independent t test, the difference in continuous variables was analyzed with independent-samples t test, and the classification of intervertebral disc degeneration was assessed with Mann-Whitney U test. $P < 0.05$ was considered as statistically significant [10].

Results

Comparison of the difference in the general clinical data of two groups

The comparison indicated that the difference in gender, average age, average weight, education level, family income, marital status, and underlying health conditions between the two groups were not statistically significant ($P > 0.05$), and was comparable (**Table 1**).

Comparison of dynamic records and intra-group differences of VWA between the two groups

The analysis indicated no significant difference in VWA in patients at preoperative stage, 2 months after operation, 12 months after operation, and 6 months after removal between the two group ($P > 0.05$). Comparisons indicated that the VWA in patients at 2 months after operation, 12 months after operation, and 6 months after removal significantly decreased in both groups ($P < 0.05$) (**Figure 1**).

Comparison of the intra-group difference and dynamic records of SPK between two groups

The comparison indicated that the SPK in patients at preoperative stage, 12 months after surgery, and 6 months after removal from the experimental group was significantly higher than that from the control group ($P < 0.05$); Besides, change trend analysis indicated that the SPK was shown to have a decreasing trend in patients during the period of preoperative stage to two months after surgery, while have an increasing trend in patients during the period of 12 months after surgery to 6 months after removal (**Figure 2**).

Comparison of dynamic records and intra-group differences of PIA between the two groups

The comparison indicated that the PIA in patients at preoperative stage, 12 months after sugary, and 6 months after removal from the experimental group was significantly higher than that from the control group ($P < 0.05$), Dynamic changes of PIA in patients from both group indicated that the PIA was shown to have a decreasing trend in patients from experimental group during the period of preoperative stage to two months after surgery, while have an increasing trend during the period of 12 months after sugary to 6 months after removal. The PIA was shown to have a decreasing trend in patients from control group during the period

Table 1. Comparison of general clinical parameters in two patient groups ($\bar{x} \pm s$)/[n (%)]

General clinical information		Experimental group (n = 56)	Control group (n = 44)	t/X^2	*P*
Gender	Male	30	24	0.005	0.945
	Female	26	20		
Average age (years old)		41.11±3.28	41.21±3.34	0.106	0.781
Average weight (kg)		65.18±3.91	65.31±3.77	0.119	0.780
Average BMI (kg/m^2)		20.19±2.19	19.98±2.28	0.331	0.724
Education level	Literacy	2	2	0.781	0.441
	Primary school	8	6		
	Middle school	20	12		
	High school and above	26	24		
Marital status	Married	50	40	0.791	0.439
	Not married	6	4		
Reasons for injury	Traffic injuries	30	24	0.889	0.231
	high falls	16	14		
	bruise injury by heavy object	6	4		
	fall injury	4	2		
fractured Segment	T11	8	6	0.891	0.221
	T12	10	8		
	L1	12	8		
	L2	14	12		
	L3	12	10		

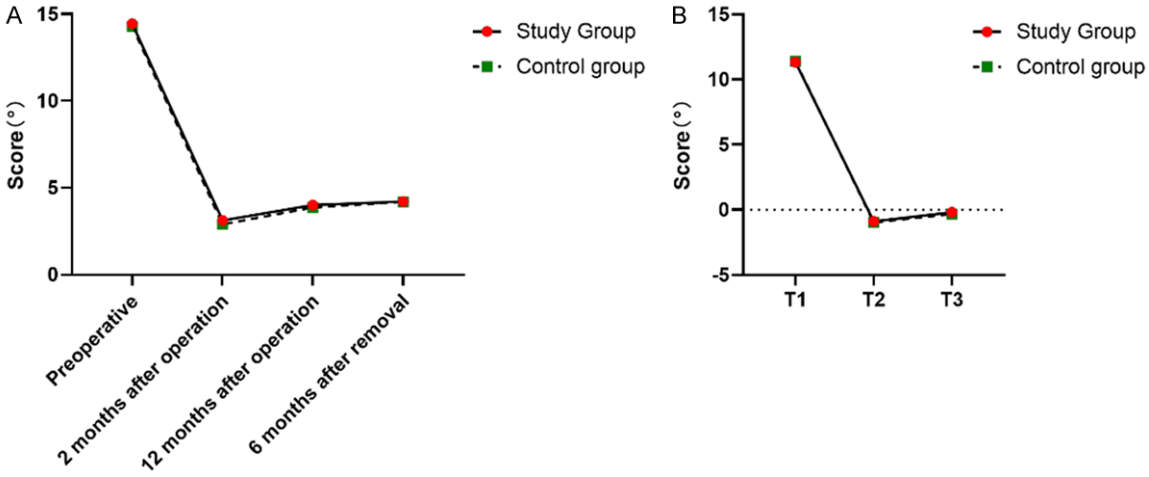

Figure 1. Comparison of dynamic records and inter-group differences of VWA between the two groups indicated no significant difference in VWA in patients at preoperative stage, 2 months after operation, 12 months after operation, and 6 months after removal between the two group (P > 0.05) (A); the change trend analysis of VWA at different time periods (T1 indicated the period of preoperative stage to 2 months after surgery, T2 indicated the period of 2 months after surgery to 12 months after surgery; T3 indicated the period of 12 months after surgery to 6 months after removal) indicated that the change of VWA was same in two groups at these three time period (B).

of preoperative stage to two months after surgery, while have a stabilizing trend during the period of two months to 12 months after surgery, and an increasing trend during the period of 12 months after surgery to 6 months after removal (**Figure 3**).

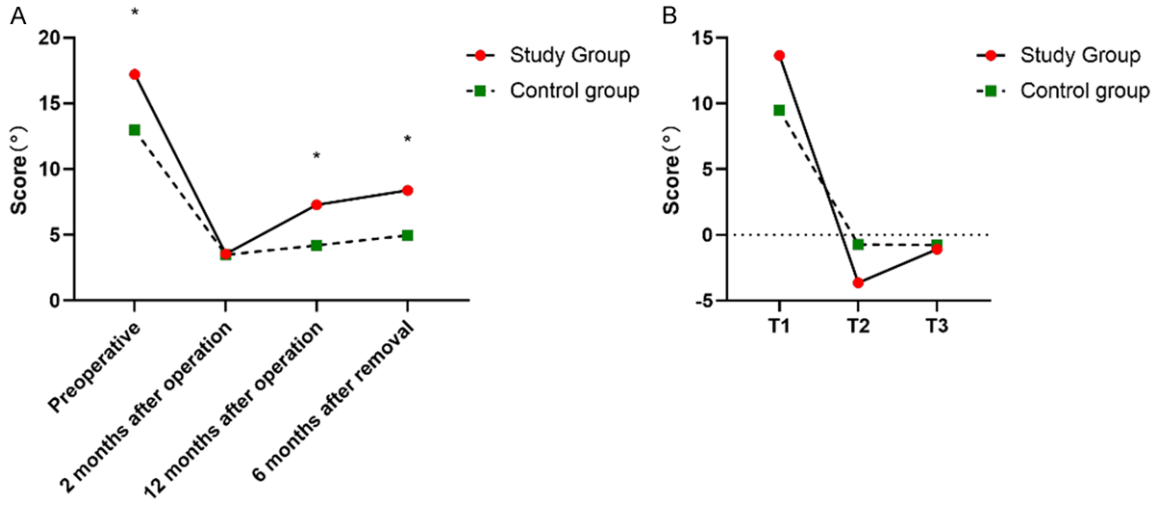

Figure 2. Comparison of the inter-group difference and dynamic records of SPK between two groups indicated that the SPK in patients at preoperative stage, 12 months after surgery, and 6 months after removal from the experimental group was significantly higher than that from the control group ($P < 0.05$). Besides, the change trend analysis of SPK indicated the changes of SPK in the experimental group at these three time periods were more significant. * indicated the difference between groups of the same parameter during the same time period is statistically significant.

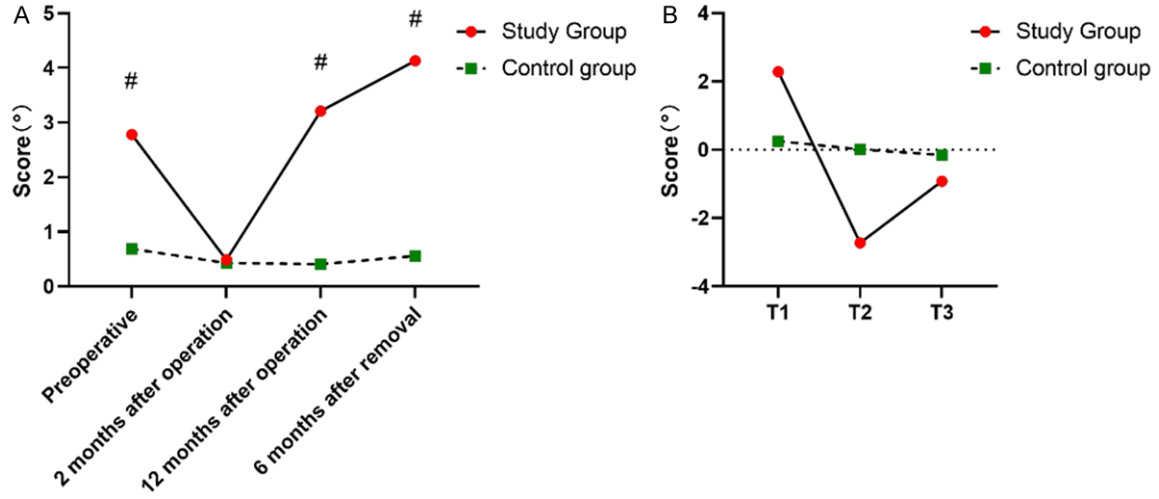

Figure 3. Comparison of dynamic records and intra-group differences of PIA between the two groups indicated that the PIA in patients at preoperative stage, 12 months after sugary, and 6 months after removal from the experimental group was significantly higher than that from the control group ($P < 0.05$) (A); Analysis of dynamic changes indicated the PIA had more significant variation at each time period in experimental group compared to the control group (B). # indicated the difference between groups of the same parameter during the same time period is statistically significant.

Comparison of dynamic records and intra-group differences of SI between the two groups

The comparison indicated that the SI in patients at preoperative stage, 12 months after sugary, and 6 months after removal from the experimental group was significantly higher than that from the control group ($P < 0.05$). Dynamic changes of SI in patients from both groups indicated that the SI was shown in have a decreasing trend in patients from experimental group during the period of preoperative stage to two months after sugary, while have an increasing trend during the period of 12 months after surgery to 6 months after removal. The SI

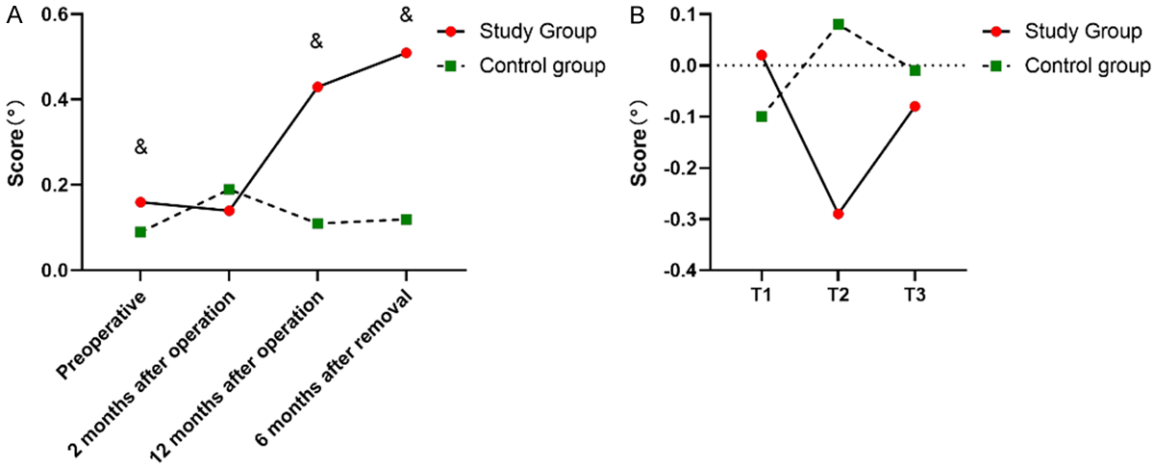

Figure 4. Comparison of dynamic records and intra-group differences of SI between the two groups indicated the SI in patients at preoperative stage, 12 months after sugary, and 6 months after removal from the experimental group was significantly higher than that from the control group ($P < 0.05$) (A); Analysis of dynamic changes of SI in patients indicated the SI in experimental group had more significant variation in these three time periods compared to control group (B). & indicated the difference between groups of the same parameter during the same time period was statistically significant.

Table 2. Comparison of classification of upper adjacent disc degeneration in two patient groups

Time period	Group	Grade of intervertebral disc degeneration					*F*	*P*
		I	II	III	IV	V		
Preoperative	Experimental group	42	12	2	0	0	0.980	0.778
	Control group	32	10	0	0	0		
2 months after surgery	Experimental group	16	24	16	0	0	2.343	0.043
	Control group	30	12	0	0	0		
12 months after surgery	Experimental group	4	30	14	8	0	4.319	0.011
	Control group	14	22	8	0	0		
6 months after removal	Experimental group	4	6	12	32	2	4.119	0.021
	Control group	12	20	12	0	0		

was shown to have an increasing trend in patients from control group from the period of preoperative stage to two months after surgery, a decreasing trend from the period of 2 months after surgery to 12 months after surgery, and no change during the period of 12 months after surgery to 6 months after removal (**Figure 4**).

The classification of upper adjacent disc degeneration in the two groups

A clinical follow-up was conducted on patients from both groups until 6 months after the removal. The analysis indicated that the grading of upper adjacent segment degeneration was shown to have an overall increasing trending with increased number of high-grade cases in both groups after the surgery. The Mann-Whitney U test of the classification indicated no significant difference in patients at preoperative stage and 2 months after sugary between the two groups ($P > 0.05$). However, the grading in patients from the experimental group at 12 months after operation, and 6 months after removal significantly increased compared to that in patients from the control group ($P < 0.05$) (**Tables 2**, **3**).

Discussion

Thoracolumbar fracture is a common type of fracture in orthopedics [11]. The symptoms of vertebral fractures could be improved by the percutaneous pedicle screw fixation, which accelerates the treatment outcomes in patients. Besides, this operative treatment had

Table 3. Differential analysis of classification of upper intervertebral disc degeneration in two patient groups

Group	n	Average grade			
		Preoperative	2 months after surgery	12 months after surgery	6 months after removal
Experimental group	56	20.29	23.98	28.98	28.67
Control group	44	19.87	17.66	14.33	14.38
Z value	-	0.518	1.289	4.098	4.331
P	-	> 0.05	> 0.05	< 0.05	< 0.05

less invasiveness and hemorrhage compared to the conventional treatment method. As a result, it was widely generalized and implemented in the clinical practice [12]. The intervertebral disc is the fibrocartilaginous joint between two adjacent vertebrae. It is composed of the exterior annulus fibrosus and the inner nucleus pulposus. The intervertebral disc plays an important role in stabilizing the spine and assisting movement. However, due to the poor vascular supply and relative isolation of the intervertebral disc, the exchange of substances could only be achieved through the microporous structure at the end plate, which was proved to be the largest structures in the body without a vascular supply [13, 14]. The incidence rate of intervertebral disc injury was high in patients with thoracolumbar fractures. In conventional operative treatment, clinicians often focus on the reduction and fixation of the fractured vertebra and neglect the diagnosis and treatment of the intervertebral disc injuries. Thus, researchers had indicated that the intervertebral disc injury could affect the prognosis of spinal fracture and could be one of the important reasons for the difference in the clinical efficacy among patients with thoracolumbar fractures [15, 16].

Many previous studies have shown that patients with thoracolumbar fractures are likely to suffer from intervertebral disc injury. When the spine is subjected to a violent impact, it not only leads to the rupture of the annulus fibrosus directly, but also induces secondary injury from high pressure in the disc caused by uncompressed nucleus pulposus [17, 18]. In current clinical practice, the percutaneous pedicle screw fixation achieves the treatment effect mainly by improving the loss of height and angle of sagittal deformity. However, low-term follow-up indicated that this treatment mainly focused on the fractured vertebra, while the injury of adjacent intervertebral discs remains untreated. This would increase the incidence rates of delayed kyphosis on the long term [19]. A follow-up of 219 patients with thoracolumbar fractures indicated compromised spinal stability in patients after surgeries. Other researchers also showed that the main reason of the reoccurrence of kyphosis is the loss of disc height. A 7 years follow-up study of 52 patients with thoracolumbar burst fracture indicated that the main reason for the loss of correction angle was the loss of intervertebral disc space [20, 21].

In this study, the patients were divided into two groups based on the presence of intervertebral disc injury to analyze the effect of intervertebral disc injury on the prognosis of patients after the percutaneous pedicle screw fixation, assess the degree of kyphosis in patients during long-term follow-up, and evaluate the difference in the intervertebral disc degeneration in two patient groups. It could be determined that the difference in VWA in patients at preoperative stage, 2 months after surgery, 12 months after surgery, and 6 months after removal was not significant, which indicated no significant effect of intervertebral disc injury on the VWA in patients with thoracolumbar fractures. However, the two groups were shown to have significant difference in SPK, PIA, and SI even at the preoperative stage with the parameters to be significantly higher in the experimental group. A retrospective analysis of patients with lumbar intervertebral disc herniation showed that the lumbar intervertebral disc is a mechanically stable tissue, and when there was no injury, its angle would not change significantly during weight bearing or heavy physical labor, but the angle of the posterior vertebral body would change after the disc injury, which could affect the spinal motion range of patients; therefore, for patients with vertebral body angle changes, timely intervention should be performed, and surgical treatment or conservative

treatment should be carried out to improve the prognosis of patients [22, 23]. We believed that disc injury would significantly affect the motion range of the vertebra, which was reflected by the changes in imaging parameters SPK, PIA, and SI.

Further analysis on the dynamic changes of the above three parameters in the two patient groups indicated no significant differences in SPK, PIA, and SI. The reason could be that the internal fixation ensured stable reduction of the fractured vertebra within two months after the surgery. The disc injury was not obvious in clinical symptoms, because the internal fixation allowed compensatory stabilization of the vertebra to some extent. However, comparison indicated the SPK, PIA, and SI in the experimental group were significantly higher than these in the control group at 12 months after surgery and 6 months after removal. This showed that the stability of injured intervertebral disc decreased overtime, which further affected the stability of the vertebra and eventually induced the occurrence of kyphosis. Some scholars have pointed out that it can be found in the follow-up of patients with lumbar intervertebral disc herniation that the lumbar spine angle of patients after intervention will still change to some extent, which is also one of the main reasons for postoperative recurrence of patients; therefore, it is suggested that patients should be regularly followed up after the surgery of intervertebral disc, so as to facilitate timely intervention if secondary lesions are found [24]. The study also analyzed the degree of kyphosis in the two patient patients. The data indicated that the degree of kyphosis was more significant in both groups at 6 months after removal compared to 2 months after surgery. This is consistent to the previous studies. Intergroup comparison showed that the SPK at 6 months after removal in experimental group was significantly higher than that in the control group. This showed that patients, who had intervertebral disc injury and did not receive active intervention, were more prone to severe kyphosis at later stage [25].

This study also compared the degree of intervertebral disc degeneration in the two patient groups. Several researchers have shown the intervertebral disc degeneration was closely correlated to the intervertebral disc injury. A multi-center retrospective analysis of patients with lumbar intervertebral disc herniation showed that local damage of the annulus fibrosis could reduce the pressure in the intervertebral disc, change its cellular structure and metabolism, and accelerate the progression of the intervertebral disc degeneration [26]. However, there are few studies on the degeneration of the adjacent intervertebral disc. The data in this study indicated no significant difference at preoperative stage and two months after sugary, while significant difference was shown in experimental group at 12 months after surgery and 6 months after removal. We believed that this was because the intervertebral disc injury significantly accelerated the progression of the intervertebral disc degeneration. As a result, it could be suggested that the intervertebral disc degeneration was closely correlated to the occurrence of kyphosis in patients. However, this could be affected by the physiological characteristics, change in mechanical properties and other factors and required further analysis.

In conclusion, obvious kyphosis was noted in patients treated with percutaneous pedicle screw fixation. The incidence rates and severity of kyphosis in patients with intervertebral disc injury were much higher than those in patients without the injury. The reasons behind this could be related to the degeneration of intervertebral disc from the injury. This study still has a few limitations as shown as following: (1) The sample size was relatively small which resulted in a lack of comprehensiveness in the results; (2) Lack of detailed classification of included samples, thereby neglecting the effect of occupation and lifestyle on the prognosis of patients with thoracolumbar fractures; (3) the follow-up duration was relatively short. Hence, a clinical study with a larger sample size and longer follow-up duration was planned to provide a more detailed clinical reference for the prognosis of patients with thoracolumbar fractures treated with percutaneous pedicle screw fixation.

Disclosure of conflict of interest

None.

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