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Original Article

Effect of nail placement in injured vertebrae combined with short segment internal fixation on clinical efficacy and related inflammatory factors in patients with thoracolumbar burst fracture

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Abstract: Objective: To investigate the effect of nail placement in injured vertebrae combined with short segment internal fixation on the clinical efficacy and related inflammatory factors in patients with thoracolumbar burst fracture. Methods: A total of 196 patients with thoracolumbar burst fracture in the Affiliated Zhongshan Hospital of Dalian University were collected for a prospective randomized controlled study and they were divided into two groups, with 98 cases in each group. The observation group was treated with nail placement through the injured vertebrae combined with short segment internal fixation, and the control group was treated with nail placement across the injured vertebrae combined with short segment internal fixation. Perioperative related indexes, anterior vertebral body height ratio and Cobb's angle before and after operation, TNF-α, IL-6, CRP levels, Oswestry disability index at the last follow-up and postoperative complications were recorded. Results: There was no difference in perioperative indexes between the two groups during and after operation (P>0.05). The level of inflammatory factors after operation was significantly higher than that before operation (P<0.05), but there was no difference between the two groups (P>0.05). There was no difference in the height ratio and Cobb's angle between the two groups before and one week after operation (P>0.05), but the height ratio of the observation group was higher than that of the control group one year after operation and two years after operation, while the Cobb's angle of the observation group was lower than that of the control group (P<0.001). The excellent and good rate of the Oswestry disability index score in the observation group was 90.52%, which is higher than that in the control group (80.21%, P<0.05). The incidence of fixation fracture in the observation group was lower than that in the control group (P<0.05). Conclusion: Compared with the control group, the treatment in the observation group of nail placement through the injured vertebra combined with short segment internal fixation in thoracolumbar burst fracture has better recovery effect, and the incidence of internal fixation fracture is low, which is worthy of clinical application.

Keywords: Thoracolumbar burst fracture, nail placement through the injured vertebrae, nail placement across the injured vertebrae, short segment internal fixation, clinical effect

Introduction

Thoracic and lumbar burst fracture refers to vertebral lamina fracture caused by trauma at the thoracic and lumbar spine [1, 2]. Among spinal fractures, 60% are thoracolumbar fractures, and about 18% are burst fractures, and the fractures are often accompanied by nerve injury and intervertebral disc injury [3, 4]. Operation is the best way to treat thoracolumbar burst fracture, including anterior, posterior and anterior vertebra combined with posterior operations [5]. Posterior pedicle screw fixation is the first choice of treatment for thoracolumbar burst fracture [6]. This operation is simple, minimally invasive and has less bleeding [7]. According to the different methods of segmental fixation during operation, it can be divided into a short segmental fixation and long segmental fixation [8]. Although the long segment fixation can effectively reduce the vertebrae height loss and prevent the fracture of the vertebral body from protruding backward, as such the mobility of the lumbar spine is limited due to the long segment of the fixed vertebral body [9]. However, short segment fixation is mainly internal fixation across injured vertebrae, although satisfactory results can be obtained in

the short term, some patients may have the risk of internal fixation failure, broken rod and broken nail in the long term [10]. In recent years, short segment internal fixation across injured vertebrae has been used in clinical practice. Some studies believe that this method can effectively avoid the failure of internal fixation in internal fixation across the injured vertebrae, but its long-term effect needs to be further verified [11].

Surgical trauma can cause an increase in the production of inflammatory mediators in the body, while some studies believe that the internal fixation of the injured vertebral body increases the trauma during operation and the release of inflammatory mediators, which is not conductive to postoperative recovery, so it is still controversial whether to place screws in the injured vertebrae [12]. Based on this, this study investigates the effects of short segment internal fixation combined with nail placement through injured vertebrae or nail placement across injured vertebrae on the clinical efficacy and inflammatory factors of patients with thoracolumbar burst fracture.

Materials and methods

General information

A total of 196 patients with thoracolumbar burst fractures admitted to the Department of Orthopedics and Traumatology of the Affiliated Zhongshan Hospital of Dalian University from May 2016 to May 2018 were collected for this prospective study. The patients were aged 20-74 years, and the average age was 49.2±6.4 years. They were divided into the observation group and the control group by a random number grouping method, with 98 cases in each group. The observation group was treated with nail placement through the injured vertebrae combined with short segment internal fixation; the control group was treated with nail placement across the injured vertebrae combined with short segment internal fixation. All the patients involved signed an informed consent, and the study was approved by the Ethics Committee.

Inclusion and exclusion criteria

Inclusion criteria: Patients with thoracolumbar burst fracture is diagnosed by CT or MRI; patients aged >18 years old; patients conforming to A3 and A4 types in the OA classification [13]; patients with the type of nerve function injury that accords with N2-N3 in the OA classification [13]; patients with thoracolumbar injury severity score system ≥5 points [14]; and the time from fracture to operation is within 3 weeks. Exclusion criteria: Patients who are not expected to tolerate surgery and have not undergone surgery; patients with severe heart, liver and kidney diseases; patients with osteoporosis; patients with a pathological fractures or open fractures; or patients with difficulty or inconvenience in the follow-up.

Surgical methods

Methods: After anesthesia, patients lay in a prone position with an empty lower abdomen, and the incision was made in the right-center behind the injured vertebrae to expose the injured vertebra and its upper and lower adjacent vertebral bodies. The Weistein method was used to determine the pedicle screw insertion point. In the control group, only four screws were placed in the upper and lower vertebral bodies of the injured vertebrae. In the observation group, four screws were placed in the upper and lower vertebral bodies of the injured vertebrae, and two screws were placed through the injured vertebra for fixation. After fixation, pre-bent connecting rods were placed on the inserted screws, and the vertebral fracture was reduced under the C-arm machine. After reduction, the transverse connecting rods were installed. After the fracture reduction was re-confirmed by C-arm machine, the wound in the operation area was washed, a negative pressure drainage tube was placed. The skin was sutured layer by layer.

Patients included in this study were followed up for at least 2 years, and the last follow-up deadline was May 2020. Patients were followed up every three months, and CT or MRI was done at reexamination.

Outcome measures

Primary outcomes: Perioperative indicators: (1) Time of operation: The time from the incision of the skin to the end of the suture. (2) Intraoperative blood loss: The amount of bleeding from the wound incision to the end of the suture. (3) Hospital stay: The number of days

Table 1. Comparison of general data between the two groups

Item	Observation group (n=95)	Control group (n=96)	χ^2/t	P
Age (years)	49.4±6.6	49.1±5.8	0.334	0.739
Gender (male/female)	57/38	55/41	0.144	0.704
Fracture site			0.270	0.966
T11	20	22		
T12	22	24		
L1	24	23		
L2	29	27		
Cause of disease			0.167	0.920
Fall injury from height	23	23		
Fall injury	30	28		
Traffic accident injury	42	45		
Fracture type			0.893	0.345
A3	42	49		
A4	53	47		
Neural functional state			0.043	0.835
N2	70	72		
N3	25	24		
Body mass index (kg/m^2)	23.98±2.51	23.86±2.71	0.317	0.751
Combined disease				
Hypertension (case)	12	13	0.035	0.852
Type 2 diabetes mellitus (case)	14	12	0.203	0.652
Hyperlipidemia (case)	10	9	0.071	0.790
Obesity (case)	11	11	0.001	0.975

from hospitalization to discharge. (4) Time of removal of the drainage tube: The time from drainage tube placement to removal of the drainage tube.

Vertebral height: The anterior height ratio and Cobb's angle of the injured vertebrae were measured before treatment and also 1 week, 1 year and 2 years after treatment.

Inflammatory factors: The levels of TNF-α, IL-6 and CRP were measured after admission and 7 days after operation by the kits all from Shanghai Enzyme-Linked Biology Co., Ltd. (China).

Secondary outcome: Lumbar function at the last follow-up: All patients underwent long-term outpatient follow-up, and the Oswestry disability index (ODI) at the last follow-up was recorded. The index score of 0-20%, 21-50%, 51-75%, 76-100% indicates excellent, good, medium and poor [15].

Postoperative complications: The incidence of postoperative wound infection, lower limb deep venous thrombosis, fracture nonunion and internal fixation fracture were recorded. Incidence of complication (%) = per case number of complications/ total number of cases * 100.

Statistical methods

SPSS 22.0 was used to analyze the data. The continuous variables are expressed by mean ± standard deviation ($\bar{x}$ ± sd), which were in accordance with a normal distribution and homogeneity of variance: independent sample t test was used for intergroup comparison and paired sample t test was used for comparisons within the group. Repeated analysis of variance combined with post-Bonferroni test was used to detect multiple time points. The counting data was analyzed by Pearson's chi-square test. $P<0.05$ indicated that the difference was statistically significant.

Results

Comparison of general data and baseline data between the two groups

There were 3 cases lost in the observation group and 2 cases lost in the control group. There was no difference in the general data between the two groups ($P>0.05$), as shown in **Table 1**.

Comparison of perioperative indexes between the two groups

There was no difference between the two groups in perioperative indexes including hospital stay, operation time, intraoperation blood

Table 2. Comparison of intraoperative and postoperative related indexes between the two groups

Item	Observation group (n=95)	Control group (n=96)	t	P
Hospital stay (d)	9.5±1.2	9.4±1.1	0.600	0.549
Operation time (min)	111.16±24.78	108.39±22.39	0.811	0.418
Intraoperative blood loss (mL)	279.46±30.96	281.56±32.56	0.456	0.648
Drainage tube removal time (d)	4.2±1.4	4.1±1.5	0.476	0.634

Table 3. Comparison of vertebral body height between two groups before and after operation

Groups	Observation group (n=95)	Control group (n=96)	F	P
Anterior vertebral body height ratio				
Before treatment	59.85±9.03	59.97±9.21	0.091	0.928
1 week after treatment	92.69±10.28[a]	91.89±9.86[a]	0.549	0.584
1 year after treatment	88.95±8.54[a]	84.26±9.32[a]	3.652	<0.001
2 years after treatment	85.85±8.16[a]	80.36±9.12[a]	4.383	<0.001
Cobb's angle				
Before treatment	14.59±1.85	14.69±1.92	0.367	0.714
1 week after treatment	4.62±0.92[a]	4.59±0.89[a]	0.229	0.819
1 year after treatment	5.76±0.62[a]	6.82±0.73[a]	10.369	<0.001
2 years after treatment	6.81±0.65[a]	7.84±0.56[a]	11.732	<0.001

Note: Compared with the same group before operation, [a]P<0.05.

Table 4. Comparison of serum TNF-α, IL-6 and CRP between two groups before and after treatment

Item	Observation group (n=95)	Control group (n=96)	t	P
TNF-α (pg/mL)				
Before treatment	629.34±103.68	631.47±124.25	0.129	0.898
After treatment	971.46±202.48[a]	972.58±203.67[a]	0.036	0.970
IL-6 (pg/mL)				
Before treatment	103.01±19.90	102.66±20.14	0.121	0.904
After treatment	182.34±30.78[a]	180.26±31.24[a]	0.464	0.644
CRP (mg/L)				
Before treatment	12.81±2.85[a]	13.42±2.28[a]	1.634	0.104
After treatment	23.71±2.84[a]	23.94±3.52	0.298	0.766

Note: Compared with the same group before treatment, [a]P<0.05.

loss and drainage tube removal time (P>0.05), as shown in **Table 2**.

Comparison of vertebral height between the two groups before and after operation

The anterior vertebral body height ratio and Cobb's angle were improved after operation in both groups (P<0.05). One year after operation and two years after operation, the anterior vertebral body height ratio of the observation group was higher than that of the control group, while the Cobb's angle of the observation group was lower than that of the control group (P< 0.001). See **Table 3**.

Comparison of inflammatory factors between the two groups before and after operation

The levels of TNF-α, IL-6 and CRP in the two groups were significantly higher than those before operation (P<0.05), but there was no difference between the two groups after operation. See **Table 4**.

Comparison of lumbar function at the last follow-up between the two groups

ODI score was used to evaluate the lumbar function of patients. The excellent and good rate of ODI score in the observation group was higher than that in the control group (P<0.05), see **Table 5** and **Figure 1**.

Comparison of postoperative complications between the two groups

The incidence of internal fixation fracture in the observation group was lower than that in the control group (P<0.05). However, there was no difference in the total incidence of complications between the two groups (P>0.05). See **Table 6**.

Table 5. Comparison of ODI scores in the last follow-up between the two groups

Item	Observation group (n=95)	Control group (n=96)	χ^2	P
Excellent	73 (76.84)	50 (52.08)	13.499	0.004
Good	13 (13.69)	27 (28.13)		
Fair	8 (8.42)	14 (14.58)		
Medium	1 (1.05)	5 (5.21)		
Excellent and good rate (%)	90.52	80.21	4.063	0.044

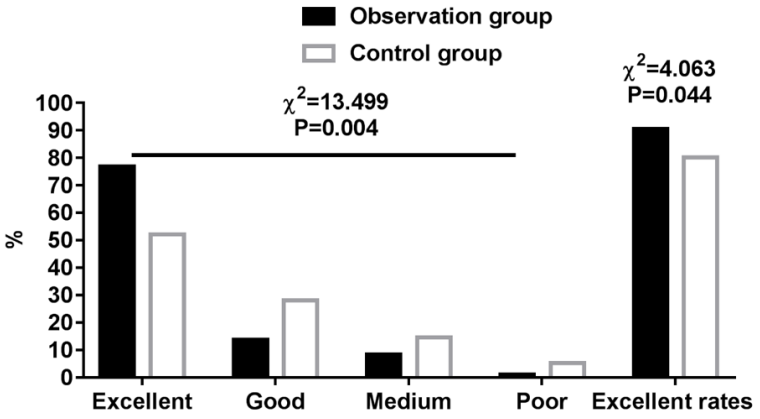

Figure 1. Comparison of lumbar function between the two groups in the last follow-up. Oswestry disability index was used to evaluate the lumbar function of patients. The index score at 0-20%, 21-50%, 51-75%, 76-100% indicates excellent, good, medium and poor lumbar function, respectively.

Discussion

The joints of the thoracolumbar segment are located in the physiological curvature of the spine, which causes fractures to often occur there under the action of external force. A high-energy external force acts upon the spine, which makes the intervertebral disc nucleus hernia and enters vertebral body, and the pressure in vertebral body increases rapidly, resulting in vertebral body bursting from inside to outside to form fractures [16, 17]. Some studies have found that short segment internal fixation in posterior reduction and internal fixation can better restore the height and physiological curvature of fractured vertebral bodies than long segment internal fixation, with the characteristics of less trauma and short operation time [8]. Because internal fixation across the injured vertebrae is not fixed in the injured vertebrae, internal fixation is prone to become loose or broken in some patients [18]. In this study, the two kinds of short segment internal fixation are studied, and we found that there is no significant difference between the two groups in perioperative indexes. The operation of the two treatment methods is basically the same, and the only difference is whether the injured vertebra is nailed or not, leading to a small difference in related indexes between the two methods during and after operation, which is consistent with the previous research results [19]. The postoperative follow-up of this study found that both methods can effectively reduce the vertebral body in the short-term after operation, and the anterior vertebral bodie's height ratio and Cobb's angle of the injured vertebra in both groups were improved 1 week after the operation compared with that before operation. The long-term follow-up found that the degree of improvement of the injured anterior vertebra, vertebral body height ratio and Cobb's angle in the observation group was better than that in the control group. Previous studies have shown that 43% of the patients without screws through the injured vertebra suffer from the collapse of the sagittal plane of the vertebral body, which affects the postoperative recovery [20]. Another study has shown that patients with short-segment internal fixation of the injured vertebra can enhance the stability of the injured vertebra after operation and help to reduce the occurrence of vertebral body loss after operation [21]. Our results were consistent with above studies.

Surgical operations are traumatic. After operation, the body often produces oxidative stress fractors to promote the production of inflammatory cells, and a large number of inflammatory cells are not conducive to the recovery of postoperative diseases. Some studies suggest that nail placement in the injured vertebrae can aggravate the injury to the patients' tissues during operation, thus aggravating the inflammatory reaction, which is not conducive to postoperative recovery [12]. CPR, IL-6 and TNF-α are all inflammatory factors that can reflect the inflammatory state *in vivo* [22, 23]. In our study,

Table 6. Comparison of postoperative complications

Postoperative complications	Observation group (n=95)	Control group (n=96)	χ^2	P
Wound infection	2 (2.10%)	3 (3.12%)	0.195	0.659
Deep venous thrombosis of lower limbs	3 (3.16%)	2 (2.08%)	0.216	0.642
Fracture nonunion	2 (2.10%)	2 (2.08%)	0.000	0.992
Internal fixation fracture	1 (1.05%)	7 (7.29%)	4.632	0.031
Total number of cases	8 (8.42%)	14 (14.58%)	1.779	0.182

we monitored the inflammatory factors, CPR, IL-6 and TNF-α of two groups of patients before and after operation, and found that there was no difference in the level of inflammatory factors between the two groups, which was inconsistent with the previous results. The possible reason may because that the bearable stress of the injured vertebra and its upper and lower vertebral bodies can be increased after fixation, and the tissue damage caused by the fixation of vertebral bodies other than the injured vertebra was reduced to a certain extent.

The 2-year follow-up of this study found that the excellent and good rate of lumbar function in the observation group treated by nail placement through the injured vertebrae and short segment internal fixation was higher than that in the control group, which suggested that in the long-term prognosis, this method was conducive to the functional recovery of the injured vertebrae.

Some studies found that 50% of patients suffered from internal fixation failure within 3 years after the operation of nail placement across the injured vertebrae combined with short segment internal fixation [24]. While nail placement through the injured vertebrae and short segment internal fixation can overcome the kyphosis stress, and after the injured vertebra is nailed, it can be moved to the abdomen, so that the original physiological curvature of the chest and waist can be restored to the maximum extent [25]. Another study shows that the nail placement through the injured vertebrae is not only beneficial to the reduction of injured vertebra, but also can pull the anterior longitudinal ligament and psoas major muscle fibers near the injured vertebra and fix the tissues around the injured vertebra [26]. Complications in this study also showed that the fracture rate of internal fixation in the nail placement across the injured vertebrae combined with short segment internal fixation was higher than that in the nail placement through the injured vertebrae, which was consistent with the above research results.

However, this study is a single-center study, which can be further improved by multi-center studies and larger samples. The short follow-up time of this study can be further increased, and the effect of nail placement through the injured vertebrae combined with short segment internal fixation on the prognosis of thoracolumbar burst fracture needs to be further observed.

In conclusion, nail placement through the injured vertebrae combined with short segment internal fixation is effective in the treatment of thoracolumbar burst fracture with good safety.

Disclosure of conflict of interest

None.

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