

Original Article

Minimally invasive percutaneous pedicle screw fixation versus open pedicle screw fixation for senile osteoporotic vertebral fracture

Gang Liu, Bin Liu, Yong Yang, Le Tian, Ya'ou Liu, Jianhua Wang

Department of Orthopedics, Affiliated Hospital of Inner Mongolia Medical University, Hohhot, Inner Mongolia Autonomous Region, China

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Abstract: Objective: To investigate the clinical efficacy of minimally invasive percutaneous pedicle screw fixation or open pedicle screw fixation for senile osteoporotic vertebral fracture. Methods: Fifty-nine cases of senile osteoporotic vertebral fracture were divided into an experimental group (n=36, minimally invasive percutaneous pedicle screw fixation) and control group (n=23, conventional posterior pedicle screw fixation) according to the surgery they received. Results: The operation time, intraoperative blood loss, incision length, hospitalization time as well as the incidence of postoperative complications in the experimental group were less than those in the control group (all $P < 0.05$). The percentage of vertebral height, kyphotic angle and disc height of the two groups were improved 1 week and 6 months after surgery (all $P < 0.05$); while the difference between groups were insignificant (all $P > 0.05$). The Visual Analogue Scale and Oswestry disability index of both groups were improved 6 months after surgery, which were more apparent in the experimental group (all $P < 0.05$). Conclusions: Both minimally invasive percutaneous pedicle screw fixation and open pedicle screw fixation can achieve satisfactory internal fixation, while the former has less trauma, short operative time, fast recovery, few postoperative complications and light postoperative pain.

Keywords: Minimally invasive percutaneous pedicle screw fixation, open pedicle screw fixation, senile osteoporotic vertebral fracture

Introduction

Osteoporosis is a common disease among the elderly, especially in females. Osteoporotic fracture can be easily triggered by a slight external force, because of loss of bone mass and failure of bone microarchitecture in patients; which is common in wrists, spines and hips [1]. Osteoporotic vertebral fracture (OVF) is one of the main causes for disability and death in the elderly [2]. How to improve the treatment of senile OVF has become a research hotspot and a difficult issue.

The goal of treating senile OVF is to promote fracture healing, reduce postoperative complications, improve immediate and long-term postoperative life quality, and prevent secondary fracture. The treatment includes non-surgical and surgical treatment. Non-surgical treatment mainly includes bed rest, lower back

functional exercise and drug therapy. Conservative treatment can prevent surgical trauma, but it may induce bedsores, hypostatic pneumonia and bring uncomfortable symptoms such as low back pain due to its inability of restoring vertebral height [2]. At present, senile OVF is usually surgically treated, and the conventional operative method is open reduction and internal fixation. Pedicle screw has good biological stability and can provide good fixation effects [3]. However, an open operation involves a large operative area and may bring surgical trauma and many postoperative complications [4]. Minimally invasive percutaneous pedicle screw fixation is a relatively new treatment type, but its clinical effect remains controversial at present.

In this study, the efficacy of minimally invasive percutaneous pedicle screw and open pedicle screw fixation for senile OVF was compared.

Methods

General information

Fifty-nine patients with senile OVF treated from January 2014 to June 2017, including 37 males and 22 females, aged 60-81 years old. The patients treated between January 2014 and March 2016 were included in the control group and the patients treated between April 2016 and June 2017 were set as the experimental group. Inclusion criteria: 1) Age ≥ 60 years; 2) Patients diagnosed with osteoporosis in bone density examination (t value of -2.5 or more), and diagnosed with compression fracture of spine with fracture time not exceeding 1 month by imaging examination [4]; 3) Patients diagnosed with single vertebral fracture; 4) Patients without nerve injury; 5) Patients who signed an informed consent form. Exclusion criteria: 1) Patients with multiple vertebral fracture; 2) Patients complicated by severe internal medicine diseases or organ failure; 3) Patients with old fractures; 4) Patients participating in other clinical research at the same time.

This study was approved by the Ethics Committee of Affiliated Hospital of Inner Mongolia Medical University. The patients and their families were informed and gave their consent and the research conformed to the provisions of the Declaration of Helsinki (as revised in Brazil in 2013).

Operative methods

All patients received general anesthesia with tracheal intubation and were placed in prone position with abdomen in the air. All patients were treated by the same group of doctors. The control group was treated with conventional open reduction and internal fixation. Under a C-arm x-ray machine, the position of injured vertebra was searched for, and the injured vertebra was taken as the center point for spinal posterior longitudinal incision, on which the incision was made conventionally, and the position of injured vertebra was exposed. Two pedicle screws were placed on the upper and lower vertebrae, and then were fixed with connecting rods until satisfactory reduction. Patients were routinely given postoperative antibiotics to prevent infection [5].

The experimental group was treated with minimally invasive percutaneous pedicle screw fixa-

tion. Anteroposterior fluoroscopy was performed through a C-arm x-ray machine, and the enter point of pedicle screws was determined according to the intersection of four 2.0 Kirschner wire projection lines. Then a small longitudinal incision of approximate 1.5-2.0 cm was made along the enter point of pedicles to bluntly separate the surrounding muscles, clear exposed joints, and insert a location pin (note that the angle of pin insertion should be abducted by 10-15 degrees). An expanding duct was inserted along the pin and a working channel was installed, and then pedicle screws were screwed in under fluoroscopy state. A curved fixe bar was inserted through subcutaneous muscle tissue from top to bottom, and the fixing nut was tightened. Reduction and fixation were done under the guide of the C-arm x-ray machine. The wound was washed with and the skin was sutured layer by layer [5].

Treatment of complications was as follows. 1) For deep venous thrombosis, active assistance for patients to help exercise ankles, knees, and hip joints after surgery, and assist them to apply drugs that inhibit thrombosis in the meantime. 2) For delayed union, we properly treated the delayed union, observed whether the union can be successful or not, conducted internal fixation when the union was not successful, and added external fixation if necessary.

Outcome measures

Main outcome measures were as follows. 1) Imaging diagnostic indexes: Percentage of vertebral height, kyphotic angle, and disc height before and after surgery. Percentage of vertebral body height = front height of injured vertebra/the average height of the front of upper and inferior vertebral body * 100%. Kyphotic angle = the angle between the upper endplate of the upper vertebral body and the lower endplate of inferior vertebral body in the injured vertebra. Disc height = the space between the injured vertebra and the lower vertebral body. 2) Clinical effect: Visual analogue scale (VAS) and Oswestry Disability Index (ODI) 6 months after surgery [6, 7]. The patients rated their pain according to their own feelings. The higher the VAS score was, the more severe the pain was. ODI covered 10 aspects of pain degree, daily self-care, sitting, standing, walking, carrying stuff, sexual life, social life, sleep disturbances, and tourism. The higher the ODI score was, the more severe the dysfunction was.

Table 1. Comparison of general information

	Case	Gender (male/female)	Age (year old)
Control group	23	15/8	70.23±9.51
Experimental group	36	22/14	71.95±10.55
t/ χ^2		0.101	-0.634
P		0.750	0.529

Secondary outcome measures: Perioperative variables: The two groups were observed and compared in operation time, intraoperative blood loss, incision length and hospitalization stay. The two groups were compared in postoperative complications (such as delayed union, deep vein thrombosis, etc.). Discharge indicator: The wound healed well. No complications occurred or complications have been treated.

Statistical analysis

The data were statistically analyzed with SPSS 19.0 and Graphpad Prism 5 software. Measurement data was expressed as mean \pm standard deviation ($\bar{x} \pm sd$). Independent sample t test was used for comparison between the two groups. ANOVA of repeated measurement and Bonferroni post test were used to compare the differences at different time points between every two groups. The enumeration data were processed with χ^2 test and expressed in χ^2 . $P < 0.05$ was considered statistically significant.

Results

General characteristics

Twenty-three patients (15 males and 8 females) in the control group received open reduction and internal fixation, and thirty-six patients (22 males and 14 females) in the experimental group received minimally invasive percutaneous pedicle screw fixation. There were no significant differences in gender or age between the two groups (both $P > 0.05$). See **Table 1**.

Comparison of perioperative variables between the two groups

Operation time in the experimental group was shorter than that in the control group (82.85±21.51 minutes vs. 105.63±19.35 minutes respectively, $P = 0.012$). Intraoperative blood loss in the experimental group was significantly less

than that in the control group (71.58±25.56 mL vs. 271.30±48.03 mL respectively, $P = 0.001$). Incision length in the experimental group was significantly shorter than that in the control group (6.54±1.52 cm vs. 12.79±1.63 cm respectively, $P = 0.001$). Hospitalization days of the experimental group were less than that of the control group (8.65±1.33 d vs. 14.25±3.41 d respectively, $P = 0.001$). The operation time, intraoperative blood loss, incision length and hospitalization days in the experimental group were all significantly less than those in the control group (**Table 2**).

Comparison of imaging diagnostic indexes between the two groups before and after internal fixation

There was no significant difference in the percentage of vertebral height, kyphotic angle, and disc height between groups before internal fixation (all $P > 0.05$). One week and 6 months after internal fixation, the percentage of vertebral height and disc height in the experimental group and the control group were increased, and the kyphotic angle in the experimental group was decreased (all $P < 0.05$). There were no significant differences in the percentage of vertebral height, kyphotic angle, or disc height between groups 1 week and 6 months after internal fixation (all $P > 0.05$, **Table 3**).

Comparison of VAS between the two groups before and after internal fixation

There was no significant difference in VAS between groups before internal fixation ($P > 0.05$). The VAS scores of two groups decreased 6 months after internal fixation (both $P < 0.01$). After internal fixation, the VAS score of the experimental group decreased more significantly than that of the control group ($P < 0.01$, **Figure 1**).

Comparison of ODI between the two groups before and after internal fixation

There was no significant difference in ODI between groups before internal fixation ($P > 0.05$). ODI of the two groups decreased significantly 6 months after internal fixation (both $P < 0.01$), and ODI of the experimental group decreased more significantly than that of the control group ($P < 0.001$, **Figure 2**).

Table 2. Comparison of perioperative variables ($\bar{x} \pm sd$)

	Operation time (min)	Intraoperative blood loss (mL)	Incision length (cm)	Hospitalization time (day)
Control group (n=23)	105.63±19.35	271.30±48.03	12.79±1.63	14.25±3.41
Experimental group (n=36)	82.85±21.51	71.58±25.56	6.54±1.52	8.65±1.33
t	4.122	20.819	14.976	8.886
P	<0.001	<0.001	<0.001	<0.001

Table 3. Comparison of imaging diagnostic indexes before and after internal fixation ($\bar{x} \pm sd$)

	Percentage of vertebral height (%)	Kyphotic angle (°)	Disc height (mm)
Control group (n=23)			
Before intern fixation	58.11±17.08	15.92±4.61	6.32±1.07
1 week after fixation	88.41±10.11*	5.66±1.24*	23.11±4.03*
6 months after fixation	86.38±9.59*	6.41±1.90*	21.97±5.39*
Experimental group (n=36)			
Before intern fixation	55.13±20.33	16.05±5.37	6.90±1.85
1 week after fixation	89.37±9.07*	4.60±1.36*	22.32±5.07*
6 months after fixation	87.93±9.35*	5.93±1.07*	21.15±5.81*

Note: Compared with before intern fixation in the same group, *P<0.05.

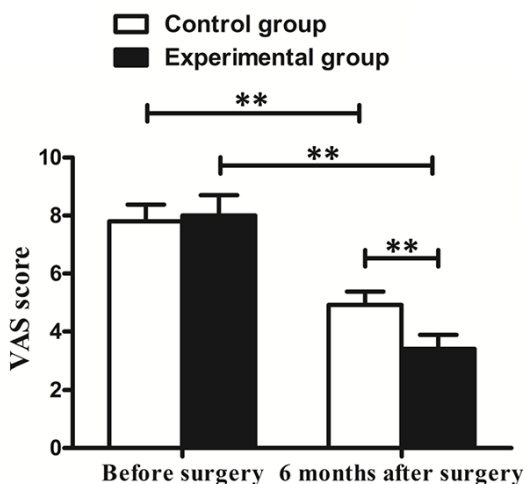


Figure 1. Comparison of VAS between the two groups before and after internal fixation. **P<0.01. VAS, visual analogue scale.

Comparison of postoperative complications between the two groups

In the control group (23 cases), there was one case of screw position error, one case of deep venous thrombosis, 2 cases of soft tissue infection and 3 cases of delayed union. However, in

the experimental group, there were only 2 cases of delayed union. No screw loosening occurred in either group. Compared with the control group, the incidence of postoperative complications in the experimental group was decreased (P<0.05, **Table 4**).

Discussion

Osteoporosis is one of the most common diseases in the elderly [8]. Senile OVF is a common and serious complication of osteoporosis. At present, there are mainly conservative treatments and surgical treatment for senile OVF in the clinic. Conservative treatment may lead to a series of complications without exact effect [9]. Therefore, patients often choose surgical treatment when their own conditions can be satisfied. The basic principle of surgical treatment is to relieve pain, promote fracture healing, reduce postoperative complications and improve the patients' life quality [10]. The operative method of it includes conventional open pedicle screw fixation and minimally invasive percutaneous pedicle screw fixation.

Conventional open pedicle screw fixation can provide good correction effects and contribute to spinal stabilization, but it needs an incision of more than 10 cm long along the back of patient and to peel a large area of paravertebral muscles away, which will destroy surrounding soft tissue, cause slow postoperative recovery, and may also cause paraspinal muscle denervation and leave complications such as chronic low back dysfunction and pain [11-13]. With the continuous development of minimally invasive surgery, minimally invasive percutaneous pedicle screw fixation has been general-

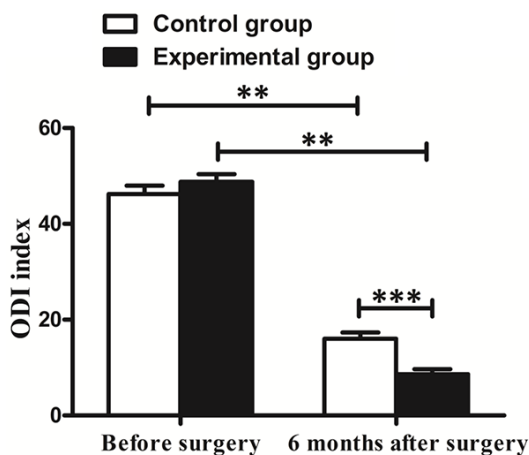


Figure 2. Comparison of ODI between the two groups before and after internal fixation. ** $P < 0.01$, *** $P < 0.001$. ODI, Oswestry disability index.

ized gradually in clinical practice. Gelb *et al.* showed that compared with conventional open operation type, minimally invasive percutaneous pedicle screw fixation can protect paraspinal muscles from injury and has advantages of less intraoperative blood loss, less normal structural trauma, rapid postoperative recovery and few complications such as postoperative low back pain [14].

A total of 59 patients with senile OVF were enrolled to compare the clinical effects between minimally invasive percutaneous pedicle screw fixation and open pedicle screw fixation. The results showed that: (1) After surgery, the percentage of vertebral height and disc height in the experimental group and those in the control group increased, and the kyphotic angle in the experimental group and that in the control group decreased, which indicated that both operation types can effectively restore the height of injured vertebrae and improve kyphosis caused by spine fracture. There was no significant difference in the percentage of vertebral height, disc height and kyphotic angle between the two groups after surgery, indicating that both operation types achieved the same therapeutic effect (Table 3). The results were consistent with the findings of Li *et al.* [7]. (2) The operation time, intraoperative blood loss, incision length and hospitalization days in the experimental group were less than those in the control group, and no screw loosening was observed in either group, indicating that minimally invasive percutaneous pedicle screw fixa-

tion has effective outcomes, little trauma, few hospitalization days, fast postoperative recovery, few postoperative complications and can provide better postoperative life quality for patients (Tables 2 and 4). The research of Chen *et al.* was also consistent with results of this paper [15]. Some scholars also believe that there is no significant difference in operation time between the two operation types, which may be due to the early reporting time and unskilled surgical techniques [16]. (3) The VAS score and ODI of the two groups 6 months after internal fixation were significantly lower than those before internal fixation, and the VAS score and ODI of the group treated with minimally invasive percutaneous pedicle screw fixation decreased more significantly, indicating that both operation types can effectively reduce pain and relieve dysfunction, but minimally invasive percutaneous pedicle screw fixation can provide better effects than open pedicle screw fixation (Figures 1 and 2). In conclusion, both open pedicle screw fixation and minimally invasive percutaneous pedicle screw fixation are effective for the treatment of senile OVF, and minimally invasive percutaneous pedicle screw fixation is featured with less trauma, short operation time, fast recovery, and can provide high postoperative life quality for patients.

Most scholars hold opinions consistent with this study that minimally invasive percutaneous pedicle screw fixation can achieve satisfactory surgical outcomes with the advantages of less trauma and fast recovery [17-20]. However, minimally invasive percutaneous pedicle screw fixation also has certain limitations: (1) It is inapplicable to upper and middle thoracic fractures and fractures with nerve injury [4]; (2) The number of X-ray exposures is increased and the time lengthened [21]. Therefore, to perform minimally invasive percutaneous pedicle screw fixation, surgeons are required to be skilled and familiar with the spine, and to confidently grasp the surgical indications.

Indications of minimally invasive percutaneous pedicle screw fixation in the treatment of senile OVF were: (1) Fresh unstable spinal fractures; (2) Fractures without stenosis of spinal canal and without hematoma and foreign body in spinal canal; (3) Spinal fractures without nerve injury; (4) Fractures without interlocking of facet

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Table 4. Comparison of postoperative complications

	Control group (n=23)	Experimental group (n=36)	χ^2	P
Screw position error	1	0		
Deep venous thrombosis	1	0		
Soft tissue infection	2	0		
Delayed union	3	2		
Total (n, %)	7 (30.43)	2 (5.56)	4.933	0.026

joints. Technical points of minimally invasive percutaneous pedicle screw fixation: (1) It is required to use a C-arm to accurately locate injured vertebrae and pedicles before internal fixation; (2) The pin end should be abducted by 15 degrees in the direction of inserting pin, and the pin can be inserted immediately when the pin touches facet joint. This study has certain limitations: since it's difficult to follow up on the elder patients in the two groups, the follow-up time in postoperative imaging, VAS score, and ODI is relatively short. Thus, it can only be proved that minimally invasive percutaneous pedicle screw fixation is superior to open pedicle screw fixation within a short time, but long-term follow-up data are still needed for analyzing the long-term effect of the two methods. Besides, it only included the patients with spinal fracture who required internal fixation treatment alone but not the patients with wide fracture space who needed combined internal fixation and vertebroplasty treatment. Thus, in future experiments remains to be discover in patients with wide fracture space which methods is better.

In conclusion, both open pedicle screw fixation and minimally invasive percutaneous pedicle screw fixation are effective for the treatment of senile OVF. Compared with conventional open pedicle screw fixation, minimally invasive percutaneous pedicle screw fixation causes less intraoperative blood loss, short operation time, small muscle and soft tissue injuries, fast postoperative recovery, small incision scar, less hospitalization days, light pain, few postoperative complications, and high quality of life, but minimally invasive percutaneous pedicle screw fixation is demanding in surgical equipment and technical operation. If economic conditions and surgical indications of patients are allowable, minimally invasive percutaneous pedicle screw fixation is worthy of clinical promotion.

Disclosure of conflict of interest

None.

Address correspondence to: Jianhua Wang, Department of Orthopedics, Affiliated Hospital of Inner Mongolia Medical University, Tongdao North Street, Huimin District, Hohhot 010050, Inner Mongolia Autonomous Region, China. Tel: +86-13015026234; E-mail: wangjianhuavk4@163.com

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