Selection of surgical treatment approaches for old osteoporotic vertebral compression fractures: A Retrospective Study of 238 Cases

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Research article

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Abstract

Background

As the population ages, osteoporotic vertebral compression fractures (OVCF) are increasing, as are acute and chronic pain episodes and progressive spinal deformities. Therefore, the aim of our study was to investigate the treatment of symptomatic old osteoporotic vertebral compression fractures.

Methods

A retrospective study was designed to enroll patients with symptomatic old OVCFs from June 2013 to 2016. According to the complexity of the disease, the patients were divided into I to V grades, and the surgical methods were developed according to the grades. Postoperative visual analog score (VAS), Oswestry disability index (ODI) scores, sagittal index (SI) and ASIA grades of neurological function were observed.

Results

VAS score, ODI score and SI of all patients were significantly improved as compared with that before surgery, and the results of the final follow-up were statistically significant in comparison to preoperative outcome ($P<0.05$). All the 16 patients with nerve injury showed significant improvement after surgery. The ASIA grade were improved from grade C (14 cases), grade D (2 case) to grade D (4 cases) and grade E (12 cases).

Conclusion

Old OVCFs are difficult to treat. Graded surgery can better restore spinal stability and improve clinical outcomes.

Introduction

As the population ages, osteoporotic vertebral compression fractures (OVCF) are increasing, as are acute and chronic pain episodes and progressive spinal deformities [1]. It has been reported that the prevalence of vertebral fracture in women over 50 years old is about 15%, and that in women over 80 years old is up to 36.6% [2]. Due to OVCF is a kind of low-energy damage, and the patient is slow to respond to pain at the old age, which fails to attract enough attention, often leading to delay in the disease, missing the best treatment opportunity, and finally the fracture is changed from a fresh fracture to an old fracture. The most common ones are changes in osteonecrosis, and even kyphosis and nerve compression [3], which seriously affects the quality of life of patients and delays the treatment effect [4].
In the early stage, Genant semi-quantitative method proposed by Genant et al. [5] and EVOSG method proposed by Ismail et al. [6] divided OVCF morphology into three types: wedge type, double concave type and collapse type, but there was no classification of nerve damage. Subsequently, Heini et al [7] further improved and proposed the Heini classification according to clinical and imaging findings, but there was crosses overlap between different types, which was not conducive to clear clinical guidance. In addition, this classification does not reflect the severity and characteristics of osteoporotic fractures. In 2013, AO [8] proposed improved AO classification on the basis of the original, and comprehensively evaluated fracture classification from three aspects: morphological classification, neurological status and clinical correction index. However, this classification system is mainly applicable to high-energy fractures, not suitable for OVCF characterized by low-energy damage. Therefore, there is still no suitable classification and corresponding treatment scheme for the old OVCF.

Herein, in this study, we retrospectively analyzed 238 cases of patients with old OVCF admitted to our hospital from 2013 to 2016. According to the imaging morphological changes and clinical manifestations, the above patients were classified, and the treatment plan for each type was formulated. Meanwhile, VAS score, ODI score, ASIA grading and imaging results were used to evaluate the efficacy of corresponding treatment regiments.

**Patients And Methods**

**Patients**

A total of 238 patients with old OCVF were entered into this study. Among them, 110 cases were male and 128 cases were female. The mean patient age was 63.1 ± 6.7 (range from 52 to 92 years). The inclusion criteria were: 1) A history of minor trauma; 2) Have a clear back pain; 3) Bone mineral density (BMD): T score ≤ -2.5; 4) OVCF clinical manifestations consistent with imaging findings; 5) Fracture to hospital interval ≥ 8 weeks; The exclusion criteria were: 1) Pathological vertebral fracture caused by tumor; 2) Abnormal coagulation function and poor cardiopulmonary function cannot tolerate surgery; 3) Surgery is not available for other reasons; 4) Unable to adhere to follow-up. This study was approved by our Hospital. Written informed consent was obtained from each patient and the study was conducted in accordance with the Declaration of Helsinki.

According to clinical manifestations and imaging examination, the patients were divided into different grades. Among them, 86 patients with grade I, the imaging examination showed old fractures of the vertebral body, but there was no obvious instability; There were 60 patients with grade II, and the imaging examination showed old fractures of the vertebral body with local instability; There were 44 patients with grade III, and imaging examination showed old fractures of the vertebral body accompanied with kyphosis; There were 30 patients with grade IV, and imaging examination showed old fractures of the vertebral body accompanied with spinal canal stenosis; There were 18 patients with grade V, and the imaging findings were mixed with the above symptoms (Table 1).
Table 1
Grading criteria and surgical procedures of included patients

| Grade | Grading standards                                                                                                                                                                                                                                                                                                                                 | Surgical methods                                                                                       |
|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| Grade I (N = 86) | 1. Recalcitrant back pain, increased pain after activity  
2. X-ray showed wedge-shaped changes in the vertebral body, and some patients could see the injured vertebral cavity; CT showed a wedge-shaped change with an internal cavity; MRI showed that the height of the injured vertebra was lost and the internal signal of the cavity was abnormal. | Vertebral augmentation                                                                                                                                                                                                     |
| Grade II (N = 60) | 1. Recalcitrant back pain, increased pain after activity  
2. X-ray showed wedge-shaped changes in the injured vertebra, while dynamical X-ray film showed obvious changes in the angle of upper and lower endplates and local instability; CT showed a wedge-shaped changes with an internal cavity; MRI showed that the height of the injured vertebra was lost and the internal signal of the cavity was abnormal. | Posterior reduction fusion internal fixation or combined vertebral augmentation                                                                                     |
| Grade III (N = 44) | 1. Recalcitrant back pain, increased pain after activity with radiating pain in the lower extremities or intermittent claudication.  
2. X-ray showed loss of height of injured vertebra; CT showed wedge-shaped lesions with internal cavities, lumbar spinal stenosis, and compression of the dural sac; MRI showed that the height of the injured vertebra was lost, the signal was abnormal, the dural sac was compressed, and the same level of spinal canal stenosis. | Posterior decompression and reduction fusion and internal fixation                                                                                               |
| Grade IV (N = 30) | 1. Recalcitrant back pain, increased pain after standing for a long time.  
2. X-ray showed a wedge-shaped change with severe height loss and kyphosis of the spine; CT showed wedge-shaped changes of injured vertebra, internal cavity and kyphosis deformity of spine; MRI showed loss of injured vertebral height, kyphosis of the spine, abnormal signals inside the injured vertebra. | Posterior osteotomy with internal fixation and fusion                                                                                                           |
| Grade V (N = 18) | 1. Recalcitrant back pain, aggravated after activity; Or accompanied by radiating pain in lower limbs, intermittent claudication; 2. X-ray showed a wedge-shaped change and kyphosis of the spine; CT showed wedge-shaped change of injured vertebra, kyphosis deformity of spine, lumbar spinal canal stenosis and dural sac compression; MRI showed that the height of the injured vertebra was lost, the signal was abnormal, the dural sac was compressed, and the same level of spinal canal stenosis. | Posterior osteotomy (decompression) with internal fixation and fusion                                                                                           |

Surgical Techniques

According to the above grading, different treatment schemes are adopted, as shown in Table 1. In patients with kyphosis and mixed kyphosis requiring orthopedics, bone cement nail reinforcement is recommended. If the instability type requires screw fixation or T score ≤ -3.0, it is also recommended to use bone cement nail reinforcement.

Postoperative Treatment
In cases of uneventful surgeries, all patients were required to be confined to bed for about 3 days after surgery. The patients were allowed appropriate ambulation 3 days after surgery while wearing a custom-made thoracolumbar orthosis. Subsequently, patients were encouraged to gradually increase the amount of exercise, perform lower back muscles strengthening exercises as soon as possible, and resume work depending on their speed of recovery. In addition, the patients were instructed to continue to receive regular anti-osteoporosis treatment in the outpatient clinic after discharge and to undergo regular reexamination.

**Evaluation methods and follow-up**

Observe and record the visual analog score (VAS), oswestry disability index (ODI) score, kyphosis Cobb angle, vertebral sagittal index, nerve functional AISA rating. Clinical examination, X-ray films, CT and MRI were performed to assess fracture healing and vertebral height loss. The follow-up period was 12–38 months, with an average follow-up period of 18.5 months.

**Statistical analysis**

SPSS 17.0 (IBM, New York, USA) was applied to analyze all data. Enumeration data were evaluated by $\chi^2$ test; Measurement data were evaluated by T-test. $P < 0.05$ was considered as statistical difference.

**Results**

**VAS score, ODI score and sagittal index at follow-up**

VAS score, ODI score and SI of 238 patients were evaluated before surgery, 12 months after surgery, and at the final follow-up. The detailed data are shown in Tables 2, 3 and 4. The VAS score for Post-12M (grade I, 2.20 ± 0.61; grade II, 2.11 ± 0.54; grade III, 2.21 ± 0.60; grade IV, 2.20 ± 0.58; grade V, 2.16 ± 0.84), for final follow-up (grade I, 2.12 ± 0.74; grade II, 2.03 ± 0.78; grade III, 2.16 ± 0.78; grade IV, 2.20 ± 0.76; grade V, 2.11 ± 0.90). The ODI score for Post-12M (grade I, 44.25 ± 3.10; grade II, 41.25 ± 3.31; grade III, 42.13 ± 2.27; grade IV, 42.54 ± 2.01; grade V, 40.93 ± 1.90), for final follow-up (grade I, 40.07 ± 2.65; grade II, 39.23 ± 2.56; grade III, 40.09 ± 2.24; grade IV, 39.07 ± 1.72; grade V, 39.56 ± 2.33). The SI for Post-12M (grade I, 87.42 ± 5.08; grade II, 85.17 ± 5.26; grade III, 87.00 ± 5.01; grade IV, 86.12 ± 4.09; grade V, 85.28 ± 4.62), for final follow-up (grade I, 86.90 ± 6.28; grade II, 84.17 ± 5.30; grade III, 85.07 ± 4.43; grade IV, 84.50 ± 4.67; grade V, 83.39 ± 4.97). There was no significant difference in VAS score, ODI score and SI between patients of different grades before surgery, but a significant difference after treatment ($P < 0.05$). Compared with preoperative VAS and ODI, postoperative VAS and ODI were significantly reduced, while SI increased significantly postoperatively. In addition, it found that there was no significant difference in VAS score, ODI score and SI between Post-12M and the final follow-up.
### Table 2
The changes of VAS of preoperation and postoperation

| Time                  | Grade I  | Grade II | Grade III | Grade IV | Grade V |
|-----------------------|----------|----------|-----------|----------|---------|
|                       | (N = 86) | (N = 60) | (N = 44)  | (N = 30) | (N = 18) |
| Preoperation          | 8.00 ± 0.69 | 8.05 ± 0.75 | 8.14 ± 0.82 | 8.00 ± 0.74 | 8.11 ± 0.76 |
| Postoperation 12 m    | 2.20 ± 0.61* | 2.11 ± 0.54* | 2.21 ± 0.60* | 2.20 ± 0.58* | 2.16 ± 0.84* |
| Final follow-up       | 2.12 ± 0.74* | 2.03 ± 0.78* | 2.16 ± 0.78* | 2.20 ± 0.76* | 2.11 ± 0.90* |

* means compared with Preoperation VAS, P<0.05.

VAS, visual analog score.

### Table 3
The changes of ODI of preoperation and postoperation

| Time                  | Grade I  | Grade II | Grade III | Grade IV | Grade V |
|-----------------------|----------|----------|-----------|----------|---------|
|                       | (N = 86) | (N = 60) | (N = 44)  | (N = 30) | (N = 18) |
| Preoperation          | 69.63 ± 2.93 | 70.23 ± 2.30 | 70.18 ± 1.87 | 70.00 ± 2.23 | 70.56 ± 2.25 |
| Postoperation 12 m    | 44.25 ± 3.10* | 41.25 ± 3.31* | 42.13 ± 2.27* | 42.54 ± 2.01* | 40.93 ± 1.90* |
| Final follow-up       | 40.07 ± 2.65* | 39.23 ± 2.56* | 40.09 ± 2.24* | 39.07 ± 1.72* | 39.56 ± 2.33* |

* means compared with Preoperation ODI, P<0.05.

ODI, oswestry disability index.

### Table 4
The changes of SI of preoperation and postoperation

| Time                  | Grade I  | Grade II | Grade III | Grade IV | Grade V |
|-----------------------|----------|----------|-----------|----------|---------|
|                       | (N = 86) | (N = 60) | (N = 44)  | (N = 30) | (N = 18) |
| Preoperation          | 89.78 ± 2.07 | 72.82 ± 7.78 | 75.00 ± 6.66 | 71.83 ± 5.14 | 71.72 ± 6.64 |
| Postoperation 12 m    | 87.42 ± 5.08* | 85.17 ± 5.26* | 87.00 ± 5.01* | 86.12 ± 4.09* | 85.28 ± 4.62* |
| Final follow-up       | 86.90 ± 6.28* | 84.17 ± 5.30* | 85.07 ± 4.43* | 84.50 ± 4.67* | 83.39 ± 4.97* |

* means compared with Preoperation SI, P<0.05.

SI, sagittal index.

**Imaging assessment**
There are 86 cases of patients with grade I. During the follow-up period, a total of 7 patients showed different degrees of vertebral height loss, and the SI decreased from 90.00 ± 2.34 to 71.67 ± 1.72. MRI examination showed no obvious abnormal signal, so it was not treated (Fig. 1). There are 60 cases of patients with grade II. Among them, 1 case showed height loss of vertebral body; No obvious abnormality was found in MRI re-examination, so no treatment was performed, but continued observation is required (Fig. 2). There were 44 patients with grade III disease, and there was no height loss and local kyphosis. All patients with nerve injury showed improvement after surgery. The ASIA grade was improved from 9 cases of grade C and 1 case of grade D to the postoperative grade E (Fig. 3). There were 30 patients with grade IV. During the follow-up period, there were 2 cases of vertebral height loss, and the SI index decreased from 86.0 ± 2.0 to 71.5 ± 1.5. The patient developed severe back pain with local kyphosis angle of 25.5° ± 3.54°. After revision surgery, the patient's discomfort symptoms were relieved (Fig. 4). There were 18 patients with grade V. During the follow-up, 1 patient had a loss of vertebral height, but the patient was not treated because of no discomfort. Among the patients with nerve injury, the AISA grade of 6 patients with nerve injury was improved from grade C (5 cases), grade D (1 case) to grade D (4 cases) and grade E (2 cases) (Fig. 5).

**Discussion**

OVCF is a common and frequently-occurring disease in the elderly [9]. For acute fresh fractures, patients tend to be treated with minimally invasive vertebral augmentation, and studies have confirmed that satisfactory results can be achieved [10, 11]. As OVCF is a kind of low-energy damage, post-injury pain is easily confused with fatigue pain. Moreover, most elderly patients are not sensitive to pain, which may easily delay the disease and eventually develop into old fractures. Most of these patients developed osteonecrosis, leading to prolonged back pain. And conservative treatments, such as bedridden, wearing braces, and anti-osteoporosis medications, do not work for most patients. It has been reported in the literature that 36.6% of patients will develop progressive vertebral compression, and 13.9% will form pseudarthrosis [12]. Non-healing of the injured vertebra and recollapse of the vertebral body will lead to local instability of the spine, leading to intractable pain [13, 14], even kyphosis of the spine [15], nerve injury [16], etc., which requires surgical treatment. However, the patient's advanced age and many other factors such as other internal and surgical diseases increase the difficulty and risk of surgery.

As mentioned earlier, many scholars have proposed classification for OVCF, but there are many problems as follows: 1) The classification lacks clinical manifestations such as nerve damage; 2) There is no corresponding treatment plan for typing; 3) There is a duplication between the types, which does not guide clinical treatment well; 4) There is no specificity in the classification, which also contains high energy injury fractures [5, 6, 8]. Therefore, based on the previous research, our study proposes five new types of grades, and proposes corresponding treatment plans for the classification.

A total of 238 patients were enrolled in this study, all of whom obtained satisfactory results in grading treatment. In this study, patients with grade I had local instability of the vertebral body, intractable low back pain, and radiographic examination revealed a cavity in the vertebral body. For these symptoms,
vertebral augmentation is performed to reconstruct spinal stability by filling the cavity with bone cement. Postoperative pain was significantly relieved and the effect was satisfactory [17]. However, in the follow-up, 7 patients were found to have re-loss of vertebral height after half a year, which may be related to the reason that the patients did not strictly follow the doctor’s advice on anti-osteoporosis treatment in the later stage. Significant pseudoarticular activity can be seen in the dynamic radiographs of patients with grade II, and pain is associated with changes in activity or position. The key to surgery in such patients is to fix unstable segments. In this study, this type of patient underwent posterior reduction fixation and fusion. If necessary, combined with vertebral augmentation, it can stabilize the spine and relieve pain caused by height loss and local instability [18]. Finally, with the nail rod fixed fusion to eliminate the pseudoarticular activity. After surgery, the spinal stability of the patient was well reconstructed, SI was improved from $72.82 \pm 7.78$ to $84.17 \pm 5.30$, and the height of the injured spine was recovered satisfactorily. Grade III patients were accompanied by nerve damage, and radiographic findings showed spinal canal stenosis. Such patients undergo surgery to relieve nerve compression and restore spinal stability. As expected, the patient's lower back pain was significantly relieved, and 10 patients with significant nerve injury had a significant improvement in postoperative AIS grade. Our results are also consistent with previous reports [3, 19]. Part IV patients had local instability of the vertebral body, and the biomechanics of the spine was destroyed. Later, the secondary collapse caused kyphosis [20, 21], accompanied by low back pain, and even serious nerve damage [22]. The purpose of this part of the patient's surgery is to correct the kyphosis and restore the sagittal balance. Some scholars argue that a posterior approach with osteotomy and orthopedic fusion can achieve satisfactory results [21, 23], however, others argue that anterior surgery can be more direct and complete decompression [24]. Currently, posterior surgery is mostly adopted. For surgeons, posterior surgery is more familiar with anatomical structure and less surgical trauma, and simple posterior surgery can achieve similar results as combined approach [23, 25]. For grade V patients, the surgical procedure depends on the main symptoms. In this study, 18 patients received posterior surgery, among which 12 patients with severe kyphosis received Posterior osteotomy and fusion internal fixation, and 6 patients with severe spinal stenosis received posterior decompression and internal fixation, all of which obtained satisfactory results. Since most patients are associated with severe osteoporosis, postoperative complications such as screw loosening and vertebral height loss may occur. Therefore, anti-osteoporosis treatment is particularly important in the treatment of old OVCF. Studies have shown that the technique of bone cement augmentation can significantly improve the pull-out resistance of the screw [23]. Therefore, according to the bone condition of patients, some patients were augmented with bone cement. From the follow-up findings, the surgical method has achieved remarkable results. However, there were still patients with postoperative height loss of injured vertebra, which was speculated to be related to the patient's failure to strictly follow the doctor's advice on anti-osteoporosis treatment.

**Conclusion**

Patients with OVCF are generally elderly and most of them have medical diseases, which increases the difficulty of treatment. Through graded surgery, the injured vertebrae can be effectively restored, local
instability can be eliminated, nerve compression can be relieved, and kyphosis deformed can be corrected to achieve the purpose of reconstructing the stability of the spine. The quality of life of the patient is significantly improved, and the final therapeutic effect is satisfactory.

**Abbreviations**

OVCF, osteoporotic vertebral compression fractures; VAS, visual analog score; ODI, oswestry disability index; SI, sagittal index.

**Declarations**

**Ethics approval and consent to participate:**

This study was approved by Xi’an Jiaotong University Affiliated Honghui Hospital. Written informed consent was obtained from each patient and the study was conducted in accordance with the Declaration of Helsinki.

**Consent to Publish:**

All of participants were given written informed consent.

**Availability of Data and Materials:**

Not applicable.

**Competing Interest:**

The authors indicated no potential conflicts of interest.

**Funding:**

Not applicable

**Authors’ contributions:**

Baorong He conceived the study. Zhengwei Xu, Dingjun Hao, Liang Dong and Liang Yan participated in study design, biomechanical stimulation, and data analysis. All the authors have read and approved the final submitted manuscript.

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**Figures**

![Figure 1](image)

**Figure 1**

Grade I, A 71-year-old female patient presented with minor trauma 5 months ago and low back pain 2 months ago, which was associated with activity. a) The X-ray showed wedge-shaped changes of the T12 vertebra with kyphosis of the spine; b) CT showed anterior collapse of the T12 vertebra with low-density shadow and peripheral sclerosis; c) MRI T2 showed low signal in the vertebral body; d) Postoperative X-ray showed that the height of the injured vertebra recovered well and the kyphosis deformity was corrected.
Figure 2

Grade II, A 56-year-old female patient presented with low back pain due to heavy lifting 7 months ago and aggravated low back pain 2 months ago, which was correlated with activity. a) The X-ray showed wedge-shaped changes in the T12 vertebra; b) CT showed wedge-shaped changes in the vertebral body, collapse of the upper endplate of the T12 vertebral body, unhealed vertebral fracture, and small fractures in front of the injured vertebral body; c) MRI T12 showed low signal in the vertebral body; d) Postoperative X-ray showed that the patient underwent posterior reduction fixation and fusion and vertebral augmentation.

Figure 3

Grade III, A 73-year-old female patient presented with mild back pain due to trauma 4 months ago, and presented with increased pain and numbness and weakness in both lower limbs 1 month ago,
accompanied by intermittent claudication. a) Lumbar spine X-ray showed the height of the L4 vertebra was lost and the endplate collapsed; b) Sagittal CT showed collapse of the L4 vertebral body, low-density shadow in the vertebral space, protrusion of fracture block into the spinal canal, and spinal stenosis at the same level; c) MRI T2 showed abnormally low signal in the L4 vertebra, with obvious dural compression and spinal stenosis at the same level; d) Postoperative X-ray showed that the patient underwent posterior decompression and bone graft fusion with cement-reinforced internal fixation.

Figure 4

Grade IV, A 63-year-old female patient presented with minor trauma 10 months ago and low back pain 2 months ago, which was associated with activity. a) Thoracic X-ray showed a height loss of the T12 vertebral body and kyphosis of the thoracolumbar segment; c) MRI T2 image showed low signal in the T12 vertebra; d) Postoperative X-ray showed that the patient underwent posterior osteotomy and fusion internal fixation.
Figure 5

Grade V, A 55-year-old female presented with back pain due to a fall 6 months ago and increased back pain accompanied by numbness and weakness in both lower limbs 2 months ago. a) Thoracic X-ray showed wedge-shaped changes of L1 and L2 vertebra with kyphosis of thoracolumbar segment; b) CT showed wedge-shaped changes in L1 and L2 vertebrae, kyphosis of the spine, and lumbar spinal stenosis; c) Sagittal MRI T2 showed low signal of L1 and L2 vertebrae, kyphosis of thoracolumbar segment, spinal canal stenosis and obvious compression of dural sac; d) Postoperative X-ray showed that the patient underwent posterior osteotomy and decompression and reduction combined with internal fixation.