Treatment of Osteoporotic Thoracolumbar Burst Fractures by Bilateral Pedicle Vertebroplasty Combined With Postural Reduction

Haoyu Wang (orthopaedics_why@163.com)
Bengbu Medical College
Lifeng Zhang
Inner Mongolia Medical University
Xiaotao Wu
Southeast University Zhongda Hospital

Research article

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Abstract

Background: Osteoporotic thoracolumbar burst fracture (OTLBF) is common in seniors. Due to the fracture of the posterior vertebra and spinal canal occupancy, the risk of cement leakage and spine injury is high in OTLBF patients, thus the application of vertebroplasty is limited in these patients. This study aims to investigate the efficacy and safety of vertebroplasty for treating OTLBF via bilateral pedicle approach combined with postural reduction. To determine whether percutaneous vertebroplasty (PVP) combined with body reduction is an alternative method for treating OTLBF that prevents major surgical complications.

Methods: Thirteen patients (aged≥65years) with thoracolumbar fractures but without neurological deficits underwent vertebroplasty. In all fracture cases, the anterior and middle columns of the vertebrae were affected and the canal was mildly compressed. To assess the clinical symptoms and the effects of the procedure, patient mobility and pain were assessed prior to the procedure and at 1 day and 3 months after the procedure. Kyphosis correction, wedge angle, and height restoration were also observed and measured.

Results: Improvements in pain and mobility were observed immediately after vertebroplasty in all patients. These results were observed for 6 months. Significant improvements were also noted at 1 day and 6 months after vertebroplasty. Pain was reduced by at least 4 levels after 6 months. No comorbidities were observed. Kyphosis Correction, Wedge Angle and height recovery were improved.
Postoperative computed tomography revealed polymethylmethacrylate leakage through the endplate fracture site into the disc space and paravertebral spacein one patient. No intraspinal leakage was found in all patients.

Conclusions: Vertebroplasty is assumed to be contraindicated in patients with osteoporotic thoracolumbar fractures with posterior body involvement. However, this procedure was successfully performed to safely treat such fractures without causing neurological deficits. PVP combined with body reduction may be an alternative method for treating OTLBF that prevents major surgical complications. Moreover, it helps patients achieve early mobilization and pain relief.

Background

Vertebroplasty is a minimally invasive surgical procedure which involves injecting polymethylmethacrylate into the compressed vertebral body. At present the indications include the treatment of osteoporotic compression fractures, vertebral myeloma, and metastases. Postoperatively, the patient's pain was relieved immediately and the quality of life was significantly improved [1, 2].The value of vertebroplasty in osteoporotic compression fracture has been discussed comprehensively. The surgical operation for burst fractures without neurological deficit remains controversial. For elderly vertebral burst fractures, it is considered as a contraindication because of the concomitant posterior wall rupture and encroachment of the fracture fragment into the spinal canal [3, 4].Some scholars [3–8]

believe that the PVP given to elderly patients with OTLBF has a significant effect on the pain level of the patients, and it has a significant effect on the correction of kyphosis and the restoration of vertebral height. After considering the patents general condition, we performed the percutaneous vertebroplasty combined with reduction for treating OTLBF,reduce the risk of surgery and fixed time to achieve satisfactory results.

Methods

1) General data

13 patients, 5 males and 8 females, aged from 65 to 84 years (mean 74.5 years), involved level T11: Vertebra 3, T12: Vertebra 6, L1: Vertebra 3, L3: Vertebra 1, all were fresh compression fracture (less than 3 weeks) .All patients had moderate chest and back pain, limited mobility, and visual analogue scale (Vas) (8.0 ± 1.4) before operation. All patients had no symptoms of nerve root or spinal cord injury. After preoperative examination, there were no contraindications such as tuberculosis of vertebral body, spondylitis, recent bacterial infection, abnormal coagulation function and so on. The patients were conscious enough to endure 1 hour prone position. Before operation, all patients were routinely examined by anterior and lateral spinal X-ray, computed Tomography (CT) or magnetic resonance imaging (MRI) .Fracture lines were found in the posterior wall of the vertebral body, and there was no sign of spinal cord or nerve compression, the Spinal Canal stenosis index ≥ 0.75. The fracture mass formed a slight space occupying (< 25%) in the spinal canal. The bone mineral density was measured: $t \leq -2.5$, the bone peak ratio was $\leq 70\%$. T1, T2 and lipid suppression phase of MRI showed signs of bone marrow edema, including compression degree 1/3 5 cases, compression degree 1/3 – 2/3 8 cases. All cases were followed up for more than 6 months.

2) Methods

On the basis of treating complex injury and chronic disease, after the patient's condition was stable, took prone position, elevated shoulders, chest and anterior superior iliac spine to make abdomen levitate, made traction under local anesthesia, and pressed down moderately with the palm of hand, the upper and lower endplates of the affected vertebrae were shown as a line shadow by C-arm x-ray machine, and the bilateral pedicle was equidistant from the spinous process, and the upper and lower edges of endplates and pedicle were shown as a line shadow by lateral position. Under the fluoroscopic monitoring of C-arm x-ray machine, bilateral pedicle puncture was performed, and the needle was inserted into the upper outer edge of the pedicle, at 10:00 on the left side and 2:00 on the right side, from the outside up to the opposite pedicle of the next vertebral body, drill the needle into the midline of the pedicle shadow. If the needle point is located at 1/2 of the pedicle, the needle should be inserted correctly. Continue to insert the needle and repeat fluoroscopy until the needle reaches about 3 mm in front of the posterior edge of the vertebral body, the working channel was established by inserting the guide pin and the working cannula in turn, and then the bone cement was injected at the later stage of drawing or the early stage of regiment, 0.25ML of fluoroscopy was injected once, the cement was stopped at 1/4 of the posterior edge

of the vertebral body, monitor the patient's vital signs at all times. The injection is stopped, the needle is removed, and a dressing is applied to cover the wound to complete the operation.

3) Observation Indicators

Observation Index

Patient front edge height, central height detection: That is, in the review of lateral x-ray measurement of the central fracture and front edge height;

Occupancy rate of bone mass in spinal canal: Using picture archiving and communication system (PACS) to measure the bone mass occupancy rate in the vertebral canal. The average area of the middle vertebral canal of the upper and lower adjacent vertebral bodies was the base A, the most obvious bone mass occupancy was B, and the formula was (A-B)/A, the average value was measured 4 times;

The Cobb angle was measured by making a straight line parallel to the vertebral endplate on the lateral x ray, and a vertical line for each of the 2 straight lines, the angle between two perpendicular lines is the Cobb angle.

Visual analogue pain scale(Vas): the patient's pain is divided into 0–10 points according to the degree of pain, 10 points for severe pain, and 0 points for no pain.

Oswestrydability Index (ODI): The index of Functional Disorders, including personal care, sitting, sleep, low back pain, weight lifting, standing, social living, travel, walking, 9 items, each of the six options, the higher the score, the more severe the dysfunction, calculated as: actual score/50(highest possible score)100% .

Quality of life score: divided into emotional function, social function, physiological function, physical pain, physiological function and mental health 6 items, the score is 100 points, the lower the score means the worse the quality of life.

Efficacy assessment CR: Completely relieved, which means the patient can take care of himself and clinical symptoms such as pain completely disappear; PR: Partial remission, which means that the patient can take care of most of his/her life, and the pain symptoms are significantly relieved without the use of painkillers. MR: Slight remission. The patient can partially take care of himself, with little relief of pain symptoms. Occasionally, oral analgesics are needed for pain relief. NR: NULL, the patient could not take care of himself, and the pain was not relieved or even worsened. ORR: represents the objective total efficiency, which is calculated by CR PR.

4) Statistical analysis

Statistical analysis was performed with SPSS 18.0. Measurement data are expressed as mean ± standard deviation ($x \pm s$), using t test. The count data is expressed in terms of rate, and the x^2 test is used for

comparison. P < 0.05 considered a statistically significant difference.

Results

1) Comparison of clinical efficacy within 3 days after operation, there were 8 patients with CR (61.53%), 4 patients with PR (30.76%), 1 patient with MR (7.69%), 0 patients with NR (0%), and 11 patients with ORR (92.30%).

2) Comparison of preoperative and postoperative indexes

The leading edge height and central height after operation were significantly higher than those before operation, and the Cobb angle and the space occupying rates of bone mass in spinal canal after operation were significantly lower than those before operation (P < 0.05), as shown in Table 1.

Table 1 Comparison of preoperative and postoperative indexes of patients (n = 13)

Time	the leading edge height (cm)	the central height (cm)	the Cobb angle(°)	the space occupying rates of bone mass(%)
Preoperative	1.65±0.46	1.73±0.51	16.38±5.12	24.23±2.56
postoperative	2.24±0.61 *	2.36±0.64 *	11.37±5.24 *	18.32±1.45 *

compared with preoperative,* P<0.05

3) Comparison of ODI and VAS scores preoperative and postoperative

Comparing the scores of ODI and vas before and after operation, the scores of ODI and VAS before operation were significantly higher than those after operation (P < 0.05), as shown in Table 2.

Table 2 Comparison of ODI and VAS scores preoperative and postoperative (n = 13)

Time	ODI （%）	VAS (score)
Preoperative	78.37±7.32	8.38±1.32
postoperative	28.39±5.25 *	1.35±0.35 *

compared with preoperative,* P<0.05

4) Comparison of preoperative and postoperative quality of life scores

The scores of social function, emotional function, physiological function, physical pain, physiological function and mental health after operation were significantly higher than those before operation (P < 0.05),as shown in Table 3.

Table 3 Comparison of quality of life scores preoperative and postoperative (score, n = 13)

Time	social function	emotional function	physiological function	physical pain	physiological function	mental health
Preoperative	58.83±9.63	46.23±6.53	50.35±9.67	48.53±10.13	56.34±8.52	54.36±10.31
Postoperative	80.64±8.76*	72.64±9.25*	76.62±10.75*	75.48±11.35*	76.68±8.43*	79.54±9.14*

compared with preoperative,* $P<0.05$

5) The effect of operation and the incidence of postoperative complications

One patient had cement leakage through the end plate fracture to the intervertebral disc and paravertebral space. The operative outcome and postoperative complications were 7.69%.

Discussion

Due to the increase of age, the physical quality of the elderly population continues to decline, osteoporosis is more serious, and the response flexibility is reduced. Therefore, it is more likely to have fracture injury when suffering from slip, fall from height, car accidents, etc. Although most of them are compression fractures, they can often lead to burst fractures if caused by traffic injuries or other serious violence. Denis B type accounted for 49.2% of thoracolumbar burst fractures, mainly including anterior and middle column injury and upper endplate rupture [9]. For elderly patients with osteoporotic Denis B thoracolumbar burst fracture with intact nerve function, conservative treatment is often used [10]. Conservative treatment requires long-time bed rest and braking, which increases the risk of accumulation pneumonia, urinary system infection, lower extremity deep venous thrombosis and bedsore. In addition, some patients have fracture nonunion and further collapse of vertebral body, resulting in kyphosis, and develop into chronic pain, even delayed nerve damage, which seriously affects the quality of life of elderly patients [3], and may even endanger their lives due to complications. However, for the majority of AO Spine type A3/A4 elderly osteoporotic thoracolumbar burst fractures are often complicated with basic diseases such as chronic bronchitis, emphysema, coronary atherosclerotic heart disease, or severe trauma and combined injury, and cannot tolerate open surgery under general anesthesia. Their own osteoporosis is easy to be treated by internal fixation, which may lead to nail removal or loosening and falling off, and the need for second-stage removal and internal fixation surgery, which not only increases the trauma, prolongs the operation time, but also increases medical costs [11–15].

For the treatment of OTLBF, because of the posterior wall rupture and a small amount of fracture mass encroaching on the spinal canal, percutaneous kyphoplasty (PKP) is easily caused by implanting an expandable balloon in the collapsed vertebral body, so that the expansion balloon can reposition the end plate of the fractured vertebral body, and the bone mass of the middle column of the vertebral body is further displaced into the spinal canal. The risk of cement leakage is increased in the case of broken vertebral periosteal wall, especially in those with fracture in the posterior wall, and cement may enter the spinal canal along the fissure and even cause spinal nerve injury, so the risk is greater.

Pain reliefs as well as stabilization of the fracture and early ambulation are the primary goals of treatment of burst fractures. For the elderly and frail patients with compound injuries, it is not strong to demand PVP without complete recovery of vertebral height and kyphosis to minimize the operation time. Our case gave PVP treatment to 13 elderly patients with osteoporotic thoracolumbar burst fractures in our hospital, with an overall response rate of 92.30%.

The results showed that the scores of ODI and VAS after PVP combined with body reduction were significantly lower than those before operation, which indicated that the operation had a significant effect on the relief of pain and the improvement of dysfunction, PVP combined with body reduction can effectively restore the height and shape of the compressed vertebral body, correct kyphosis, restore the stability of the vertebral body, and reduce the compression and stimulation of the nerve, so it can effectively relieve the pain.

According to our experience, the technical points are as follows:

1) After admission, while treating the composite injury, the flat hard bed was used during the perfect examination, and the fracture site was added with supine back pitch, which can assist the reduction. Preoperative hyperextension facilitates the return of a burst vertebral posterior border bony mass to the spinal canal under the influence of the posterior longitudinal ligament. Intraoperatively, it was found that most of these patients could obviously relieve the kyphosis angulation and relax the compressed vertebral body by positional reduction.

2) Staged continuous bone cement filling technique: under continuous monitoring by dynamic C-arm X-ray machine, first irrigate with cement at the end of a small amount of drawing, push back of cement into the tube by 2-3mm wait for 40-50s after closing the defect, and push back of cement remaining in the pushed in tube can effectively prevent the leakage of cement.

3) Cement leakage is the main complication. The most common sites of cement leakage were paravertebral venous plexus, intervertebral space, paravertebral soft tissue and intraspinal canal. The leakage was related to the amount, viscosity, pressure and velocity of the bone cement injection. The indication for stopping cement injection is that the cement has exceeded the posterior 1/3 of the vertebral body, but has not reached the posterior wall to prevent cement from leaking into the vertebral canal. The senile burst fracture is different from the young and middle-aged fracture. The pathological basis is osteoporosis, so the degree of comminution of the fracture is light, the fissure of the fracture block is small, and the leakage is relatively small. Moreover, the enlarged space between the trabecular bone is beneficial to the diffusion of bone cement, to increase the effect of vertebral body strengthening. External forces cause burst fractures in most older adults, but the posterior longitudinal ligament is generally intact, enabling partial bone block reduction due to the pressure on the posterior longitudinal ligament.

4) During the operation, the appropriate hyperextension posture was adjusted to reduce the patient's kyphosis and reduce the vertebral body. The x-ray film and CT SCAN should be observed before operation in the elderly patients with thoracolumbar burst fracture to grasp the fracture line, the position and

condition of vertebral body rupture, and make the operation plan. At the same time, the puncture path should be parallel to the vertebral endplate.

5) Unilateral paracentesis is easy result in leakage of bone cement because of the need to increase the inclination angle and too fine injection of bone cement to increase the diffusion effect. Bilateral puncture with less cement injected into each side with less pressure can achieve satisfactory clinical results, thus reducing cement leakage [4].

6) At the time of puncture, the needle should be as far as possible as 4 ~ 5 mm from the anterior edge of the vertebral body, at least 1/3 of the anterior column should be filled with bone cement. The Cement Push Rod should be placed in front of the vertebral body first. According to the images during the operation, after the anterior column of the Vertebral Body is diffused satisfactorily, the position of the push rod should be reversed, Once cement is found to cross the posterior 1/3 of the vertebral body, the injection should be stopped to prevent entering the spinal canal to burn the spinal cord or compress the nerve root and spinal cord;

7) Timing and dosage of bone cement injection: for burst fractures, we do not seek to inject too much bone cement, a single vertebral body can be 4 ~ 5 ml, bone cement thick stage of injection, to reduce leakage. Because of more vertebral fractures, the cement should be thicker than a simple compression fracture to reduce the rate of leakage. During the course of injection, a small amount of bone cement was slowly injected, then the bone cement was pushed back 2 ~ 3mm and waited for 40 ~ 50s, and then continued to push into the bone cement after the broken edge of the bone cement hardened to form a hard shell.

About half a year follow-up, we found no serious complications, pain relief and vertebral height recovery rate remained good. Osteoporosis is the underlying cause of this condition,PVP is only to solve the problem of fracture and pain. Normal anti-osteoporosis treatment is still needed after PVP. Otherwise, it is easy to refracture and adjacent vertebral fracture.

This study evaluated the quality of life of patients through six items: Social Function, emotional function, physiological function, physical pain, physiological function and mental health, the quality of life of the patients after the operation was significantly higher than that before the operation. Because the combination of PVP and the reduction of the body position during the operation had a better ability to correct kyphosis and promote the reduction of the vertebral body, the utility model can significantly relieve the pain of patients, improve the clinical symptoms of patients, thereby improving the quality of life.

The results of this study support the growing interest in minimally invasive techniques in the management of spinal injuries with no neurological deficit. In addition, advances in surgical techniques have made it possible to treat vertebral compression fractures in full compliance with traditional PVP procedures, including reduction maneuvers, while limiting muscle injury by using a purely percutaneous approach. Rigorous patient selection is necessary and the time to learn the procedure must be taken into account. Studies with a longer follow-up are required to confirm the stability of the correction over time.

Abbreviations

OTLBF：Osteoporotic thoracolumbar burst fracture

CT：computed Tomography

MRI：magnetic resonance imaging

PACS:picture archiving and communication system

PVP: percutaneous vertebroplasty

PKP: percutaneous kyphoplasty

ODI: oswestrydability index

Vas：Visual analogue pain scale

Declarations

Ethics approval and consent to participate

The study was performed according to the Declaration of Helsinki. The study protocol was approved by the Research Ethics Committee of Bengbu Third People's Hospital：(Reference Number: 2/2018).

Consent for publication

Not applicable.

Availability of data and materials

The datasets will be available from the corresponding author on reasonable request.

Disclosure of interest

The author declares that he has no conflicts of interest concerning this article.

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Author's Contributions

Haoyu Wang, MD: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Writing-original draft; Writing-review & editing

Lifeng Zhang, MD: Conceptualization; Formal analysis; Investigation; Writing & editing

Xiaotao Wu, MD: Supervision; Methodology

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Figures

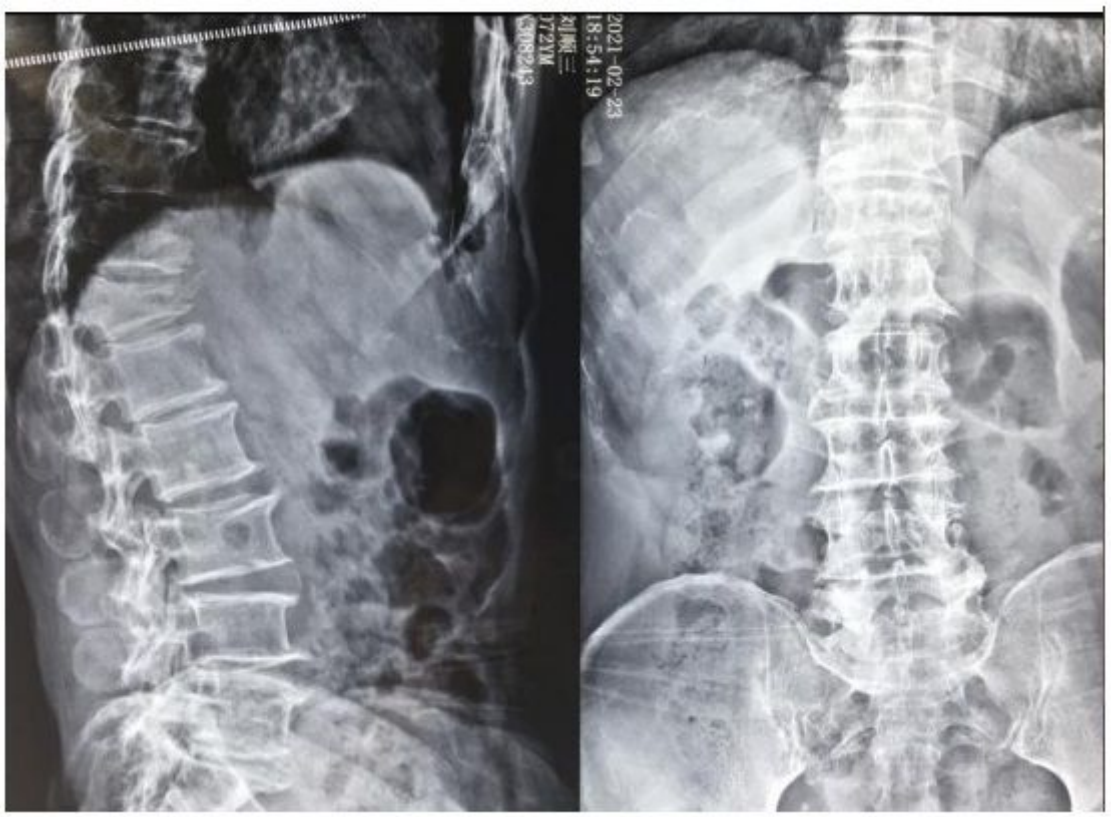

Figure 1

Preoperative X-ray front and side view: thoracic 12 fracture;

Figure 2

thoracic CT: sagittal thoracic 12 burst fracture, pedicle, lamina and transverse process fracture;

Figure 3

two dimensional CT of 1week thoracic vertebra in bed overstretched position: basic reduction of vertebral height;

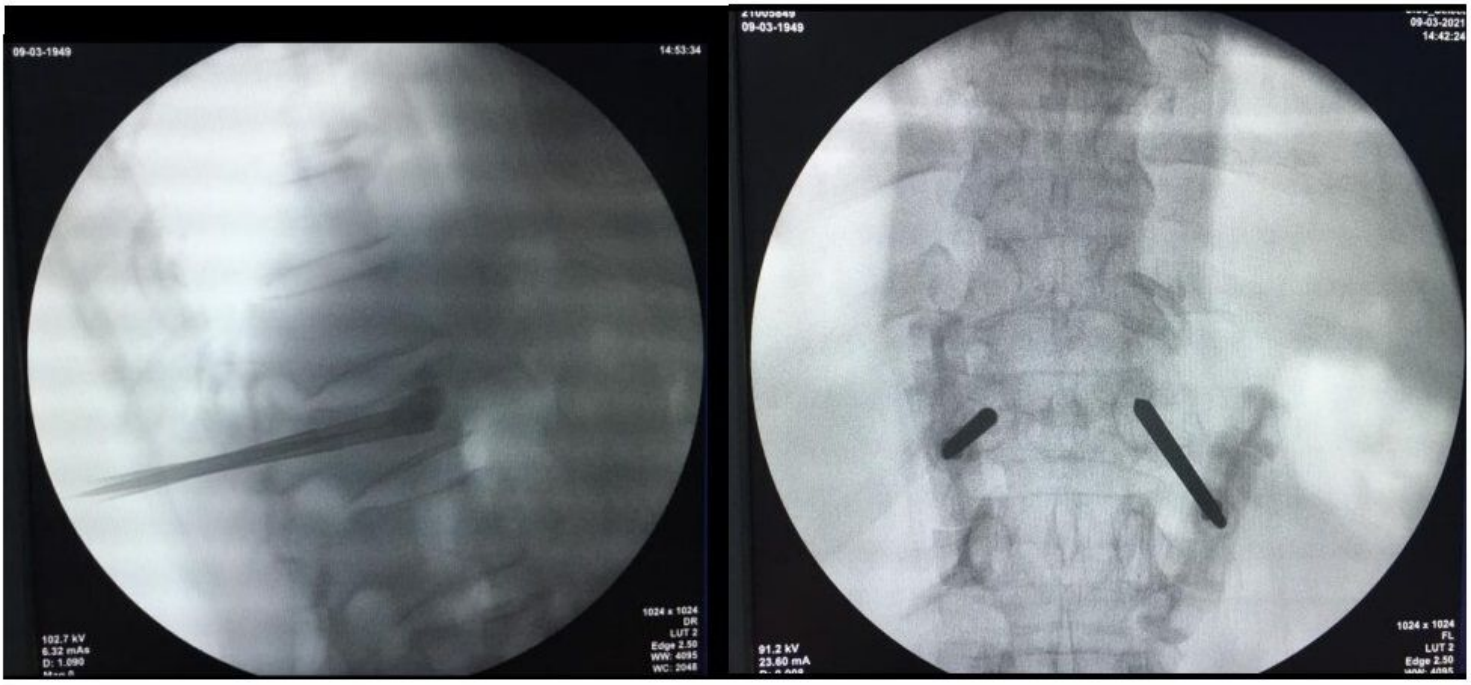

Figure 4

intraoperative puncture, cannula at the anterior edge of vertebral body, and bone cement injection;

Figure 5

the operation is completed without suture;

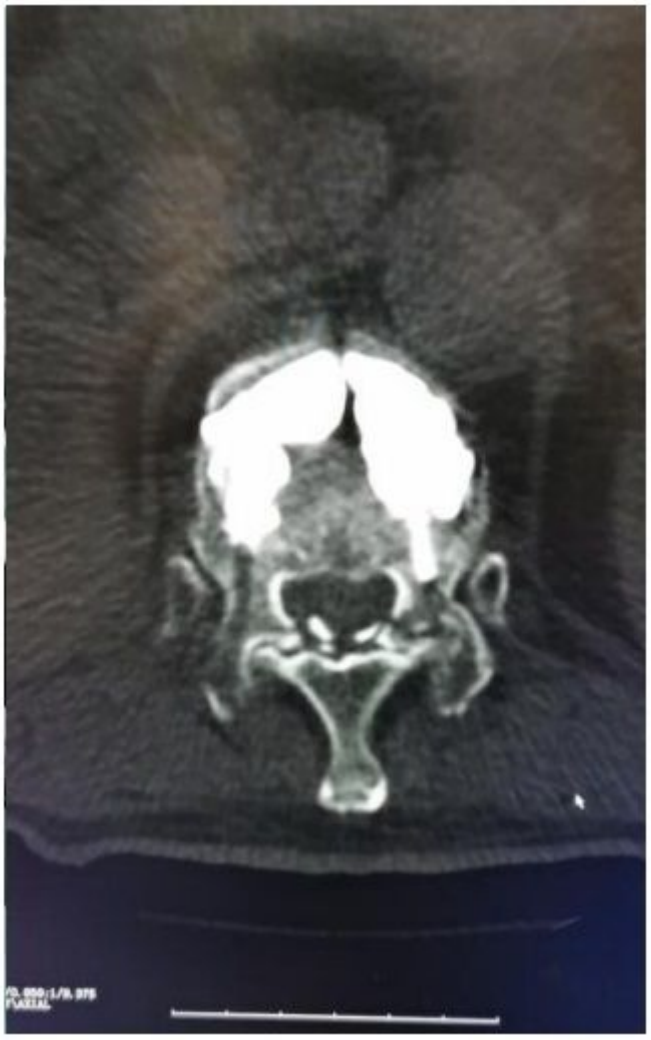

Figure 6

CT Reexamination of thoracic spine after operation: no leakage of bone cement;

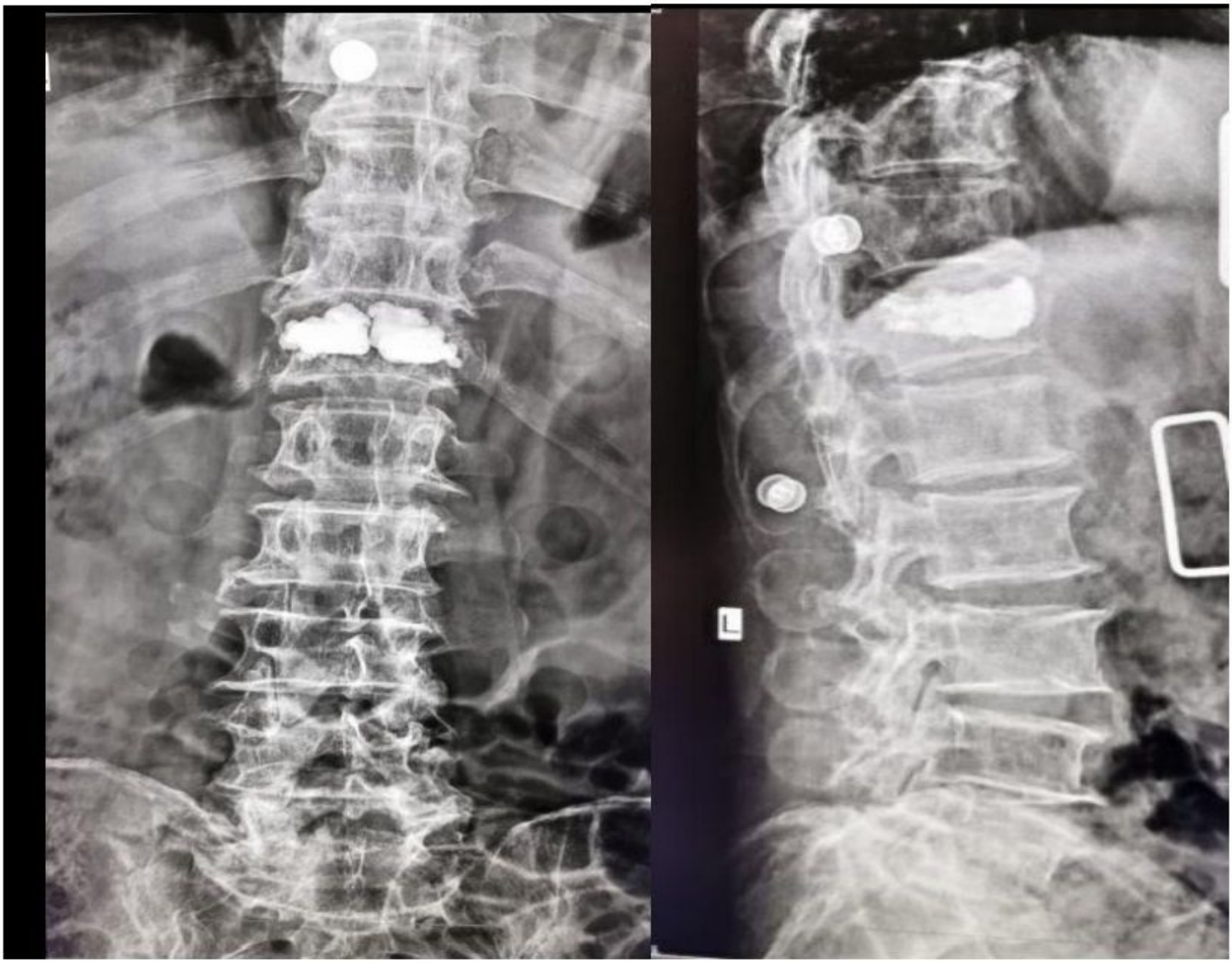

Figure 7

preoperative X-ray anteroposterior and lateral position after operation: the height of thoracic 12 vertebral body recovered satisfactorily.