Clinical Case Report

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Percutaneous vertebroplasty with granulated allogeneic bone grafting using screw-view model of navigation for thoracolumbar compressive fracture

A case report

Jianwu Zhao, MD[a], Xin Zhao, MD[a], Lili Yang, MN[a], Yang Qu, MD[a], Rongpeng Dong, MM[a], Mingyang Kang, MD[a], Xiwen Zhang, MM[b], Changjun Zheng, MM[a,*], Tong Yu, MM[a,*]

Abstract

Rationale: The aim of this study was to assess the accuracy of percutaneous puncture needle with screw view model of navigation (SVMN) and the effect of periacetabular vertebroplasty (PVP) with granulated allogeneic bone grafting in thoracolumbar compressive fracture (TCF).

Patient concerns: A 46-year-old female patient associated with high fall injury showed symptoms characterized by back pain and restricted movement of the right lower extremity.

Diagnoses: The patient was diagnosed with a TCF, right femoral neck fracture, and lumbar vertebrae hyperosteogeny.

Interventions: A SVMN was used to guide our puncture needle insertion; and PVP was performed with granulated allogeneic bone grafting in this patient.

Outcomes: The follow-up lasted for 29 months. It took 2.4 minutes to design the trajectory of puncture needle, 2.1 minutes to implant the puncture needle, and 6.3 minutes to undergone fluoroscopy. Postoperative visual analog scale and Oswestry disability index scores were improved obviously compared with those before the operation. The Cobb angle of fractured vertebrae improved from 9.3° to 7.3° after treatment. The height ratio of fractured vertebrae increased from 79.5% to 90.6% postoperatively. Intraoperative blood loss amounted to 11 ml. No clinical complications were observed, including neurovascular injury and new fracture of adjacent vertebra.

Lessons: Puncture needle placement under the guidance of SVMN is verified as a convenient, safe and reliable method, and PVP with granulated allogeneic bone grafting can effectively restore the height of anterior fractured vertebra, filling the gaps in the fractured vertebrae, and reconstructing the completeness of the fractured vertebrae.

Abbreviations: 3D = three dimensional, CT = computed tomography, L = lumbar, MRI = magnetic resonance imaging, ODI = Oswestry disability index, OVCF = osteoporotic vertebral compression fracture, PMMA = polymethylmethacrylate, PVP = periacetabular vertebroplasty, SVMN = screw-view model of navigation, TCF = thoracolumbar compressive fracture, VAS = visual analog scale.

Keywords: allogeneic bone, compression fracture, navigation, PVP, screw-view model of navigation

Editor: N/A.

JZ and XZ contributed equally to this work

The authors declare that they have no conflict of interest.

[a] Department of Orthopedics, [b] Department of Gynaecology, The Second Hospital of Jilin University, Changchun, Jilin Province, China.

[*] Correspondence: Tong Yu, Department of Orthopaedics, The Second Hospital of Jilin University, Changchun, Jilin Province, China (e-mail: spinesurgery@yeah.net); Changjun Zheng, Department of Orthopaedics, The Second Hospital of Jilin University, Changchun, Jilin Province, China (e-mail: k1763@365office.group).

Medicine (2019) 98:20(e15715)

Received: 31 December 2018 / Received in final form: 10 April 2019 / Accepted: 22 April 2019

http://dx.doi.org/10.1097/MD.0000000000015715

1. Introduction

Vertebral compression fractures have numerous causes and seriously affect the quality of life of the elderly population.[1] Osteoporosis is considered the most common cause of vertebral compression fracture.[2] Traditionally, most patients with osteoporotic vertebral compression fracture (OVCF) were managed conservatively with pain management, short periods of bed rest and bracing.[3] In recent years, surgical interventions have been preferred, including periacetabular vertebroplasty (PVP) and percutaneous kyphoplasty.[4,5]

However, this technique remains challenging. On the one hand, inaccurate puncture may lead to pain in the puncture sites caused by facet joint violation,[6] pedicle invasion, and even nerve injury. One the other hand, there has been an ongoing controversy regarding the effective time of cement augmentation along with various perspectives on issues (eg, pain relief, vertebra height restoration, quality of life, and surgical complications).[4,7–9] Buchbinder et al,[10] Kallmes et al,[11] and Kallmes et al[11] reported that painful control in patients with OVCF was similar among those having received PVP and those having not. Besides, there are other risks related to the use of bone cement, including leakage of cement canal,[7–9,12–14] new fracture in vertebrae adjacent to the fracture treated previously[1,15] and even intracardiac bone cement embolism.[16]

Surgical techniques were improved here to avoid complications. Screw view model of navigation (SVMN) technology was employed to guide puncture needle insertion, and granulated allogeneic bone was used to renew the completeness of lesion vertebral. To the best knowledge of the author, the application of SVMN and granulated allogeneic bone for the treatment of OVCF has been rarely studied. This study presented this surgical technique and clinical results.

2. Ethical approval

Informed consent was obtained from the patient for publication of this case report. This paper was approved by the Second Hospital of Jilin University, Changchun, China. (2019) Research and Inspection No. (010).

3. Case report

3.1. Patient characteristics

A 46-year-old female patient associated with high fall injury was selected the subject of the investigation here, (Table 1). Physical examination revealed percussion pain positive of her back and restricted movement of the right lower extremity. Both lower extremities showed no abnormal cutaneous sensation.

As shown in the pre- and postoperative computed tomography (CT) scan images (Fig. 1A), the bone morphology of the upper margin of the L1 vertebral body was irregular, the shape of anterior edge of L1 vertebral body was irregular, the shape of L1 vertebral body was wedge-shaped, the bone of the L1 vertebral body was discontinuous, lumbar vertebrae hyperosteogeny, no space occupancy was found in the spinal canal, and bone discontinuity of right femoral neck. Lumbar magnetic resonance imaging (MRI) (Fig. 2A) revealed that L1 vertebral height was lost, signal was decreased, and no abnormal signal was found in the spinal cord. The patient was diagnosed primarily with a L1 vertebral compression fracture, right femoral neck fracture, lumbar vertebrae hyperosteogeny.

Table 1

Basic characteristics of patient.

Case	Age, yr	Sex	VLT	Diagnosis
1	46	Female	L1	OVCF

OVCF = osteoporotic vertebral compression fracture, VLT = vertebral level treated.

3.2. Evaluation parameters

Age, sex, vertebral level treated, blood loss volume, and surgical complications of each patient were recorded (Table 1). Also, surgery design time, puncture times, and fluoroscopy time were recorded (Table 2). Visual analog scale (VAS)[17] and Oswestry disability index (ODI)[18] scores were assessed preoperatively and 1, 30, 60, 180, and 840 days after the operation, respectively (Table 3). The Cobb angle and the height ratio of anterior edge of fractured vertebrae were measured both pre- and postoperatively. The height ratio of anterior edge of fractured vertebrae = anterior height of fractured vertebra/[(anterior height of the upper vertebra adjacent to the fractured vertebra + anterior height of the lower vertebra adjacent to the fractured vertebra)/2] *100%[19] (Table 3).

3.3. Surgical technique

3.3.1. *General preparation.* The fractured vertebra was scanned with three dimensional (3D) CT in prone position preoperatively. The scanned image data was recorded on a compact disc read-only memory, which can be recognized by computer navigation for the preparation of preoperative surgery

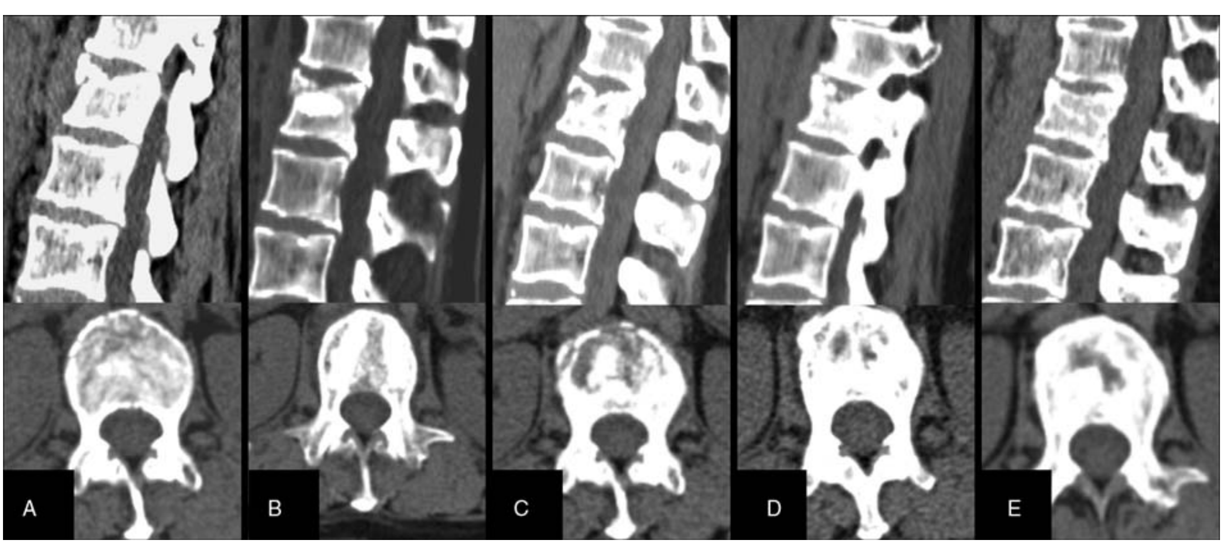

Figure 1. CT images of thoracolumbar segment. A 46-yr-old female patient suffered a high falling injury. (A) According to the preoperative sagittal and axial images, L1 vertebral was fractured, (B) CT images of 1 d after operation, (C) CT images of 30 d postoperative, (D), CT images of 60 d after operation, and (E) CT images of 180 d after operation. CT = computed tomography.

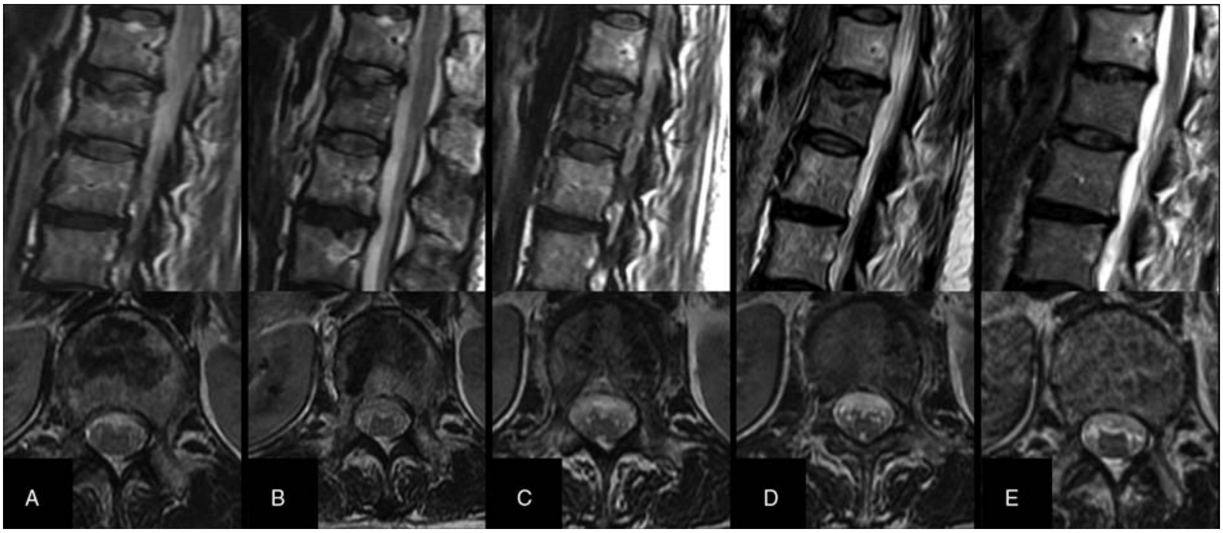

Figure 2. MRI images of thoracolumbar segment. (A) Preoperative sagittal and axial images revealed that L1 vertebral height was lost, signal was decreased, and no abnormal signal was found in the spinal cord, (B) MRI images of 1 d after operation, (C) MRI images of 30 d postoperative, (D), MRI images of 60 d after operation, and (E) MRI images of 180 d after operation. MRI = magnetic resonance imaging.

design. The entry point of the puncture needle and the best trajectory of the puncture needle were designed at the navigation workstation preoperatively.

The patient was placed in the prone position. Thirty minutes before operation, parecoxib sodium for injection (40 mg, Pfizer Pharmaceuticals Limited) was dissolved in sodium chloride physiological solution (0.9 g: 100 ml; Shandong Qidu Pharmaceutical Co, Ltd) and intravenous infusion was performed. Since the patient was fixed on the operating table with medical tap, the position between the patient and the operating table remained unchanged. Local anesthesia was used with lidocaine hydrochloride injection (0.1 g: 5 ml; Heilongjiang Harbin Medical University Pharmaceutical Co, Ltd).

3.3.2. Patient tracker installation and image acquisition. A patient tracker (Stryker Leibinger GmbH & Co, Freiburg, Germany) was fixed on the operating table by connecting the mechanical arm so that the position between the patient and the patient tracker remained unchanged. The Navigation System II-CART II with SpineMap 3D 2.0 software (Stryker Navigation, Kalamazoo, MI) was adopted in the procedure. The puncture needle can be recognized by computer navigation after being registered (Fig. 3). The fracture vertebra was scanned by C-arm at 190°, thus, 3D images of the lesion were acquired. To manipulate under the guidance of high-resolution image, the intraoperative images were matched with the preoperative CT images.

3.3.3. Puncture needle insertion. The screw view mode was selected on the navigation workstation, and the skin puncturing point was selected under navigation. The navigated puncture needle was moved until the direction was fully consistent with the planned position. It is the optimal time for puncture needle insertion when the image at the lower right-corner of the screen display green (Fig. 4). During the insertion of the puncture needle, the relative position of the patient tracker and the compression fractured vertebra remained stationary.

3.3.4. Allogenic bone implantation. The granulated allogeneic bone was implanted into the injured vertebrae through bilateral pedicle bone grafting channels through funnel. The bone grafting area should be in the anterior 2/3 area of vertebral body.[20] The total amount of granulated allogeneic bone implanted was up to 7.9 g, walking with brace at 2 to 4 weeks postoperatively.

3.4. Outcomes and follow-up

A L1 vertebra treated with PVP under SVMN and granulated allogeneic bone grafting. It took 2.4 minutes to design the

Table 2

Clinical outcomes of PVP with granulated allogeneic bone implantation assist by SVMN.

Parameter	Outcomes
The time of surgery designing*	2.4
The time of percutaneous puncture insertion*	2.1
The time of fluoroscopy*	6.3
The amount of GAB implantation†	7.9
Blood loss volume‡	11
Follow up duration§	29

GAB = granulated allogeneic bone.
* min.
† gram.
‡ ml.
§ mo.

Table 3

Parameters pre- and postoperative.

		Post-, d				
Parameter	Pre-	1	30	60	180	840
VAS score	8.7	2.9	1.3	1.1	0	0
ODI score	61.2	31.5	15.8	10.1	6.3	0
Cobb angle (°)	9.3	6.6	6.4	6.5	7.3	7.3
HRFV (%)	79.5	86.4	92.1	91.6	90.6	90.2

HRFV = height ratio of fractured vertebrae, ODI = Oswestry disability index, Post- = postoperative, Pre- = preoperative, VAS = visual analog scale.

Figure 3. The surgical instrument tracker was fixed on the puncture needle. After registration, the puncture needle can be recognized by the navigation system.

trajectory of percutaneous puncture, 2.1 minutes to implant the percutaneous puncture, and 6.3 minutes to undergone fluoroscopy. VAS and ODI scores improved significantly postoperative. The Cobb angle of fractured vertebrae decreased from 9.3° to 7.3° after treatment. The height ratio of fractured vertebrae rose from 79.5% to 90.6% postoperatively, and details are listed in Table 3. Intraoperative blood loss amounted to 11 ml. Postoperative X-ray, CT and MRI (Figs. 5A–E, 1B–E, and 2B–E) showed no invasion of bilateral pedicles, good dispersion of granular allografts, and recovery of fracture vertebral height. No clinical complications (eg, neurovascular injury) were observed during 29-month follow-up.

4. Discussion

Vertebra compression fractures were caused by trauma of the spine, osteoporotic degeneration, metastatic disease, or primary tumor.[1,2,5,21] Vertebra compression fracture can lead to chronic back pain in 84% of symptomatic patients,[22] increased incidence of new vertebra compression fracture,[1,15] deformity of kyphosis, loss of mobility and pulmonary dysfunction.[23,24] As a result, mortality is also higher. Conservative treatment includes bed rest, postural reduction, and braces, which may help reduce pain for a few weeks or months. However, prolonged bed rest is associated with higher incidence of bedsores, pneumonia, venous thromboembolism, and even mortality, especially in those elderly patients with poor physical fitness. Furthermore, open reduction and pedicle screw fixation were also at great risk for these patients.[21]

PVP has been widely applied in the treatment of OVCF because of its advantages for example minimally invasive and good curative effect.[3,25,26] Bone cement (polymethyl methacrylate) injected into the vertebral body can restore vertebral strength rapidly and relieve pain remarkably. However, the elastic modulus of the bone cement differs significantly from that of the bone, thereby enhancing the local strength of the vertebral body in bone cement vertebroplasty. With the rise in local vertebral stress, new fractures of the upper and lower adjacent segments of the vertebral body will occur.[25,26] Moreover, complications (eg, cement leakage) are directly related to the use of cement.

Bone cement leakage is considered a serious complication of this operation,[9,12–14] which may cause spinal cord or nerve root

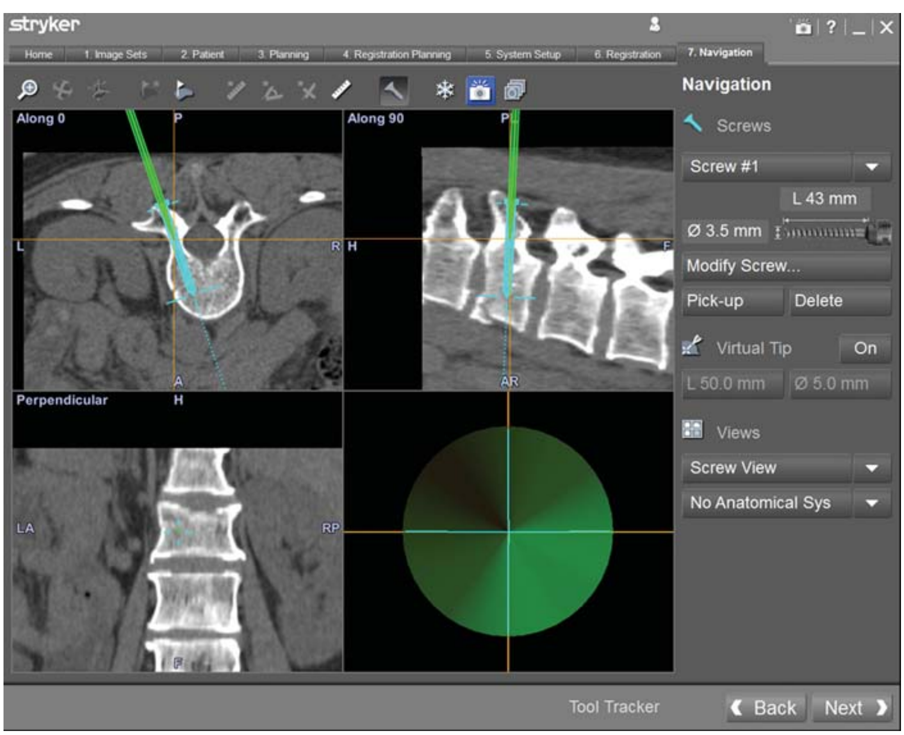

Figure 4. Puncture needle was inserted into fractured vertebra with the assistance of SVMN technology.

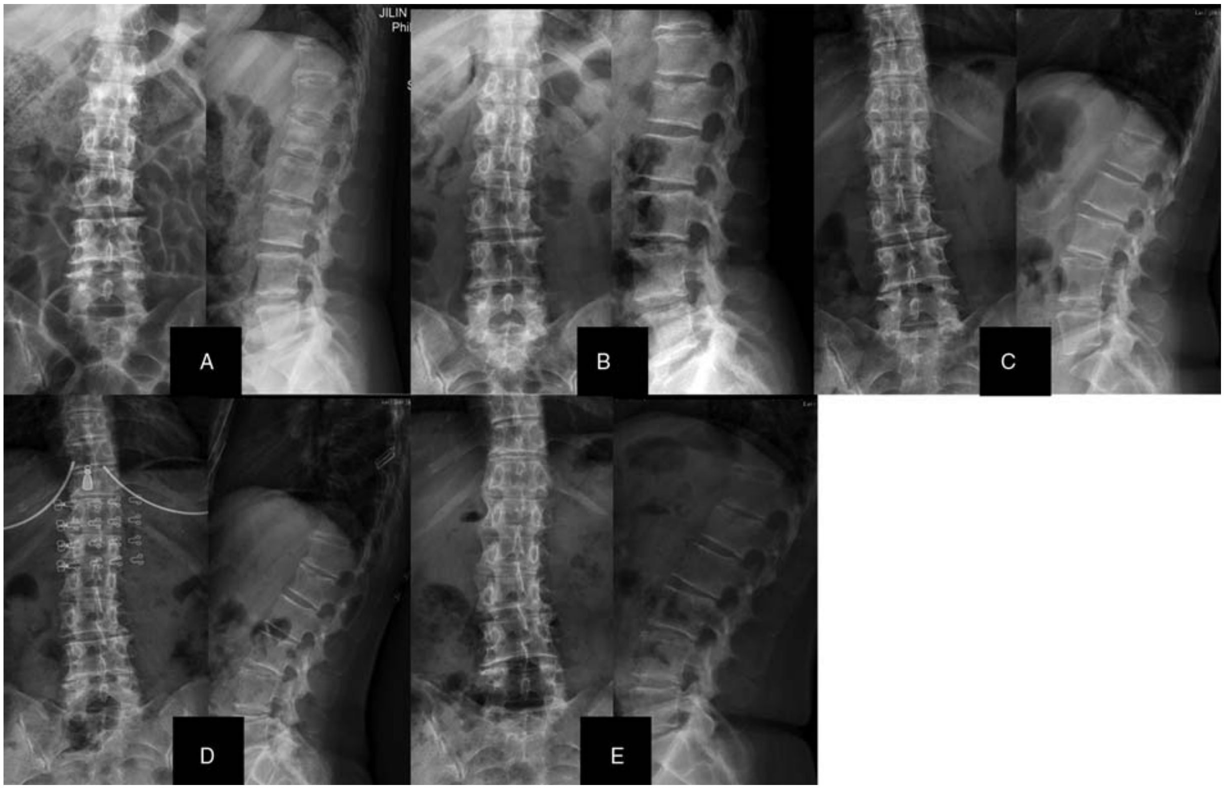

Figure 5. Postoperative x-ray examination of spine. X-ray films of (A) 1 d, (B) 30 d, (C) 60 d, (D) 180 d, and (E) 840 d after operation.

injury[13,14] and even paraplegia. The major factors affecting cement leakage include cortical defect, poor location of puncture needle target, repeated insertion of puncture needle, amount of cement injection as well as the viscosity of bone cement.[27] Here, anterior vertebral cortical defect increased the risk of cement leakage. Cement leakage was effectively avoided by replacing bone cement with granular allogeneic bone. Besides, under the guidance of SVMN, we have achieved precise bone grafting.

New vertebral fracture after PVP in osteoporosis patients is also a common complication.[1,15] Uppin et al[15] reported that two-thirds of new fractures occur in the vertebrae adjacent to those previously treated. Wasnich et al[28] explained the reason for new fractures was probably because deformity and kyphosis vary the vectors of the forces which were in action throughout the spine after a vertebral compression fracture. After the fracture vertebral body was solidified with bone cement, the load-bearing dynamics redistributes the force to the vertebral body adjacent to the original fracture.[28] New vertebral fracture was not observed here during 29-month follow-up. We attribute this positive result to the precise implantation of granular allogeneic bone guided by SVMN technology.

Traditional PVP surgery requires multiple fluoroscopy to ensure accurate insertion of puncture needle into fracture vertebra. In this study, puncture needle was inserted under SVMN guidance. According to the results, the number of puncture, the fluoroscopy time was better than that of literature,[9,12–14,29] while there existed no significant difference in the improvement of VAS and ODI scores compared with literature.[3,10,29] Such positive result resulted from the use of the navigation system for preoperative planning and the guidance of puncture needle insertion with SVMN.

Cao et al[30] reported that the implantation of allogeneic bone in thoracolumbar vertebral fracture can effectively correct the Cobb angle and the height of the anterior edge of the injured vertebra and reduce the degree of the injured vertebral bone defect. The bone trabeculae cannot be fully restored to the original callus structure after reduction, leaving a large space, causing the loss of vertebral height in the later stage. With transpedicular bone grafting, the defect in the vertebral body can be filled, the height of the vertebral body can be maintained after the fractured vertebra reduction, and the bone structure of the vertebral body can be restored. Thoracolumbar fractures are primarily anterior flexion injuries, and the stress is concentrated in the anterior cancellous bone of vertebral body. Thus, the bone grafting area should be in the anterior 2/3 area of vertebral body.[20] Here, the Cobb angle and height ratio of fractured vertebrae was significantly improved postoperatively. Our experience is that precise implantation of granular allografts assisted by SVMN is a major factor in achieving this satisfactory outcome.

Several limitations of this study are summarized as follows. First, it is hard to implant granulated allogeneic bone through narrow pedicle channel, which requires a larger diameter passage, thereby increasing the incidence of pedicle invasion. Second, since granulated allogeneic bone is less fluidity than bone cement, bilateral transpedicular bone grafting is required. Third, the effect of granulated allograft implantation on pain relief remains unclear. Accordingly, a larger sample size-randomized controlled study is required.

5. Conclusions

To sum up,

(1) Puncture needle placement under the guidance of SVMN is verified as a convenient, safe and reliable method;
(2) PVP with granulated allogeneic bone grafting can effectively restore the height of anterior fractured vertebra, fill gap in the fractured vertebrae and renew the completeness of the fractured vertebrae.

Author contributions

Conceptualization: Lili Yang.
Data curation: Mingyang Kang.
Methodology: Xin Zhao, Yang Qu.
Project administration: Rongpeng Dong, Xiwen Zhang.
Supervision: Jianwu Zhao.
Writing – original draft: Xin Zhao, Changjun Zheng.
Writing – review and editing: Jianwu Zhao, Tong Yu.

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