

Clinical effect of a new type of transpedicular reducer for fracture reduction via pedicle and bone grafting combined with pedicle screw fixation for thoracolumbar burst fractures

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Research Article

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Abstract

Background: Short-segment transpedicular screw fixation is a common method for the treatment of thoracolumbar burst fractures (TBFs), but this technique has many problems. Therefore, the purpose of this article is to observe and evaluate the clinical efficacy of a new type of transpedicular reducer that we designed for fractured vertebral body reduction and bone grafting in the treatment of TBFs.

Methods: From July 2018 to November 2020, 70 cases of TBFs were included. 35 cases were treated with the new transpedicular reducer for fracture reduction via pedicle and bone grafting combined with pedicle screw fixation (observation group), 35 cases were treated with short-segment transpedicular screw fixation (control group). Before operation, after application of the transpedicular reducer (not needed in the control group), 3 days after operation, 3 months after operation, 6 months after operation, and 12 months after operation, the two groups were recorded and compared respectively: the anterior and middle heights of the injured vertebrae, the ratios of the anterior and middle heights of the injured vertebral body to the respective heights of the adjacent uninjured vertebral bodies (AVBHR and MVBHR, respectively), and the Cobb angle of patients. And we compared the pain VAS score and quality of life GQOL-74 score at the last follow-up. At last, we evaluated the distribution of bone grafts and bone healing 12 months after the operation.

Results: All 70 cases were followed up for at least 12 months. The observation group's anterior and middle heights of the injured vertebral, AVBHR and MVBHR were higher than those of the control group at 3 days, 3 months, 6 months and 12 months after operation, the Cobb angle was smaller than that in control group, the pain VAS score and the quality of life GQOL-74 score at the last follow-up were better than those of the control group, and these differences were statistically significant ($P < 0.05$). The observation group showed no obvious defects on CT at 12 months after operation, and the bone healing was good.

Conclusion: The new type of transpedicular reducer for fracture reduction via pedicle and bone grafting combined with pedicle screw fixation for TBFs has a good clinical efficacy.

1. Background

Thoracolumbar burst fractures (TBFs) are one of the most common forms of spinal trauma in clinical practice. The axial compressive force on the centre column typically collapses the bone and causes the front and centre support columns to fail. Burst fracture subsequently occurs [1]. Most of these fractures (70%) occur at the thoracolumbar junction (Th11-L2) [2]. In young patients, falls from heights, traffic accidents, and sports injuries are the most common causes of vertebral fractures [2]. Simple falls are the most common cause of incomplete burst fractures in the elderly [3]. In the AOSpine thoracolumbar spine injury classification system, burst fractures are classified as A3 or A4 based on whether one or two end plates are damaged (A3 involves a single endplate fracture of the posterior wall of the vertebral body; A4 involves the upper and lower endplates and posterior wall of the vertebral body) [4]. The sequelae of these injuries can be devastating, including paralysis, pain, deformity and loss of function [5–8].

The purpose of TBF treatment is to stabilize the spine, prevent short-term and long-term deformities, prevent neurological decline, and improve clinical outcomes [9]. Nonsurgical treatment is ineffective for most patients with burst fractures, and there may be a longer immobilization time and failure to restore the normal sagittal position

[10]. Rapid surgery not only restores the sagittal position more reliably in some cases [11–13] but also restores nerve function more effectively for a more rapid recovery.

Clinically, the most widely used surgical method for the treatment of TBFs is short-segment fixation with pedicle screws, and this surgical treatment has good results. However, domestic and foreign clinical studies have found that reduction of short-segment fixation with pedicle screws fails [14–15] mainly because only the pedicle screw instrument is used to indirectly reduce the fractured vertebrae through distraction, which will cause insufficient reduction of the depressed endplate [16]. In addition, failure to reposition the injured vertebrae after short-segment transpedicular screw fixation without bone grafting will result in the formation of a "hollow-like" vertebral body [17], which will subsequently fail to provide sufficient support and stimulation to heal fractures inside the vertebral body. However, the "hollow-like" vertebral body with incomplete bone healing will further decrease the height of the injured vertebral body under the action of a slight external force, and the vertebral body may eventually be lost or even fracture again, causing instability [18–20]. As a result, the structural integrity of the anterior and middle column of the spine and the stability of the load are reduced [21–22], and kyphosis is aggravated [23–25]. Due to the lack of support for the injured vertebrae due to this operation, the fractured vertebral body will not heal well, and bone grafting is consequently required for the "hollow-like" vertebral body.

To reduce the height of the injured vertebrae, correct kyphosis, and promote healing of the injured vertebrae, we designed a new type of transpedicular reducer according to the anatomical nature of the thoracic and lumbar pedicles, which can better restore the height of the vertebral body by manipulating the mechanical force. In addition, we intraoperatively implanted allogeneic bone. We compared and studied the clinical results of 35 cases with TBFs treated with new transpedicular reducer through pedicle fracture reduction and bone grafting combined with pedicle screw fixation and 35 cases with TBFs treated with short-segment transpedicular screw fixation alone at the First Affiliated Hospital of Zunyi Medical University from July 2018 to November 2020.

2. Method

2.1 Inclusion criteria

The following inclusion criteria were employed in this study: (1) vertebral burst fracture confirmed by X-ray examination or CT scan; (2) AO classification as A3 or A4 burst fracture; (3) no serious heart, brain or lung problems; (4) no surgical contraindications, such as infections and blood clotting disorders; (5) no history of thoracolumbar surgery.

2.2 Clinical data

From July 2018 to November 2020, 70 patients with TBFs met the eligibility criteria for the use of posterior short-segment pedicle screw internal fixation and distraction reduction surgery. 35 cases were performed with the new transpedicular reducer through pedicle fracture reduction and bone grafting combined with pedicle screw fixation (observation group), they included 12 female and 23 male patients, aged from 33 to 55 years (average 47.2 years). Among them, 14 cases were injured by traffic accidents and 21 cases were injured by falling from height. The fractured vertebrae were T11 (3 cases), T12 (11 cases), L1 (17 cases), and L2 (4 cases). Among them, 25 cases were A3 type and 10 were A4 type; 35 cases were performed with short-segment transpedicular screw fixation alone (control group), they included 15 female and 20 male patients, aged from 29 to 58 years (mean 46.3 years). Among them, 13 cases were injured by traffic accidents and 22 cases were injured by falling from height. The fractured vertebrae were T11 (2 cases), T12 (10 cases), L1 (19 cases), and L2 (4 cases). Among them, there

were 24 cases of type A3 and 11 cases of type A4. The posterior wall of the vertebral body remained largely intact. No neurological deficit was observed.

2.3 New transpedicular reducer

2.3.1 Structural design

A new type of transpedicular reducer (Chinese patent number: ZL 2019 2 1561649.5) (as shown in Fig. 1) was designed. The reducer includes a knob (1), a fixed sleeve (2), a transmission rod (3), a pin (4), a movable pull rod (5), a fastening nut (6), a fixed pull rod (7) and a support assembly. The support assembly includes a link mechanism (8), a rivet (9), and a support plate (10). There are two support plates. Turning knob 1 drives transmission rod 3 to move, thereby driving movable rod 5 to move. Moveable rod 5 moves to drive linkage mechanism 8 to contract or expand, thereby driving support plate 10 to open or close, which can open up and down or left and right.

2.3.2 Operational technical points

First, a path through the pedicle is established to reach the centre of the fractured vertebral body, and the new transpedicular reducer is implanted in its unexpanded state through the path to make it reach the proper position in the vertebral body. Then, the knob is turned to expand the reducer and make it burst. The fractured vertebral body restores its height and shape and finally rotates the knob to close the reducer to withdraw from the vertebral body. See Fig. 2.

2.4 Operation

All patients were intubated under general anaesthesia with bent hips, bent knees, bowed waist and a prone position on the operating bed as well as with moderate overextension of the trunk to increase the lamina space for the operation. The two iliac abdomens were placed on cushioned support for fixation, and the abdomens were suspended to reduce abdominal pressure and reduce intraspinal venous plexus bleeding. Regular disinfection was employed, and sterile towels were spread slightly laterally on bilateral marked points at approximately 0.5 cm. Needle biopsy was applied to the pedicle centre under the C arm with an oblique perspective to adjust the needle position and direction satisfactorily after needle positioning was fixed to guide the needle puncture point in the centre-cut skin and subcutaneous tissue. The fascia was cut with a high frequency electric knife followed by periosteal stripping on both sides of the shaft, electric coagulation and gauze tamponade haemostasis, which revealed the spinal segment, vertebra, and articular process. On both sides of vertebral pedicle, the positioning needle was placed into the needle point from the perspective of the C arm machine. The position and direction of the satisfactorily enlarged hole was adjusted from the vertebral segment. Four pedicle screws with a suitable diameter and length were installed, and C arm fluoroscopy was used to ensure that the pedicle screw position and direction were satisfactory. After the needle was used to place the pedicle into the needle point and after C arm fluoroscopy revealed that the location was accurate, the injured vertebral pedicle was used to establish an open channel. The bone graft in the C arm fluoroscopy guided vertebrae reset the device implanted in a central location. The handle was reset clockwise, and the device was reset in the open, bottom plate, and then the rotating handle was rotated anti-clockwise. The reset was slowly exited. The height of the injured vertebra was recovered under the C arm. The defect was filled with allogeneic bone granules implanted into the vertebra through the bone graft channel of the injured vertebra. Prebent titanium rods were installed and properly propped and fixed. C arm fluoroscopy showed that the pedicle screw position and direction as well as the injured vertebral body were satisfactory. Next, the horizontal connecting rod was installed. A large amount of normal saline was used to wash the wound surface. No active bleeding was detected, and the gelatine sponge was covered. After the dressing, the

instruments and brain cotton were assessed, a negative pressure drainage tube was placed, the incision was closed layer by layer, a sterile dressing was wrapped and fixed, and the operation was completed.

2.5 Patient evaluation

2.5.1 Measurement

The injured thoracolumbar vertebrae were measured before the operation; after reduction with the new transpedicular reducer, and 3 days, 3 months, 6 months and 12 months after the operation. Surgimap software was used to measure and determine the height of the injured vertebral body.

2.5.1.1 Measurement of the anterior height and ratio of the injured vertebrae (AVBHR); (see Fig. 3a).

2.5.1.2 Measurement of the middle height and ratio of the injured vertebrae (MVBHR); (see Fig. 3b)

2.5.1.3 Measurement of the Cobb angle of the injured vertebrae (see Fig. 3c).

2.5.2 Observation

The pain VAS score and the quality of life GQOL-74 score of the two groups at the last follow-up were compared. The quality of life GQOL-74 scale is divided into four dimensions: psychological function, social function, physical function, and material life. Each dimension counts 100 points for a total of 400 points. The higher the score, the better the patient's quality of life. And we evaluated the distribution of bone grafts and bone healing 12 months after the operation.

3. Statistical Analysis

The data was analyzed using SPSS18.0 statistical software. The measurement data conforming to the normal distribution are expressed as mean \pm standard deviation ($+s$), the one-way analysis of variance was used for comparison before and after surgery, and two independent sample t-tests were used for comparison between the two groups, χ^2 test or Fisher's exact test was used for comparison of count data, rank sum test was used for comparison of grade data, and $P < 0.05$ was considered statistically significant.

4. Results

4.1 Perioperative situation

All subjects successfully underwent the the new transpedicular reducer for fracture reduction via pedicle and bone grafting combined with pedicle screw fixation (observation group) or short-segment transpedicular screw fixation alone (control group) and have been followed up for more than 12 months. Each consisting of 35 vertebral bodies. The mean operative time of the observation group was 120.3 ± 22.6 min, and the mean operative time of the control group was 78.2 ± 19.4 min. No wound infection occurred after operation. In the observation group, only 1 case (2.9%) had urinary retention, which was cured after symptomatic treatment; in the control group, 7 cases (20%) had complications, 1 case of cerebrospinal fluid leakage, 1 case of dural tear, 3 cases of urinary retention, Healed after symptomatic treatment; the incidence of complications in the observation group was lower than that in the control group, and the difference was statistically significant ($P < 0.05$). The patients became active 2 to 3 days after bed rest.

4.2 Measurement results for the vertebra height and Cobb angle

The anterior height and middle height of injured vertebrae, AVBHR, MVBHR and Cobb angle of 35 cases with the new transpedicular reducer for fracture reduction via pedicle and bone grafting combined with pedicle screw fixation in TBF patients (observation group) preoperatively, after application of vertebral body fracture restoration, and postoperatively at 3 days, 3 months, 6 months and 12 months are presented in Table 1.

The anterior height and middle height of injured vertebrae, AVBHR, MVBHR and Cobb angle of 35 cases treated with posterior pedicle screw fixation alone in TBF patients (control group) preoperatively, and postoperatively at 3 days, 3 months, 6 months and 12 months are presented in Table 2.

According to the statistical analysis, the anterior vertebral height, middle vertebral height, AVBHR, MVBHR and Cobb angles after the application of the vertebral fracture reduction device and 3 days, 3 months, 6 months and 12 months after the operation were each significantly different from the corresponding values before the operation ($P < 0.05$), but the differences among the postoperative data points were not significant ($P \geq 0.05$).

4.3 Observation results of VAS score and GQOL-74 score

At the last follow-up, the pain VAS score of the observation group was (1.3 ± 0.6) points, and that of the control group was (2.9 ± 0.7) points; the GQOL-74 score of the observation group was (253.8 ± 7.8) points, and that of the control group was (219.6 ± 7.2) points. The pain VAS score and quality of life GQOL-74 score in the observation group were better than those in the control group at the last follow-up, with statistical significance ($P < 0.05$).

4.4 Observational results of bone grafting

In the observation group, 4 ~ 9 g allograft bone was used to fill in the vertebral body (the average bone graft was 5.4 g) during the operation, and there were no complications, such as pedicle rupture and intravertebral haematoma. Three days after surgery, the allograft was evenly wedged in the anterior and medial columns (see Fig. 4). CT re-examination 12 months after the operation revealed that the allograft bone that filled the anterior and middle columns was absorbed, and no defects were found. Moreover, the trabecular structure was visible in the cancellous bone, and good bone healing (supporting the fractured vertebra) and a good therapeutic effect were observed.

4.5 Typical cases

A 32-year-old male had a burst fracture of the L1 vertebra due to a fall as shown in Fig. 5.

5. Discussion

TBFs are clinically common. Spinal fractures typically occur in the thoracolumbar segment, and burst fractures that occur at the thoracic-lumbar junction (T11-L2) account for 70% of fractures [2]. A burst fracture is the result of a compression mechanism or is part of an excessive bending, extension or rotation injury [26]. The front and centre columns cannot be supported due to axial loading [27–28]. The transition from the less mobile thoracic spine and its associated ribs and sternum to the more mobile lumbar spine makes the thoracolumbar junction (T11-L2) a large area of biomechanical stress. The imaging features include rupture of the posterior wall of the vertebral body, retrograde entry of the posterior edge of the vertebral body into the lumen, a decrease in the height of the vertebral body and an increase in the distance between the pedicles. This injury is typically caused by traffic accidents, sports injuries or falls. Therefore, from a biomechanical or neurological point of view, many people consider burst fractures to be unstable. Burst fracture injuries are classified as A3 or A4 in the AOSpine thoracolumbar spine injury classification system. The objectives of treatment after a TBF are to stabilize the

spine, prevent nervous system deterioration, restore sagittal balance, maintain as much segmental activity as possible with as little tissue damage as possible, and mobilize the patient as quickly as possible. Conservative treatment includes bed rest and reduced posture and orthotics, which may help relieve pain for weeks or months. Conservative treatment of fractures has been shown to be useful in most stable fractures [10.29-32] but not in all cases, and long-term bed rest is associated with an increased incidence of bedsores, pneumonia, venous thromboembolism, and even death [33]. Compared with nonsurgical methods, surgical treatment of thoracolumbar fractures does provide some advantages, especially for patients who cannot tolerate orthotics or plaster orthotics for several months, such as patients with multiple limb injuries, skin lesions, and obesity, etc. [11]. Therefore, in the present study, patients with contraindications to surgery were excluded, and surgical treatment was recommended for the remaining patients. Surgical decompression can also be more reliable and effective in removing damaged spinal canals, restoring neurological function and improving rehabilitation. In 1984, Denis et al. conducted a retrospective comparison between the surgical and nonsurgical treatment of 52 cases of blowout fractures without neurological defects and found that all patients treated with surgery had no relevant disability and returned to full-time work, whereas 25% of the patients treated without surgery were unable to return to full-time work [34]. In addition, neurological problems were reported in 17% of nonsurgical patients. Siebenga et al. concluded that surgical treatment not only offered better clinical outcomes but was also more cost-effective than nonsurgical treatment [35]. Two other large systematic evaluations [36–37] demonstrated that early surgery for thoracolumbar fractures was associated with reduced complications and shorter hospital and ICU stays.

Surgical treatment of TBFs varies with many factors. The shape of the fracture, the state of the nervous system, and the surgeon's preference all play important roles in determining the surgical procedure. Short-segment pedicle screw fixation is now widely used and can be performed in a minimally invasive manner. This operation can effectively reconstruct the injured vertebra and enhance the stability of the anterior central column [38–39]. In addition, the surgical method has a low incidence of complications [18]. However, the acknowledged disadvantages of this procedure are early reduction failure and recurrent kyphosis [18.40–41]. These disadvantages are probably due to the fact that posterior pedicle screw fixation alone does not provide sufficient support to heal the fractured vertebra without the assistance of anterior column reconstruction. Posterior pedicle fixation through the short segment of the vertebral pedicle involves homeopathic compression of the injured vertebra to repair the fractured injured vertebra, but this homeopathic pressure cannot repair the compressed cancellous bone in the injured vertebra, thus forming a "hollow" vertebra [18]. Therefore, placing these screws directly onto the vertebrae without reduction may weaken the vertebrae, affecting subsequent reduction of the fracture and possibly leading to fracture displacement. Moreover, failure to perform targeted bone grafting and filling of the local "eggshell-like" cavity formed after the reduction of the injured vertebra will lead to further loss of vertebral height. Many scholars have further explored this concept and invented such as SpineJack, Sky Bone Expansion System Kyphoplasty (SKP), Opti Mesh Vertebroplasty, Intravertebral Expandable Pillar (I-VEP) and Lantern bracket skeletal angioplasty and other technical to restore and support the shape and height of the fractured vertebral body, but there are still common shortcomings: 1. All need to combine the existing bone cement technology or nail rod internal fixation system to achieve its application; 2. Cannot Provides a more uniform expansion and reduction force and the expansion height cannot be determined by itself.

Therefore, we designed a new type of transpedicular reducer to treat compressibility and blowout fractures. Our new type of transpedicular reducer has the advantage of different from other reducers in that it uses the lever-regulating principle, a minimally invasive channel into the vertebral body can even open in two directions. The contact surface of the stent surface with the bone tissue interface is increased to solve the problem posed by

existing techniques that do not provide uniform opening, the surface of the scaffold and bone tissue interface stress is too large. The new transpedicular reducer can provide uniform support to repair the burst vertebral body fracture, restore good controllability (according to the actual need) of the reset height and is easy to operate. According to our experimental research, application of the new transpedicular reducer in the treatment of vertebral burst can effectively recover the anterior and middle height of injured vertebral bodies from preoperative values of 20.56 ± 3.74 mm and 20.36 ± 4.20 mm to 28.53 ± 2.53 mm and 26.84 ± 1.00 mm, respectively, at 12 months after surgery; both increases were statistically significant. The Cobb angle decreased from $11.80 \pm 1.44^\circ$ before surgery to $3.26 \pm 1.00^\circ$ at 12 months after surgery, indicating that the Cobb angle decreased significantly after surgery, significantly correcting kyphosis. In general, in addition to being very good at restoring the height of the vertebral body and correcting kyphosis, the new transpedicular reducer allows the injured vertebra to remain approximately in the corrected spinal position for a longer period of time after surgery.

Because the trabecular bone cannot be completely restored to the original callus structure after reduction, there will be a large space, which will directly lead to the loss of vertebral height in the later stage. Over the past decade, several studies have demonstrated that reinforcing fractured vertebrae with absorbable bone cement can enhance fracture healing and prevent implant failure. However, the increase in bone cement is also a controversial issue. Polymethacrylate (PMMA) is commonly used in vertebroplasty (VP) and balloon kyphoplasty (BK) for the treatment of osteoporosis and fresh thoracolumbar fractures. However, PMMA has been reported to be associated with undesirable characteristics, such as a high temperature setting, possible damage to local nerve and vascular structures, inadequate bone fusion and a severe stiffness mismatch with bone, resulting in subsequent adjacent fractures and even vertebral restenosis [42]. Moreover, the leakage rate is high (7–10%). It has been reported that distal cement emboli enter the cardiac cavity and pulmonary system [43–44]. PMMA is also non-absorbable: thus, bone cement is retained rather than gradually replaced by biological tissue, which has a particularly adverse effect on young people. As a result, scientists are now also looking for a new implant to minimize the incidence of complications. Cao et al. reported that allograft bone implantation in thoracolumbar fractures can effectively correct the Cobb angle and the height of the injured vertebral front and reduce the degree of the injured vertebral defect [45]. Therefore, we applied the new transpedicular reducer and filled the damaged vertebral cavity with allograft bone through the bone graft channel, which effectively restored the vertebral bone structure and avoided leakage caused by the use of bone cement. CT results of the patients 12 months after the operation showed that the allograft was evenly distributed in the front and middle columns in a wedge shape. In addition, some allografts were absorbed. No defects were found, and trabecular structures were visible in the cancellous bone.

And according to our research results, the reduction effect of the new transpedicular reducer for fracture reduction via pedicle and bone grafting combined with pedicle screw fixation is better than that of short-segment transpedicular screw fixation alone, the difference was statistically significant ($p < 0.05$). According to the results of the VAS score and GQOL-74 score, the clinical effect of the new transpedicular reducer for fracture reduction via pedicle and bone grafting combined with pedicle screw fixation is better than that of short-segment transpedicular screw fixation alone, the difference was statistically significant ($p < 0.05$).

6. Conclusion

The new transpedicular reducer for fracture reduction via pedicle and bone grafting combined with pedicle screw fixation has a good therapeutic effect on patients with TBFs, which can effectively reduce the injured vertebra and

reduce complications and postoperative pain, thereby improving the quality of life.

Declarations

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Competing interests Each author certifies that he or she or a member of his or her immediate family has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted manuscript.

Ethics approval In our study involving humans, signed informed consent was provided by participants. This study was designed in accordance with the Declaration of Helsinki and approved by the ethics committee of The Affiliated Hospital of Zunyi Medical University.

Consent to participate In our study involving human subjects, signed informed consent was obtained from all participants.

Authors' contributions

MHC and ZJX contributed to the writing of the paper and drafting of the manuscript. WBL contributed to the study design. MHC and JLH collected and analyzed the data. WBL and MHC reviewed and edited the manuscript. WJK, QD, WJJ, FJW and JL performed the experiment. All authors read and approved the final manuscript.

Consent for publication Not applicable

Availability of data and material All data generated or analysed during this study are included in this published article.

Code availability Not applicable

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46. **Legends**

Tables

Table 1 Changes in the anterior height and central height of the injured vertebrae and Cobb angle in the observation group at different times

	Before the operation	After reduction with the new type of transpedicular reducer	3 days after the operation	3 months after the operation	6 months after the operation	12 months after the operation
anterior height(mm)	20.56±3.74	28.53±2.53	29.88±2.52	28.36±1.93	28.12±1.42	27.96±0.72
middle height(mm)	20.36±4.20	26.84±1.00	27.70±2.01	27.05±2.45	26.94±1.84	26.83±2.45
AVBHR (□ □)	63.09±8.91	93.62±7.38	97.54±5.08	96.46±3.87	95.93±4.75	94.89±4.21
HVBHR (□ □)	68.97±8.43	90.44±4.85	97.40±6.11	96.05±5.21	94.90±4.60	93.11±3.22
Cobb angle(°)	11.80±1.44	3.26±1.00	2.72±0.70	3.03±0.65	4.12±0.63	4.34±0.56

Table 2 Changes in the anterior height and central height of the injured vertebrae and Cobb angle in the control group at different times

	Before the operation	3 days after the operation	3 months after the operation	6 months after the operation	12 months after the operation
anterior height(mm)	20.70±4.57	28.5±5.09	27.03±1.43	24.12±1.76	23.7±0.66
middle height(mm)	19.36±3.06	26.56±4.56	24.12±3.23	23.65±1.33	22.45±2.57
AVBHR (□ □)	63.76±4.68	93.06±3.57	85.64±3.23	83.86±5.02	82.77±4.97
HVBHR (□ □)	64.91±4.84	89.13±4.5	77.95±5.67	75.86±3.79	74.8±3.68
Cobb angle(°)	11.84±1.78	3.65±0.69	4.68±0.23	5.77±0.79	7.89±1.24

Figures

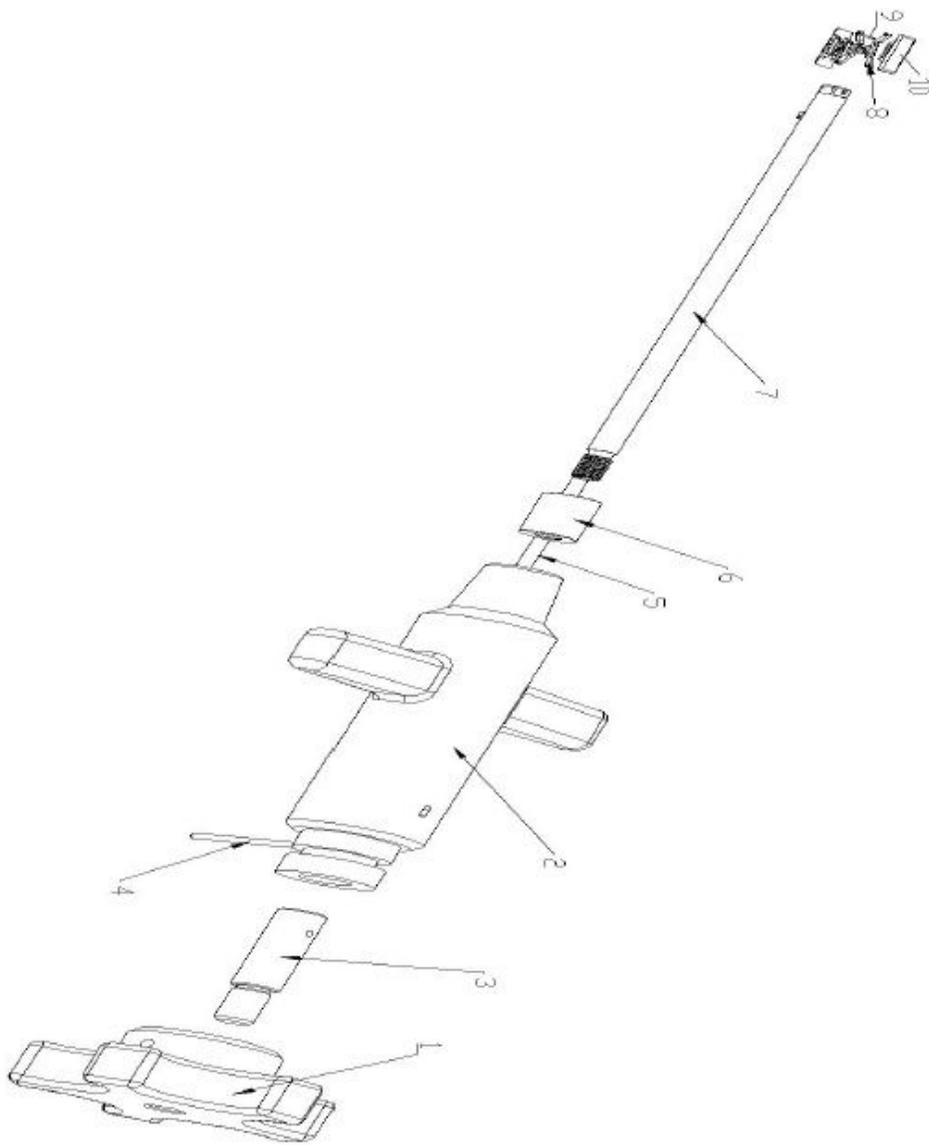


Figure 1

Structural diagram of the new type of transpedicular reducer

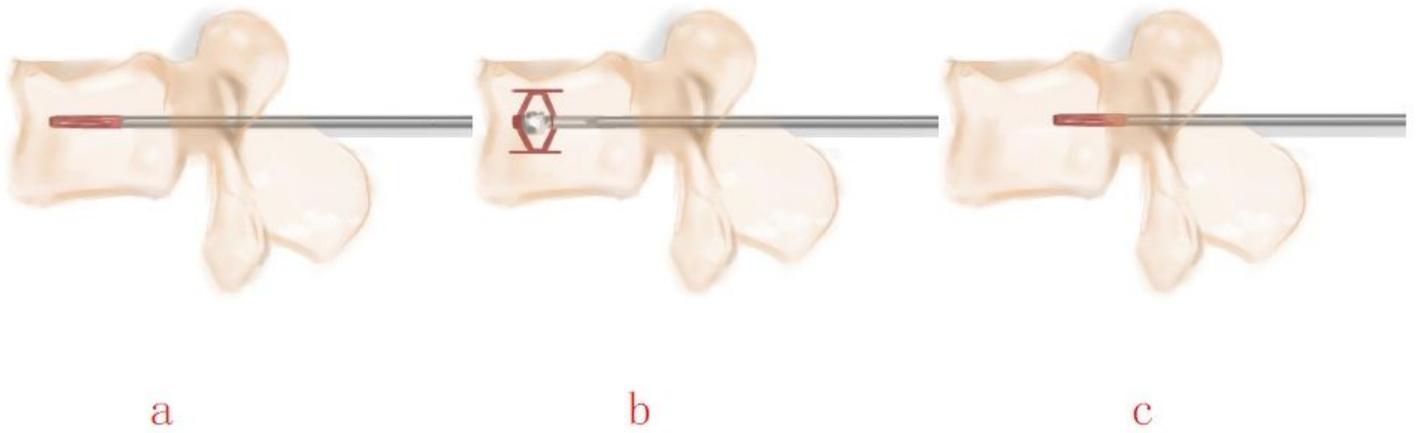


Figure 2

Schematic diagram of the strategic design for the application of the new transpedicular reducer to a vertebral burst fracture. A: The new transpedicular reducer enters the fracture through the pedicle; B: Performs open reduction; and C: Closes and exits the injured vertebra

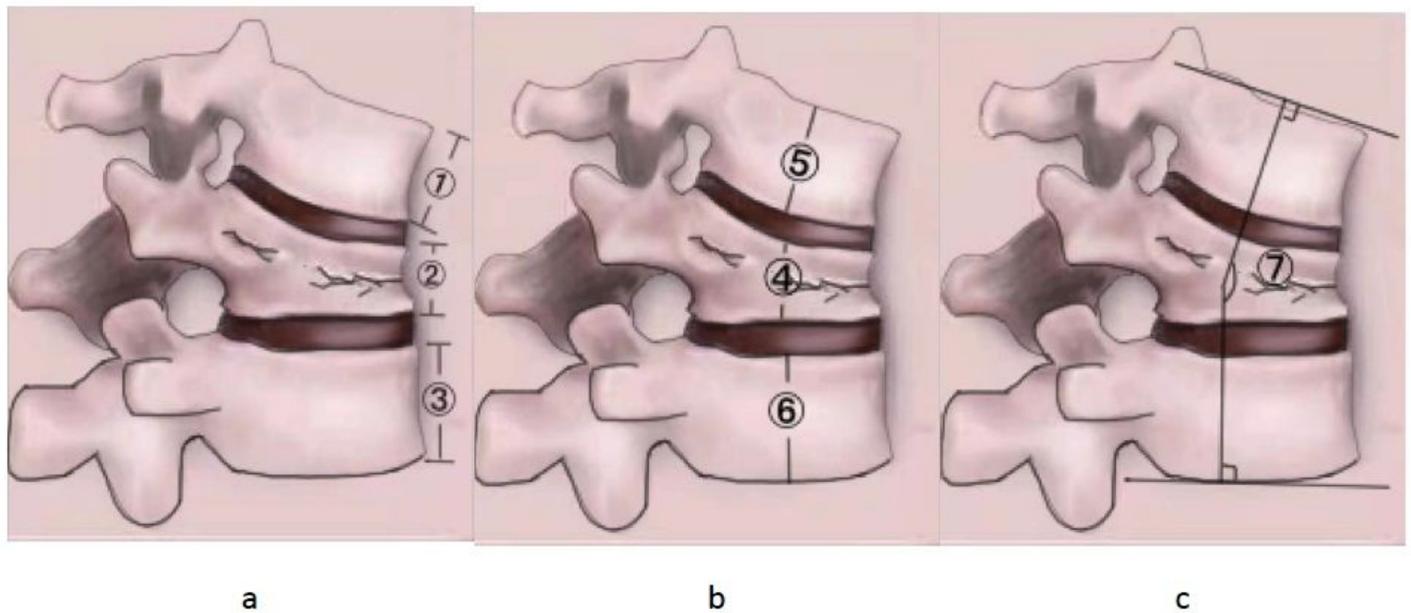


Figure 3

Measurement of the injured vertebral body. A: \square The injured vertebral anterior height; $AVBhr = \square / [(\square + \square) \times 0.5]$; B: \square The injured vertebral medium height, $MVBhr = \square / [(\square + \square) \times 0.5]$; C: \square Cobb angle

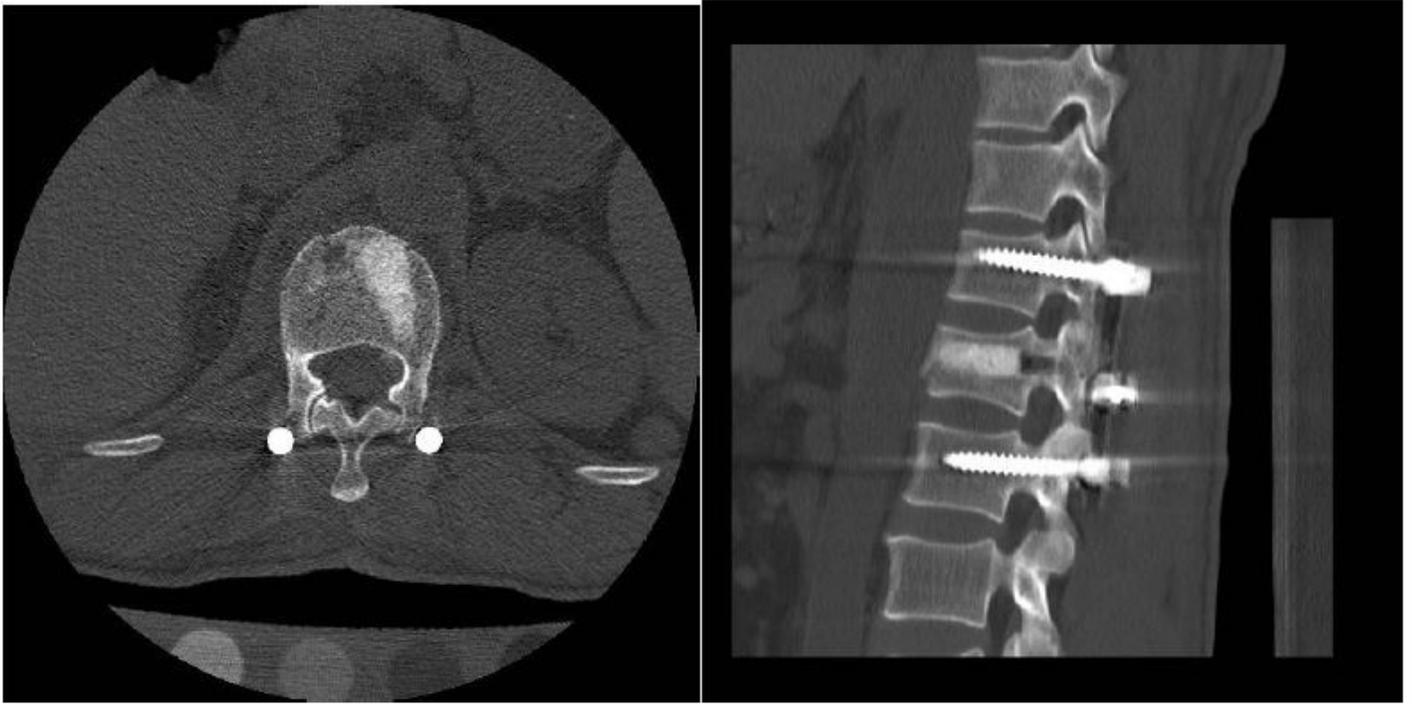


Figure 4

The CT of the observation group at 12 months after operation—the allogeneic bone was distributed in the front and middle column of the fractured vertebral body.

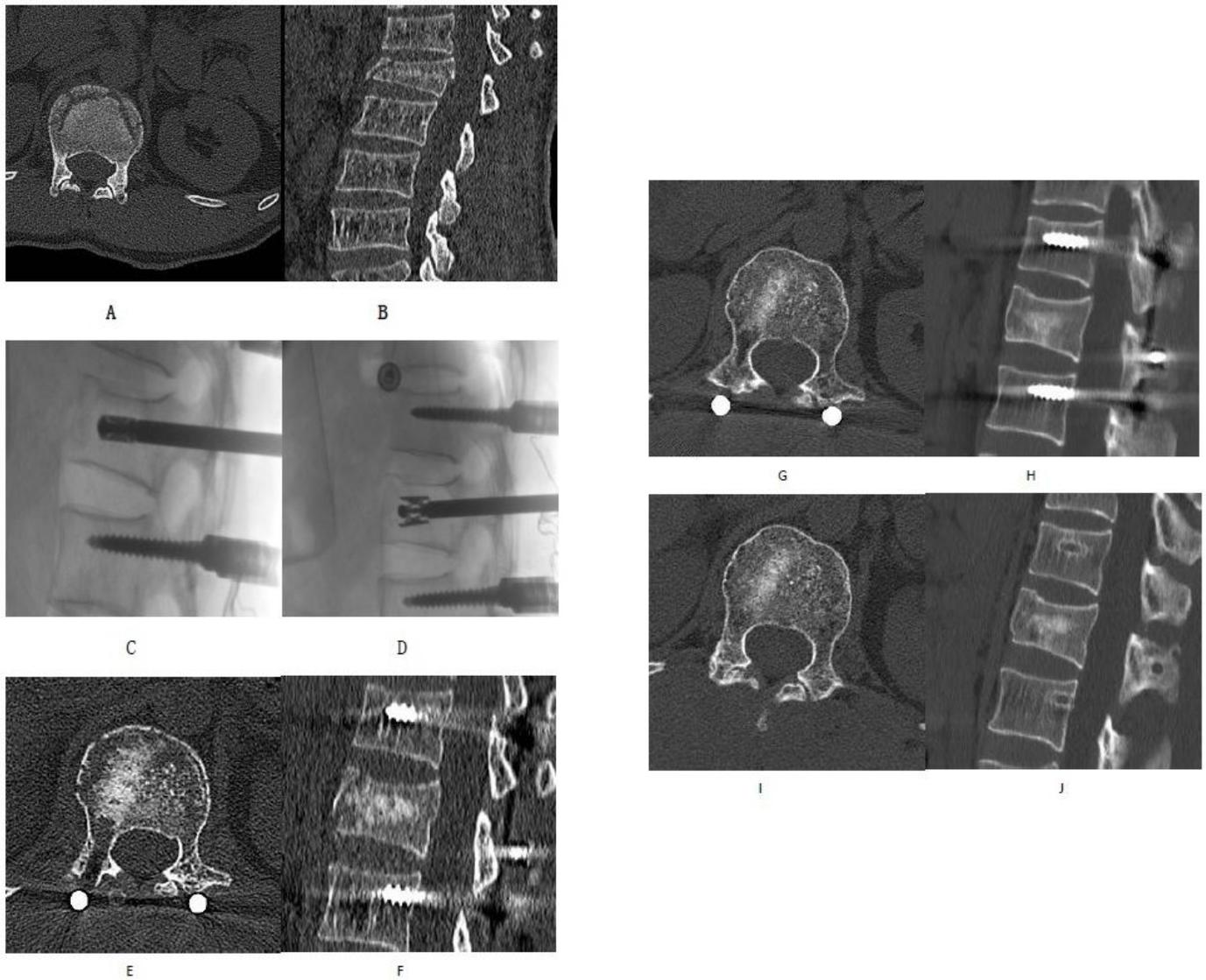


Figure 5

Imaging data of typical patient before, during and after operation A, B: Preoperative coronal and sagittal CT demonstrating a burst fracture of the vertebral body. C, D: During the operation, the new transpedicular reducer was used to reset the injured vertebra. E, F: Coronal and sagittal CT 3 days after the operation demonstrating that the allograft was evenly wedged into the anterior and medial columns. G, H: Coronal and sagittal CT 12 months after the operation. The allograft bone that filled the anterior and middle columns was partially absorbed. No defects were found, and the trabecular structure was visible in the cancellous bone. I, J: Coronal and sagittal CT after removal of the internal fixation.