Clinical Effect of Vertebral Column Decancellation Osteotomy Combined with Ponte Osteotomy in Elderly Patients with Old Thoracolumbar Fracture Combined with Kyphosis Deformity

Tongtong Zhang
Chao Kong
Xiangyao Sun
Wei Wang
Shudong Jiang
Longxi Ren
Shibao Lu

Abstract. **Objective.** The purpose of this study was to investigate the clinical effect of vertebral column decancellation (VCD) osteotomy combined with Ponte osteotomy in elderly patients withold thoracolumbar fracture combined with kyphosis deformity.**Methods.**36 elderly patients with old thoracolumbar fracture combined with kyphosis deformity admitted to our hospital from August 2015 to November 2018 were selected as the study subjects, and all of them were treated with VCDosteotomy combined with Ponte osteotomy.The Cobb angle of thoracolumbar kyphosis, sagittal vertical axis (SVA), visual analog scale (VAS) score,Oswestry disability index (ODI) and life quality were compared at 1 week before and after surgery as well as at the last follow-up. **Results.** ① All the 36 patients underwent the surgery successfully without serious complications, with the average duration of surgery of (5.13±0.62) h, average blood loss of (821.58±142.67) ml and average hospital stay of (14.02±2.43) d. ② The Cobb angle of thoracolumbar kyphosis and SVA at 1 week after surgery and at the last follow-up were smaller than those at 1 week before surgery ($P < 0.01$), but the Cobb angle of thoracolumbar kyphosis and SVA at the last follow-up were slightly larger than those at 1 week after surgery ($P < 0.01$). ③ The VAS score and ODI score at 1 week after surgery and at the last follow-up were lower than those before surgery ($P < 0.01$), and the VAS score and ODI score at the last follow-up were lower than those at 1 week after surgery ($P < 0.01$). ④ The scoliosis research society 22-item (SRS-22) score at the last follow-up was higher than that before surgery ($P < 0.01$). **Conclusion.** VCD osteotomy combined with Ponte osteotomy in the treatment of old thoracolumbar fracture combined with kyphosis deformity in the elderly can reduce the Cobb angle of thoracolumbar kyphosis, improve sagittal balance, reduce pain symptoms and functional disorders, and improve patients' life quality, having a good clinical effect.

Keywords: the elderly, old, thoracolumbar fracture, kyphosis deformity, vertebral column decancellation (VCD)osteotomy, Ponte osteotomy

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Tongtong Zhang[1,2,3],[1]Department of Orthopedics, Xuanwu Hospital Capital Medical University; [2]National Clinical Research Center for Geriatric Diseases,Beijing100078,China. [3]Department of Orthopedics,Chuiyangliu Hospital Affiliated to Tsinghua University,Beijing100078,China, Chao Kong[1,2] , [1]Department of Orthopedics, Xuanwu Hospital Capital Medical University; [2]National Clinical Research Center for Geriatric Diseases,Beijing100078,China, Xiangyao Sun[1,2], [1]Department of Orthopedics, Xuanwu Hospital Capital Medical University; [2]National Clinical Research Center for Geriatric Diseases,Beijing100078,China, Wei Wang[1,2], [1]Department of Orthopedics, Xuanwu Hospital Capital Medical University; [2]National Clinical Research Center for Geriatric Diseases,Beijing100078,China, Shudong Jiang, Department of Orthopedics,Chuiyangliu Hospital Affiliated to Tsinghua University,Beijing100078,China, Longxi Ren, Department of Orthopedics,Chuiyangliu Hospital Affiliated to Tsinghua University, Beijing100078,China, Shibao Lu[1,2][1]Department of Orthopedics, Xuanwu Hospital Capital Medical University; [2]National Clinical Research Center for Geriatric Diseases, Beijing100078,China, [*]Corresponding author: Shibao Lu, Department of Orthopedics, Xuanwu Hospital Capital Medical University; National Clinical Research Center for Geriatric Diseases,No.45 Changchun Street, Xicheng District, Beijing100078,China (Email:spinelu@163.com,Tel:13910727070)*

No standard treatment for thoracolumbar fracture in the early stage can easily lead to kyphosis deformity in the late stage. In recent years, with the aggravation of aging process in China, the incidence of old thoracolumbar fracture combined with kyphosis deformity in the elderly is also increasing, and the delayed neurological damage and low back pain caused by kyphosis deformity also have a serious impact on patients' health and life [1]. At present, the medical community generally believes that vertebral osteotomy is an effective means to treat old thoracolumbar fracture combined with kyphosis deformity. Ponte osteotomy is a typical single posterior column osteotomy, which has the advantages of simple operation and less complications, but its orthopedic ability is limited because the anterior column is not effectively released during the surgery [2]. VCD osteotomy is a new surgery that combines the advantages of pediclesubtraction osteotomy, total spinectomy and Smith-Peterson osteotomy [3], which is mainly conducted by opening the anterior column and closing the posterior column. Due to less resection of the injured anterior and medial column during the surgery, VCD osteotomy beneficially reduces the risk of vascular injury and the displacement of the cut end of the osteotomy. Besides, it can effectively release the anterior column to make up for the deficiency of Ponte osteotomy, thus some scholars have proposed that VCD osteotomy combined with Ponte osteotomy can be conducted for the treatment of old thoracolumbar fracture combined with kyphosis deformity, but there is no relevant study in clinical practice at present [4]. In this study, in order to investigate the clinical effect of VCD osteotomy combined with Ponte osteotomy in elderly patients with old thoracolumbar fracture combined with kyphosis deformity, 36 elderly patients with old thoracolumbar fracture combined with kyphosis deformity admitted to our hospital from August 2015 to November 2018 were selected to receive VCD osteotomy combined with Ponte osteotomy, and now summary report is as follows.

MATERIALS AND METHODS

General Information

In this study, 36 elderly patients with old thoracolumbar fracture combined with kyphosis deformity admitted to our hospital from August 2015 to November 2018 were selected to receive VCD osteotomy combined with Ponte osteotomy. Among them, there were 12 males and 24 females aging from 62 to 81 years old, with an average age of (75.32±6.21) years old. There were several underlying diseases in patients including hypertension of 7 cases, diabetes of 6 cases, anemia of 14 cases, chronic bronchitis of 7 cases, and atrial fibrillation of 2 cases. There were thoracic kyphosis of 21 patients and thoracolumbar kyphosis of 14 patients. Schwab classification included grade 2 of 10 patients, grade 5 of 12 patients, grade 3 of 8 patients, and grade 4 of 6 patients.

Inclusion/Exclusion Criteria

Inclusion criteria

① Elderly patients with old thoracolumbar fracture combined with kyphosis deformity were diagnosed and treated in our hospital.

② Patients had complete imaging and clinical data, and finished the follow-up and the last follow-up examination.

③ This study has been approved by the Hospital Ethics Committee, and all patients voluntarily participated in the study and signed the informed consent.

Exclusion criteria

①Patients had coronal imbalance.

② Patients had severe kyphosis requiring double-segmental osteotomy.

③ Patients didn't cooperate with the study or withdraw from the study halfway.

Method **Surgical instruments**

Table 1.
Statistical table of instruments / materials used in the study

Instruments / Materials	Manufacturer / Company
C-arm X-ray machine	Siemens AG (Germany)
Laparoscopic instruments	Unimicro Medical Systems Co.,Ltd (Shenzhen)
Optical host and optical lens of 30°	Karl Stor Co.,Ltd (Germany)
Surgical equipment	Chongqing Dechuan Medical Instruments Co.,Ltd
Artificial biomaterial patch	Covidien Co.,Ltd (USA)
Allograft bone	Shanghai Anjiu Biotechnology Co.,Ltd

Preoperative managements

(1) After the patients were admitted to the hospital, they should undergo various routine examinations and operative risk evaluations. (2) A surgical model should be established according to the patients' imaging data, and doctors should estimate the degree of surgical correction and design the surgical plan. (3) Patients with other diseases should go to relevant departments for consultation to control their conditions before surgery. ① The blood pressure of the patients with hypertension and the blood glucose of patients with diabetes should be controlled below 160/100 mmHg and 10 mmol/L respectively by drugs and other means. ② The respiratory inflammation of patients with chronic bronchitis should be controlled by anti-inflammatory and anti-asthmatic drugs. ③ The cardiac function of patients with atrial fibrillation should be evaluated by cardiac color Doppler ultrasound, electrocardiogram, etc. and the drugs should be used to control the level of cardiac function to grade 1-2. ④ The targeted anemia correction should be carried out according to the etiology of the patients with anemia [5]. (4) All the patients in this study were operated on by the same group of surgeons.

Surgical methods

(1) Pedicle screw placement

With taking a prone position, the patients underwent general anesthesia. A posterior median incision was made with the apex of the kyphosis of injured vertebra as the center, and the length that can fully expose the injured vertebra and its upper and lower vertebrae was appropriate [6]. The paraspinal muscles were stripped to ensure adequate exposure of bilateral lamina, spinous processes, transverse processes, and zygapophyseal joints. C-arm X-ray machine was adopted to locate the injured vertebra fluoroscopically, and pedicle screw placement was performed at the upper and lower vertebral bodies of the osteotomy site [7].

(2) Ponte osteotomy

Ponte osteotomy was performed at each kyphotic segment of the injured vertebrae according to the preoperative osteotomy plan. Referring to the osteotomy angle measured before surgery, the spinous processes of injured vertebrae, bilateral lamina, superior articular processes, the spinous processes of the upper vertebra, the lower part of the vertebral plate, the interlaminar ligamentum flavum, the inferior articular processes, and the transverse processes were removed until the pedicle cortex was completely exposed and then the lower edge of the pedicle was preserved for the VCD osteotomy [8,9]. At the same time, the soft tissues of autogenous bones such as vertebral plate and spinous processes mentioned in the above operation were removed for bone graft fusion. If insufficient, the autologous bones can be mixed with allogeneic bones for bone graft.

(3) VCD osteotomy and incision closure

After the cortex of the pedicle entry point was ground by an abrasion drill, a scaled pedicle opener was drilled into the pedicle and vertebral body, and the depth of the screw track and the integrity of the surrounding bone wall were both explored with a

blunt-pointed probe. The cancellous bones were ground with a high-speed abrasion drill which was flushed with brine ice, and gradually expanded to the head side [10]. Cancellous bones in the vertebral body were then removed to ensure that the lateral wall was exposed to cortical bones and its head side was exposed to the superior end plate. During the above operation, the integrity of the pedicle wall should be ensured with much attention. After the treatment was performed with the same method, the contralateral side was washed with normal saline. Then, the preflex connecting rods were placed at both ends of the osteotomy gap, whose screw spacing could be gradually compressed by evaluating the closure condition of the osteotomy gap, the degree of spinal cord atrophy and the monitoring results of somatosensory evoked potential to ensure that the osteotomy surface was completely closed or nearly closed [11,12]. The above prepared materials were used for bone graft fusion and a horizontal beam was installed. After the wound was washed to stop bleeding, a drainage tube was placed and the incision was closed.

Postoperative treatment

(1) Routine treatment: ① Fluid infusion, anti-infection and nutrition support therapy were performed. ② Vital signs monitoring was conducted including respiration, circulation, etc. ③ Electrolyte balance was maintained and the control of primary complications was conducted with the assistance of internal medicine. (2) Targeted treatment: ① Anti-osteoporosis drug therapy was performed. ② The application of antibiotics lasted for less than 48 hours. ③ Negative pressure drainage tube was removed when the drainage volume was less than 50 mL [13,14]. (3) Postoperative rehabilitation: ① Patients can leave bed with thoracolumbar braces after 2 weeks. ② Patients can remove the thoracolumbar braces after 3-6 months. ③ Patients cannot do strenuous exercise within 1 year. ④ All patients had telephone or outpatient follow-up for 22 months[15,16].

Evaluation Indexes

(1) Perioperative indexes: the perioperative indexes of 36 patients including duration of surgery, postoperative complications, etc. were observed and recorded.

(2) Imaging indexes: the frontal and lateral X-ray films of thoracolumbar spine of 36 patients in standing position were taken at 1 week before and after surgery and at the last follow-up, and their Cobb angle of thoracolumbar kyphosis and SVA were also measured. ① Cobb angle refers to the angle formed by the upper and lower edges of the top two vertebral bodies in the upper and lower curves. Cobb angle (>50°) required surgical treatment, Cobb angle (25°~50°) required brace treatment and Cobb angle (<25°) required posture correction training only. Surgery was not required for patients with Cobb angle of 25°~50°, but intensive orthodontic treatment should be performed.② SVA refers to the vertical distance between the C7 plumb line and the posterior upper corner of S1. SVA (> 4 cm) is sagittal imbalance, and SVA (> 9.5 cm) is severe sagittal imbalance.

(3) VAS score: VAS was adopted to score thoracolumbar pain in 36 patients at 1 week before and after surgery and at the last follow-up. The scale with the total score of 10 points is divided into no pain (0 points), mild pain (1-4 points), moderate pain (5-7 points), and severe pain (8-9 points).

(4) ODI score: 36 patients with thoracolumbar dysfunction were evaluated by ODI scale at 1 week before surgery and after surgery and at the last follow-up. There are 10 items in this scale, and each item scores 0-5 points, with the total score of 50 points. Higher score indicates severer dysfunction.

(5) Life quality score: The life quality of 36 patients was assessed by the Chinese version SRS-22 questionnaire, which includes 5 aspects such as pain, appearance, function, mental health and satisfaction. Higher score indicates better condition.

Statistical Treatment

SPSS19.0 statistical software was adopted to process and analyze relevant data in this paper. Measurement data were expressed by ($\bar{x}\pm s$) and tested by t-test. The differences had statistical significance when $P<0.05$.

RESULTS

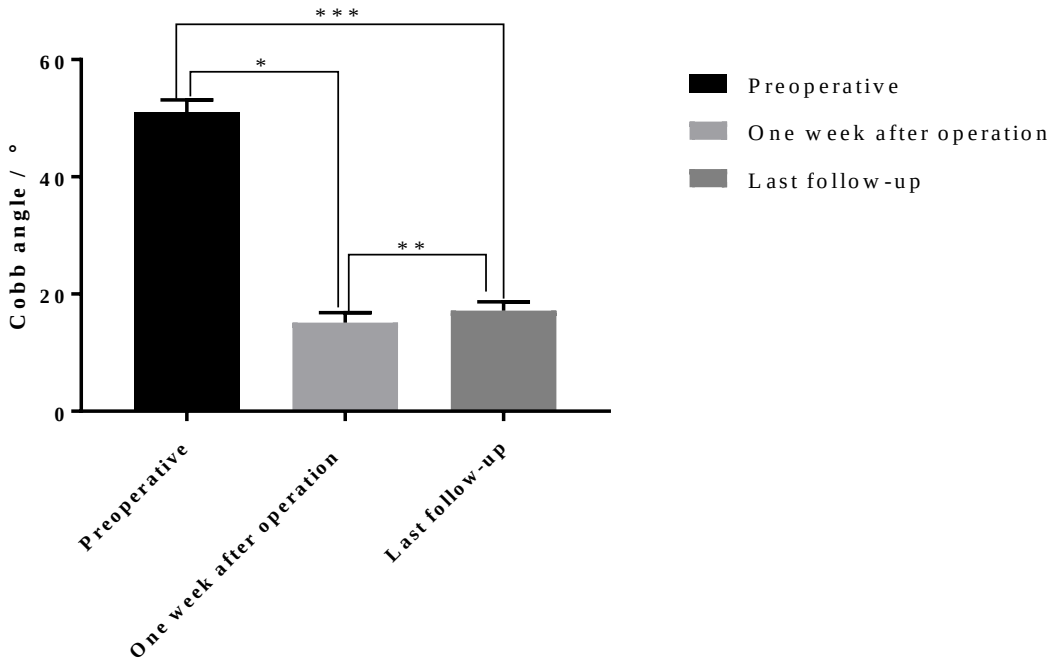
Perioperative Conditions of the Patients

All the 36 patients underwent the surgery successfully. The duration of surgery was 4.09-6.28h, with the average duration of surgery of (5.13±0.62) h, the intraoperative blood loss was 820-1260 ml, with the average blood loss of (821.58±142.67) ml, and the hospital stay was 13-17 d, with the average hospital stay of (14.02±2.43) d. There were no serious intraoperative complications in 36 patients, of which 2 patients had leakage of cerebrospinal fluid after surgery and healed after dural repair and 3 patients had postoperative superior mesenteric artery syndrome and got improved after fasting and gastrointestinal decompression.

Changes of Cobb Angle of Kyphosis before and after Surgery

The Cobb angle of kyphosis at 1 week after surgery and at the last follow-up was smaller than that before surgery (P < 0.01), but the Cobb angle of kyphosis at the last follow-up was slightly larger than that at 1 week after surgery (P < 0.01), as shown in Figure 1.

Figure 1.
Changes of Cobb angle of kyphosis before and after surgery

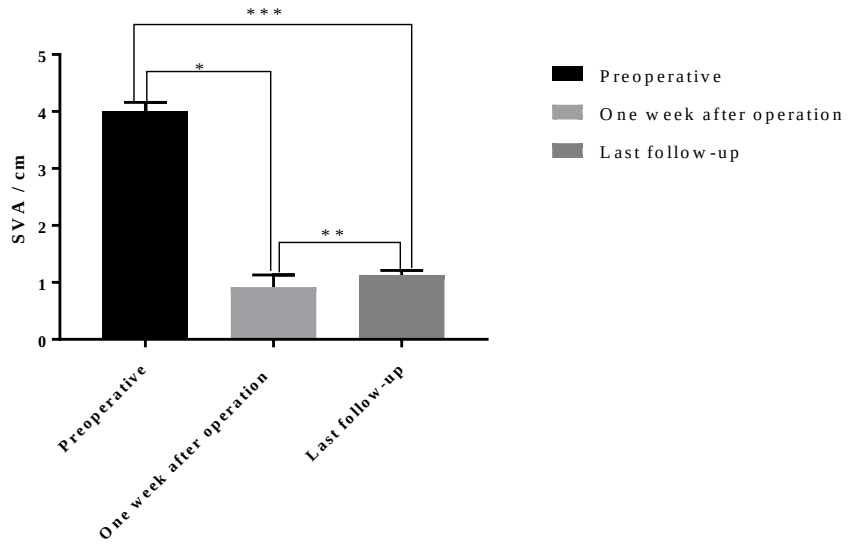


Note: The abscissa represents the time period, while the ordinate represents the degree of Cobb angle. Preoperative value was 51.02±2.11, the value at 1 week after surgery was 15.14±1.67 and value at the last follow-up was 17.18±1.52. The values at 1 week before and after surgery were compared *P < 0.01, the values at 1 week after surgery and at last follow-up were compared **P < 0.01, and the values at the last follow-up and before surgery were compared ***P < 0.01.

Changes of SVA in Patients before and after Surgery

The SVA at 1 week after surgery and at the last follow-up was smaller than that before surgery (P < 0.01), but the SVA at the last follow-up was slightly larger than that at 1 week after surgery (P < 0.01). The details are shown in Figure 2.

Figure 2.
Changes of SVA in patients before and after surgery

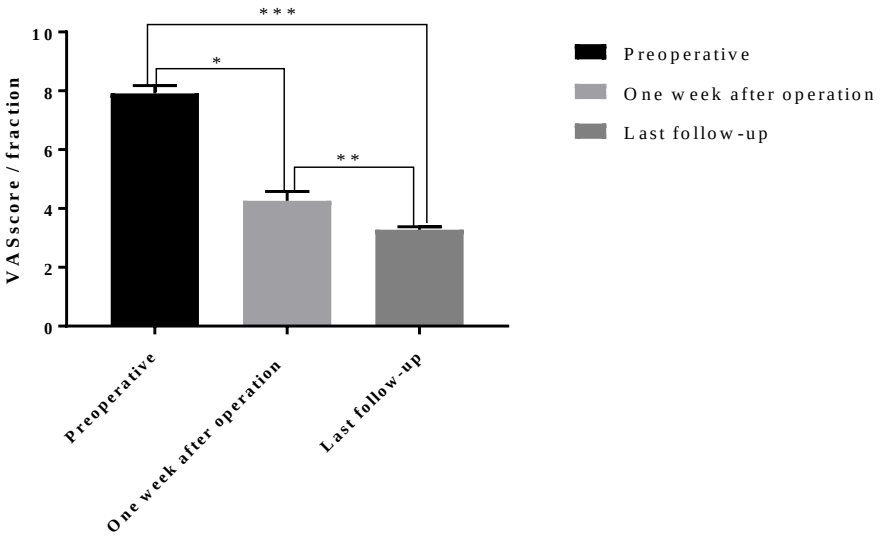


Note: The abscissa represents the time period, while the ordinate represents SVA. The preoperative value was 4.01±0.15, the value at 1 week after surgery was 0.92±0.21, and value at the last follow-up was 1.13±0.08. The values at 1 week before and after surgery were compared *P < 0.01, the values at 1 week after surgery and at the last follow-up were compared **P < 0.01 and the values at the last follow-up and before surgery were compared ***P < 0.01.

Comparison of Patients' VAS Score before and after Surgery

The VAS scores at 1 week after surgery and at the last follow-up were lower than that before surgery (P < 0.01), and the VAS score at the last follow-up was lower than that at 1 week after surgery (P < 0.01). The details are shown in Figure 3.

Figure 3.
Comparison of patients' VAS scores before and after surgery



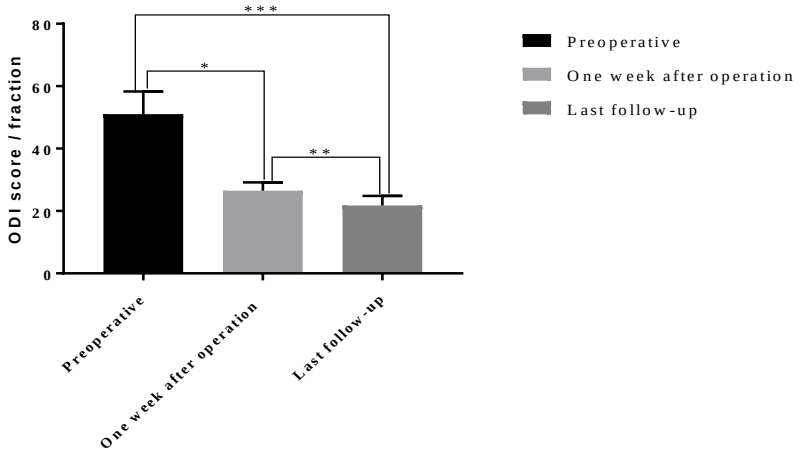
Note: The abscissa represents the time period, while the ordinate represents VAS score. The preoperative value was 7.91±0.27, the value at 1 week after surgery was 4.26±0.32, and the value at the last follow-up was 3.28±0.10. The values at 1 week before and after surgery were compared *P < 0.01, the values at 1 week after surgery and at the last follow-up were compared **P < 0.01 and the values at the last follow-up and

before surgery were compared ***P < 0.01.

Comparison of Patients' ODI Score before and after Surgery

The ODI scores at 1 week after surgery and at the last follow-up were lower than that before surgery (P < 0.01), and the ODI score at the last follow-up was lower than that at 1 week after surgery (P < 0.01). The details are shown in Figure 4.

Figure 4.
Comparison of patients' ODI scores before and after surgery



Note: The abscissa represents the time period, while the ordinate represents ODI score. The preoperative value was 51.03±7.24, the postoperative value is 26.51±2.66, and the value at the last follow-up is 21.79±2.78. The values at 1 week before and after surgery were compared *P < 0.01, the values at 1 week after surgery and at the last follow-up were compared **P < 0.01 and the values at the last follow-up and before surgery were compared ***P < 0.01.

Comparison of SRS-22 Score before and after Surgery

The SRS-22 score (pain, function, appearance, mental health and satisfaction) at the last follow-up were higher than that before surgery (P < 0.01), as shown in Table 2.

Table 2.
Comparison of SRS-22 score before and after surgery

Evaluation period	Pain	Function	Appearance	Mental health	Satisfaction
Before surgery	2.92±0.64	2.57±0.63	2.29±0.52	2.80±0.85	2.03±0.46
Last follow-up	4.28±0.62	4.45±0.38	4.34±0.45	4.57±0.62	4.71±0.22
t	10.792	18.069	21.097	11.896	37.165
P	0.000	0.000	0.000	0.000	0.000

DISCUSSION

Old thoracolumbar fracture combined with kyphosis deformity is very common clinically, which is mainly caused by improper conservative treatment after fractures with destroying the stability of spine without reconstruction. The data showed that the incidence of old thoracolumbar

fractures combined with kyphosis deformity in the elderly was higher than that in other age groups [17]. After traumatic injury, elderly patients often do not pay much attention to the examination of vertebral fractures and only receive conservative treatment or even incorrect treatment, which eventually leads to delayed kyphosis deformity of the thoracolumbar spine [18]. Kyphosis deformity often accompanies with pains in wound region, difficulty in turning over, inability to stand up, spasm of lumbodorsal muscle and other symptoms, which has a great impact on the patients' life quality and physical health.

In recent years, with the continuous increase of the elderly population, the incidence of old thoracolumbar fracture combined with kyphosis deformity in the elderly is also rising. It is an important clinical task to find safe and effective treatment methods and improve patients' life quality [19]. Ponte osteotomy is a common surgery for the treatment of old thoracolumbar fracture combined with kyphosis deformity. Compared with other osteotomies involving three-column osteotomy, Ponte osteotomy only carries out posterior column osteotomy with relatively simple operation and less nerve injury. However, Ponte osteotomy also has its own limitations that it does not involve the release of the anterior column, thus the correction effect is limited. Research analysis showed that more than three Ponte osteotomies can achieve a similar degree of correction as pediclesubtraction osteotomy, and its correction effect on coronal imbalance was also not ideal [20,21]. In addition, Ponte osteotomy results in inadequate support of anterior intervertebral body and the increase in the probability of loss of correction and pseudoarthrosis formation.

In order to increase the stability of the spine and improve its orthopaedic ability, VCD osteotomy is adopted on the basis of Ponte osteotomy, which preserves the integrity of the anterior longitudinal ligament while ensuring adequate release of the intervertebral space. VCD osteotomy has been a new treatment of thoracolumbar fracture combined with kyphotic deformity in recent years. It mainly provides the medial column of injured vertebral as the fulcrum for the reduction and fixation of pedicle screw-rod system by resecting the posterior superior part of vertebra with wedge injury, superior intervertebral disc and posterior appendages of wedge-shaped injuries, so as to achieve the purpose of correcting kyphotic deformity by opening the anterior column of injured vertebra and closing the posterior column [22,23]. VCD osteotomy combined with Ponte osteotomy can achieve gradual opening of the anterior column of the vertebral body. After primary correction, secondary correction with the help of the rods for correction can effectively improve the correction degree and integrity of kyphosis deformity.

This study found that 36 patients who were treated with the VCD osteotomy combined with Ponte osteotomy successfully received the surgery without any serious complications. In addition, the Cobb angle and SVA of the patients at 1 week after surgery and at the last follow-up were smaller than those before surgery ($P < 0.01$), but the Cobb angle and SVA of the patients at the last follow-up were slightly larger than those at 1 week after surgery ($P < 0.01$). This is similar to the findings of Wen C B [24] et al., who retrospectively analyzed the data of 24 patients with old osteoporotic vertebral fractures and thoracolumbar kyphosis deformity who underwent Ponte osteotomy combined with bone cement augmentation, and found that the Cobb angle of thoracolumbar kyphosis was significantly improved after surgery compared with that before surgery ($P < 0.05$), suggesting that Ponte osteotomy can improve the Cobb angle of patients with thoracolumbar kyphosis deformity. Ponte osteotomy combined with VCD osteotomy has a significant clinical effect on the treatment of elderly patients with thoracolumbar fracture combined with kyphosis deformity, and significantly improves the Cobb angle of kyphosis and sagittal balance.

Moreover, it was also found that the VAS scores and ODI scores of the patients at 1 week after surgery and the last follow-up were lower than those before surgery ($P < 0.01$), and the VAS score and ODI score at the last follow-up were lower than those at 1 week after surgery ($P < 0.01$). This is similar to the results of Jian-Wei L [25], in which 5 middle-aged and elderly patients with thoracolumbar kyphosis after chronic trauma were selected for VCD osteotomy and it was found that the VAS score and ODI score of the patients after surgery and at the last follow-up were better than those before surgery (All $P < 0.01$), suggesting that VCD osteotomy can reduce pains and functional impairment in patients with thoracolumbar kyphosis. Additionally, VCD osteotomy combined with Ponte osteotomy can improve pain symptoms and functional impairment better in elderly patients with old thoracolumbar fracture combined with kyphosis deformity.

In addition, the study also found that SRS-22 score (pain, function, appearance, mental health and satisfaction) at the last follow-up was higher than that before surgery ($P < 0.01$), revealing that VCD osteotomy combined with Ponte osteotomy in elderly patients with old thoracolumbar fracture combined with kyphosis deformity can significantly improve their life quality.

In conclusion, VCD osteotomy combined with Ponte osteotomy has good clinical effect on the treatment of old thoracolumbar fracture combined

with kyphosis deformity in the elderly, which can reduce the Cobb angle of kyphosis, improve the sagittal balance of patients, reduce the pain symptoms and functional disorders of patients, as well as improve patients' life quality.

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