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Original Article

Unilateral posterior vertebral column resection for severe thoracolumbar kyphotic deformity caused by old compressive vertebrae fracture: a technical improvement

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Abstract: Severe thoracolumbar kyphotic deformity caused by old compressive vertebrae fracture remains a big challenge for spine surgeons. When symptoms related to significant deformities cannot be adequately managed conservatively, posterior vertebral column resection (PVCR) is required, but with long operating time and severe blood loss. We develop a UPVCR technique, which is done through a unilateral approach instead of a bilateral approach, vertebral body resection advancing to cross the midline in an abrasive way from an extreme oblique orientation enable the resection of most contralateral vertebral body. In the present study, the effects of UPVCR for severe thoracolumbar kyphotic deformity were investigated. We did find that satisfactory correction of sagittal deformity, functional improvement and pain relief can be achieved by UPVCR, and it has the advantage of shortening surgery time, reducing blood loss and incidence of nerve root impingement over PVCR.

Keywords: Unilateral posterior vertebral column resection, unilateral approach, less blood loss, short operating time

Introduction

Severe thoracolumbar kyphotic deformity caused by old compressive vertebrae fracture remains a big challenge for spine surgeons. Patients with significant kyphotic deformity typically present with cosmetic and functional problems related to the bio-mechanical changes associated with the kyphosis, such as substantial back pain and/or neurological symptoms [1]. When symptoms related to significant deformities cannot be adequately managed conservatively, surgical correction is required. However, the surgical options in current use are controversial.

Concerning the vertebrae is severely compressed, spine-shortening osteotomy by Pedicle Subtraction Osteotomy may lead to the bulking of the spinal cord [2-4]. Combined anterior and posterior vertebral column resection requires a wide surgical exposure and poses a risk of damage to the anterior neurovascular structures [5-7]. Posterior vertebral column resection (PVCR) is an alternative for providing anterior decompression and reconstruction through posterior bilateral approach and a technically demanding procedure with long operating time, severe blood loss [8-10].

To minimize the technical difficulties during the operation process and assure the best surgical effects, we developed a new method of posterior vertebral column resection through a unilateral only approach, where contralateral vertebrae and pedicle are left. This new method is termed as ''Unilateral Posterior vertebral column resection (UPVCR)''. In the present study, the effects of UPVCR for severe thoracolumbar kyphotic deformity caused by old compressive vertebrae fracture were investigated.

Materials and methods

Subjects

The study was approved by Ethics Committee of The Third Hospital of HeBei Medical University.

Table 1. Distribution of the compressed vertebrae in UPVCR and PVCR groups

	T10	T11	T12	L1	L2	L3	Total
UPVCR	1	2	5	7	5	3	23
PVCR	2	3	4	6	7	4	26

The inclusion criteria: 1. Diagnosis of severe thoracolumbar kyphosis caused by old compressive vertebrae fracture (duration from fracture to the surgery more than 3 years); 2. Conservative treatment more than three months and does not work (bed, oral pain medication, physical therapy, etc.); 3. No serious underlying disease (myocardial infarction, cerebral hemorrhage, cerebral embolism, etc.). All patients provided written informed consent to participate in this study before the enrollment and the authors confirm that all ongoing and related trials for this study are registered.

From Jan 2008 to Aug 2012, 49 patients underwent surgical treatment in our hospital. 28 were male and 21 were female, with an age range of 43-63 years old (mean, 54.8). Patients were randomly divided into UPVCR group (23 cases who underwent UPVCR) and PVCR group (26 cases who underwent PVCR) according to random number table method. The two groups are compatible in age, sex composition, and preoperative kyphotic angle. Distribution of the compressed vertebrae is shown in **Table 1**.

Surgical methods

All surgeries were performed by the same surgery team under general anesthesia. MEPs and SSEPs were all used in every patient. A standard posterior exposure of the spine was given, pedicle screws were inserted two levels above and below the target vertebrae under C-arm guidance. A laminectomy was then performed to decompress and fully visualize the spinal cord. The screws were connected on one side with a temporary stabilizing rod contoured to the shape of the deformity. Careful subperiosteal dissection was carried out on contralateral side (opposite to the stabilizing rod) to follow the lateral wall of the vertebral body until the anterior aspect was reached. The pedicle and lateral aspect of the vertebral body were removed using an osteotome, high-speed drill, and/or rongeur. Resection of the vertebral body and intervening disks was then accomplished in a piecemeal fashion, extending toward the medial side and crossing over to the contralateral side. A thin shell of the posterior wall bone was left anterior to the dural sac.

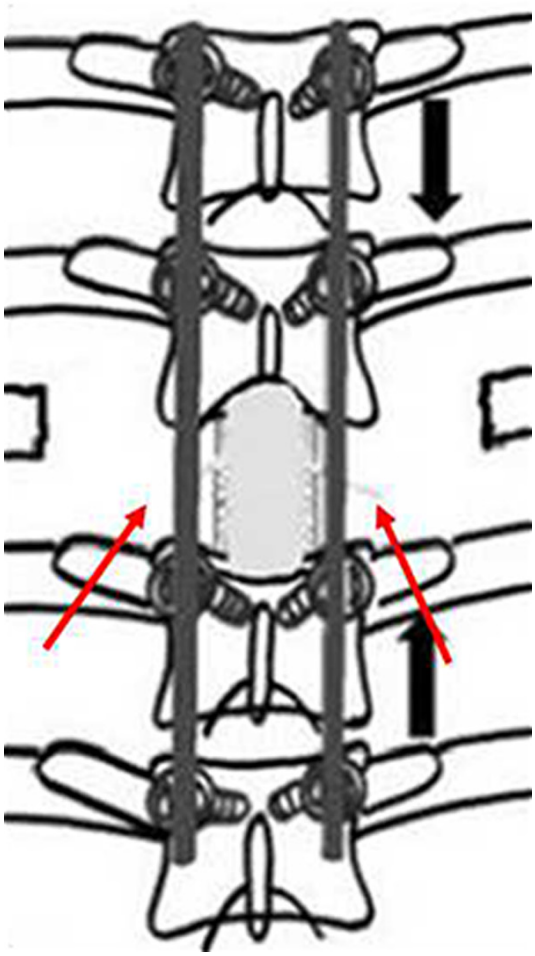

Figure 1. In PVCR group, bilateral pedicle and the whole vertebrae and adjacent discs were completely resected through two sides, with 360 degrees decompression of the dural sac.

i) In PVCR group: A second temporary rod contoured to fit the shape of the deformity was then inserted into the working side and the rod on the other side was then removed to facilitate complete removal of any residual bone or disc, the shell of the posterior cortical bone anterior to dural sac was removed by reverse-cutting curette or gouge. Bilateral nerve roots should be identified and protected during the procedure (**Figure 1**).

ii) In UPVCR group: Vertebral body resection advancing to cross the midline in an abrasive way from an extreme oblique orientation enable

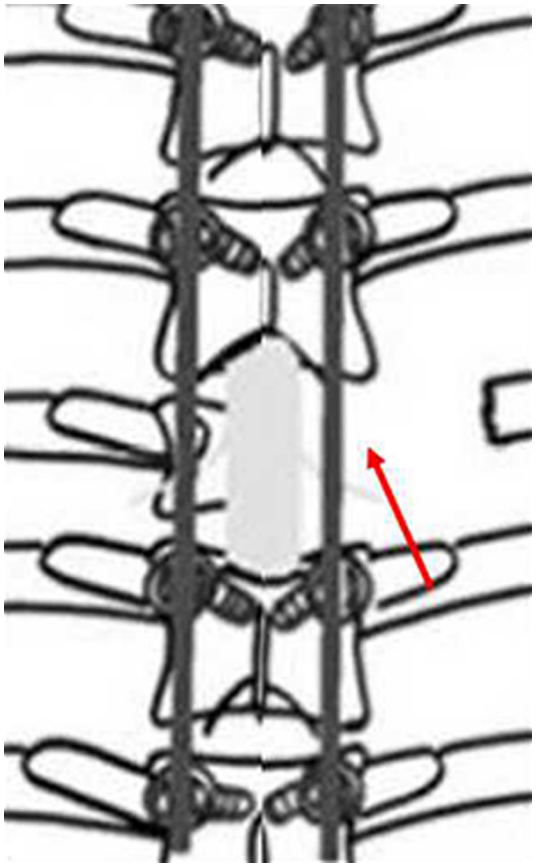

Figure 2. In UPVCR group, unilateral pedicle and most of the vertebrae were resected from a side, with about 330 degrees decompression of the dural sac.

the resection of most contralateral vertebral body (**Figures 2**-**4**), the shell of the posterior wall bone anterior to dural sac was removed by reverse-cutting curette or gouge. Ipsilateral nerve roots should to be identified and protected during the procedure (case example see **Figure 5**).

Then the stabilizing rod was replaced by rods precontoured to the desired (corrected) contours, a mesh cage placed anteriorly acted as hinge for closing the wedge and also prevents the buckling of the cord. Posterior fusion was performed at all instrumented levels by good decortication of lamina/spinous process and placement of autologous bone graft. Adequate hemostasis was ensured and wound was thoroughly irrigated with saline, closed suction drains were inserted at the resection sites, and the surgical wound was closed layer-by-layer. Postoperatively, the loss through the drains was measured and recorded everyday, the

Figure 3. Intra-operative view of the surgery field, unilateral pedicle and most of the vertebrae were resected from a side, with a temporary stabilizing rod contoured to the shape of the deformity on the other side.

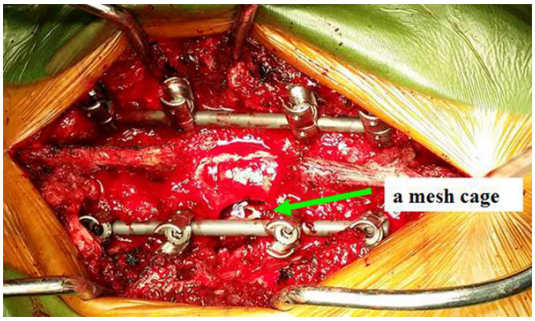

Figure 4. Intra-operative view of the surgery field, the osteotomy space was reconstructed by a mesh cage.

drain was removed when the blood loss through drain was less than 50 ml per 24 h. Patients were allowed out of bed with a custom-made plastic thoracolumbosacral orthosis (TLSO) at the second postoperative week. The TLSO was kept for at least 3 months.

Effect evaluation

Pre-operative and post-operative pain assessments were conducted using the visual analogue scale (VAS, pain scores of 0 to 10). The Oswestry Disability Index (ODI) was used to make a comprehensive and systematic evaluation of the overall physical condition of the patient at 1 day pre-operation and 24 month post-operation.

Imaging evaluation

Standard radiographic measurement was made from standing posterior-anterior and lateral radiographs, the angle of the deformity was measured using lines projected from the

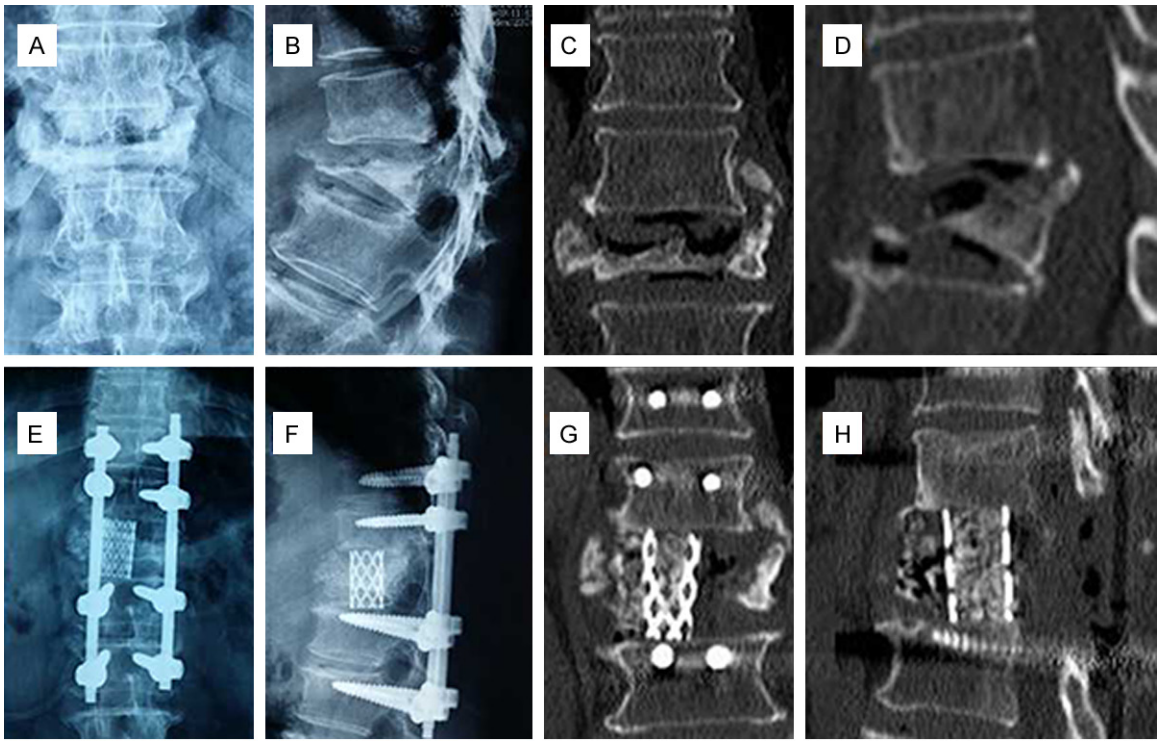

Figure 5. A 63-year-old woman with a severe kyphotic deformity, the duration from injury to surgery was 4 years. A: Preoperative antero-posterior X-ray and B: lateral X-ray showed severe compression of the T12 vertebrae and Cobb's angle is 61 degrees. C: Coronal plane and D: Sagittal plane of CT showed the anterior cortex of the T12 vertebrae is severely compressed. E: Two weeks postoperative antero-posterior X-ray showed right side of the compressed vertebrae was resected and reconstructed by a mesh cage, part of the vertebrae left in the left side. F: Two weeks postoperative lateral X-ray showed the kyphotic angle had been corrected to 5 degrees. G: Two years follow-up coronal plane CT and H, sagittal plane CT showed right side of the compressed vertebrae was replaced by a mesh cage, the kyphotic angle was 6 degrees.

upper border of the vertebra above and lower border of the vertebra below the compressed vertebrae. Pre-operative and post-operative (2 weeks and 24 months) lateral views were prepared in order to assess deformity correction (preoperative kyphotic angle-kyphotic angle at 2 weeks postoperative) and loss of correction (kyphotic angle at 24 months postoperative - kyphotic angle at 2 weeks postoperative).

Statistical analysis

Data were analyzed using Statistical Product and Service Solutions software (version 13; SPSS, Chicago, IL), the independent-t test was used to evaluate numeric variables (age, preoperative kyphotic angle, surgery time, blood loss, correction of kyphotic angle, loss of correction, decrease of ODI and decrease of VAS) and Chi^2 test was used to evaluate countable variable (sex composition). Statistical significance was accepted at the 0.05 alpha level.

Results

The surgeries were successfully performed in all cases. The mean operating time was shorter in the UPVCR group than in the PVCR group (174.6 min ± 26.7 min vs. 226.4 min ± 32.6 min; P=0.002). In addition, blood loss was less severe in the UPVCR than in the PVCR group (870.3 ml ± 92.5 ml vs. 997.4 ml ± 107.3 ml; P=0.001). There was no difference in terms of decrease of ODI (55.8% ± 6.2% vs. 56.1% ± 5.5%; P=0.231) or decrease of VAS (5.5 ± 0.8 vs. 5.3 ± 0.9; P=0.356) between two groups in 2-year follow up. The incidence of intra-operative nerve root impingement was 8.7% (9/104) in PVCR group and 4.3% (2/46) in UPVCR group, which were detected by MEPs and/or SSEPs.

At 1 day pre-operation, 2 weeks post-operation and 24 months post-operation, the mean kyphotic angle were 58.3 ± 4.9, 6.3 ± 0.7, 8.1 ± 0.6 in PVCR group, and 56.8 ± 5.5, 6.0 ± 0.5,

7.8 ± 0.6 in UPVCR group. No statistically significant difference was identified in deformity correction (52.1 ± 2.8 vs. 50.8 ± 5.4; P=0.514) or loss of correction (1.7 ± 0.2 vs. 1.7 ± 0.4; P= 0.604) between two groups. All patients achieved bony fusion on basis of presence of trabecular bone bridging at the osteotomy site in two-year follow up, no pseudarthrosis or instrumentation-related failure occurred in both groups.

Discussion

The key steps of the UPVCR is summarized as follows: i) After implantation of pedicle screws, a temporary stabilizing rod contoured to the shape of the deformity is connected with screws on one side, providing stability in osteotomy procedure; ii) There is usually thick fibrocartilaginous tissue at the apex of the deformity, and this needs to be cleared with a curette in order to open the apex of the deformity from the anterior aspect, care should be taken to avoid injury to the segment vessels during this step; iii) After the pedicle and lateral aspect of the vertebral body are removed, vertebral body resection advancing to cross the midline in an abrasive way from an extreme oblique orientation enable the resection of most contralateral vertebral body; iv) The nerve root on the operative side should be identified and protected during the procedure; v) A mesh cage with an autograft inside is inserted into the osteotomy gap to act as a hinge for closing the wedge and also to prevent buckling of the cord.

UPVCR is not a revolutionary modification of the classical PVCR technique and just simplifies the procedure through a unilateral approach instead of a bilateral approach. The anterior reconstruction with mesh cage and posterior compression with the screws and rods are both performed in PVCR and UPVCR techniques, which effectively correct the kyphotic deformity. After vertebral body resection in PVCR technique, no residual bone or disc tissue anterior to the dura can be confirmed (360 degrees decompression) [4, 5]. While in the procedure of UPVCR technique, complete resection of the bone or disc tissue through unilateral approach is impossible, however, vertebral body resection advancing to cross the midline in an abrasive way from an extreme oblique orientation enable resection of the most contralateral vertebral body (about 330 degrees decompression). This does not make sense in the correction of sagittal deformity, as both of the two groups achieved more than 50 degrees correction of kyphosis two weeks postoperatively and little loss of correction in two years follow-up. Preoperative neurological dysfunction and back pain are closely related to the kyphotic deformity, while deformity correction is an effective way to improve neurological function and relief pain [11]. In the present study, both of the two groups experience a significant decrease in ODI and VAS scores, possibly due to the effective correction of the sagittal kyphotic deformity.

The relationship of UPVCR and PVCR is similar that of to transforaminal lumbar interbody fusion (TLIF) and posterior lumbar interbody fusion (PLIF) in terms of surgical approach, as unilateral decompression is performed in TLIF and bilateral decompression in PLIF [12]. Exposure of bilateral pedicle and lateral vertebral wall is required in PVCR technique, upper and lower nerve roots should be identified bilaterally and protected during the procedure. While unilateral pedicle and lateral vertebral wall need to be exposed in UPVCR technique, only ipsilateral nerve root need to be protected during the procedure. From the perspective of safety, the incidence of nerve root impingement in TLIF is less than that in PLIF [13], which is also similar to our findings. 104 nerve roots in PVCR technique and 46 nerve roots in UPVCR technique were identified, intra-operative impingement occurred in 9 nerve roots (8.7%) in PVCR technique and 2 nerve roots (4.3%) in UPVCR technique, suggesting that the more complicated the surgical procedure, the higher the risk of nerve root impingement. The mean operation time and blood loss in TLIF are less than those in PLIF have been confirmed by many literatures [12-14], which is also similar to our findings, and we suppose that the mean operation time and blood loss are shorter/lower in UPVCR may be due to simplification of the surgery procedure.

Disclosure of conflict of interest

None.

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