

# Novel intervertebral space release for the treatment of moderate and severe degenerative scoliosis

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## Abstract

To investigate the clinical effectiveness and feasibility of novel intervertebral space release without Smith–Petersen osteotomy/pedicle subtraction osteotomy/Ponte osteotomy in the treatment of adults with moderate to severe degenerative scoliosis. The data of 49 patients with moderate to severe degenerative scoliosis treated with a novel intervertebral space release and balance correction technique from January 2010 to January 2016 and followed up until January 2021 were collected based upon pre-designated inclusive and exclusive criteria for retrospective analyses. The Japanese Orthopaedic Association score and coronal Cobb angle were employed for the assessment of clinical symptoms and scoliosis correction improvements. Forty-nine patients were followed for a median time of 5.2 (1–11) years. The Japanese Orthopaedic Association score was significantly increased from  $9.45 \pm 3.33$  preoperatively to  $19.65 \pm 4.58$  postoperatively ( $P < .001$ ), and the coronal Cobb angle was significantly improved from  $39.95^\circ \pm 9.04^\circ$  preoperatively to  $8.28^\circ \pm 4.21^\circ$  ( $P < .001$ ) after 1 year. There were no major complications occurred in patients. The novel intervertebral space release and balance correction at the original lesion and maximal imbalance site without vertebral osteotomy showed a promising clinical profile and may be considered as an alternative for the treatment of moderate to severe degenerative scoliosis.

**Abbreviations:** JOA = Japanese Orthopaedic Association, MIS = mini-invasive surgery, PSO = pedicle subtraction osteotomy, SPO = Smith–Petersen osteotomy, TLIF = transforaminal lumbar interbody fusion, VCR = vertebral column resection.

**Keywords:** Cobb angle, degenerative scoliosis, JOA score, scoliosis correction, surgery

## 1. Introduction

Adult degenerative scoliosis (de novo) is believed to be secondary to lumbar disc and facet degeneration, and is characterized by spinal scoliosis, kyphosis and stenosis caused by coronal stress asymmetry due to the asymmetry of the intervertebral disc and facet degeneration.<sup>[1]</sup>

The patients with de novo scoliosis commonly present with different degrees of pain in the legs and lower backs, and typical root pain with or without neurogenic intermittent claudication as the result of lumbar disc and facet degeneration, which often progresses to the deformity of sagittal imbalance in the later stages. Since the management requires complexity in de novo scoliosis, the treatments are generally staged, and tailored to the specific needs of each unique patient. Although some patients can be managed successfully by noninvasive methods including physical therapy, lower back muscle exercise, analgesics and injection-based regimens, many patients may still need

operative treatment which varies from simple compression to long fusion.

However, these operations, especially long fusion for those patients with moderate to severe degenerative scoliosis, involves facetectomy as well as resections of the lamina, pedicle, intervertebral disc and vertebrae according to the individual deformity. Thus, they may carry various complications and a great amount of blood loss due to extensive exposure of the spine and the outcome of various vertebral osteotomy procedures.<sup>[2–4]</sup> Because this specific disease often occurs in an aged population, most cases are complicated with a certain degree of cardiopulmonary diseases and higher rates of intra and postoperative complications may occur, especially in those patients treated with complete vertebral and intervertebral disc resection.<sup>[5]</sup> Therefore, alternative operations have been devised to avoid extensive vertebral osteotomy for the treatment of moderate to severe adult degenerative scoliosis. In our practice, we found a non-osteotomy intervertebral space release and balance correction at

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*The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.*

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the maximal unbalance site indeed achieved the clinical betterment of the symptoms and deformity of de novo scoliosis patients. Herein, we retrospectively report the clinical outcomes of patients with moderate to severe adult degenerative scoliosis who were treated with this novel intervertebral space release and balance correction.

## 2. Methods

This study was approved by our hospital ethical committee (approval number: IRB SOP/01.03/01.2). All patients provided written informed consent.

### 2.1. Patient

The data from 49 patients with moderate to severe degenerative scoliosis treated with novel intervertebral space release and balance correction from January 2010 to January 2016 were retrospectively collected and followed up to January 2021. The inclusion criteria for this study were: patients with the diagnosis of “de novo scoliosis” who had a Cobb angle of  $\geq 30^\circ$  in the imaging study; presented with persisting symptoms; failed conservative management; and underwent the primary procedure of “intervertebral space release with balance correction.” Patients with various serious medical comorbidities who could not tolerate general anesthesia were excluded from the study. In the present study, moderate scoliosis refers to a curve between  $25^\circ$  and  $40^\circ$ , while severe refers to a curve  $>50^\circ$ .

### 2.2. Diagnostics and preoperative assessment

All patients underwent preoperative X-ray examination, which demonstrated that all exhibited the various degrees of scoliosis, and further magnetic resonance imaging examinations which revealed that all patients presented with moderate to severe lumbar disc herniation with dural compression, as well as spinal stenosis (found in 21 patients).

### 2.3. Surgical methods

1. Recognition and definition of the original lesion site and the maximal unbalance space

In our experience, patients with adult degenerative scoliosis always have an original lesion site and a maximal unbalanced space, which are the initial vertebral disc or facet degenerative site with the most serious degeneration, and an intervertebral space with a maximum intervertebral intersection angle. Before the operation, patients underwent a thorough assessment of their spinal flexibility through careful analysis of radiographic images to determine the range of fixation based on the

Scoliosis Research Society-Schwab classification of adult spinal deformity.<sup>[6]</sup>

### 2. Surgical steps

Surgical protocol was individually tailored according to preoperative X-ray and magnetic resonance images, and patient symptoms and demands. After general anesthesia, the patient was positioned prone on the operating table. The whole scoliosis segment was exposed through a posterior median incision. First, the original lesion site and the maximal unbalanced space were selected; a series of intervertebral space releases (only at these 2 special sites) were performed afterwards. At this stage, partial or complete facet, spinous process, lamina or ligamentum flavum were resected, which was similar to the release procedure in transforaminal lumbar interbody fusion (TLIF). Second, decompression, especially at the nerve root exit, was performed at those spaces with obvious intervertebral disc herniation or epidural compression or stenosis, and the spaces in concave side were then opened for accommodating the insertion of 1 cage. Third, the pedicle screws were further inserted and used for vertebral rotation and scoliosis correction to the lumbar spine physiological curve, then 2 pre-bended titanium alloy rods were respectively connected for fixation. Finally, those resection bone fragments, such as facet or lamina were implanted into the decompressed intervertebral space. A drainage tube was placed and the incision closed (Fig. 1).

### 2.4. Clinical assessment

The Japanese Orthopaedic Association (JOA) score was employed to quantitatively assess the clinical symptoms and the coronal Cobb angle was used to radiographically evaluate the postoperative improvement in the curve of scoliosis. Since this study was retrospective in nature, the data regarding quantitative parameters and objective assessments including the VAS score, ODI as well as Scoliosis Research Society-22, were not extractable from the medical records of the enrolled patients.

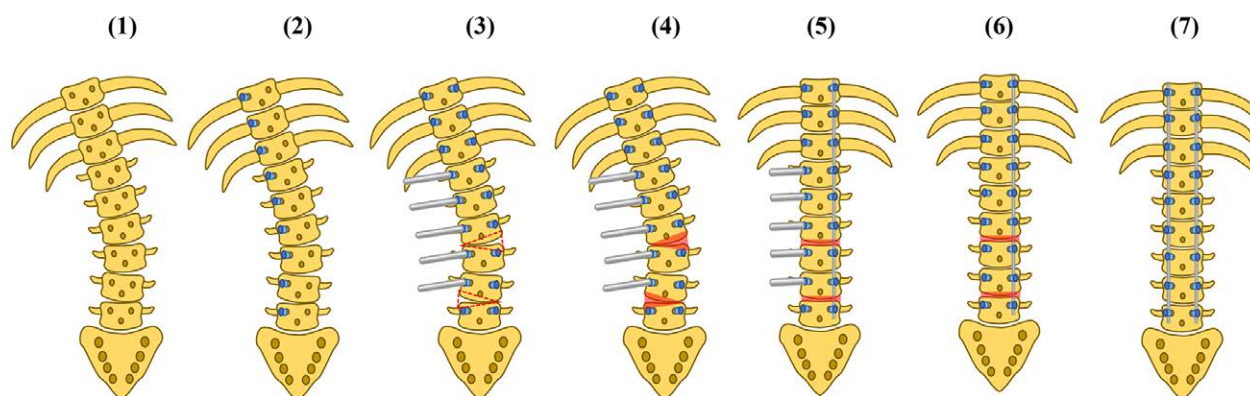
### 2.5. Statistical analysis

SPSS (ver. 16.0) was used for all analyses. All data are presented as means  $\pm$  standard deviations ( $\bar{x} \pm SD$ ). Normally distributed data were compared using a *t* test. Statistical significance was set at a *P* value  $<.05$ .

## 3. Results

### 3.1. Patient demographics

Demographically, the patients were 14 males and 35 females, with an average age of 62.27 years (range 45–78), the course of their scoliosis ranged from 5 months to 30 years (average



**Figure 1.** (A) The intervertebral space release only at the original lesion site and the maximal unbalance space; (B) insertion of pedicle screws; (C and D) vertebral rotation and scoliosis correction; (E–G) connection of the titanium alloy rod.

6.28 years), and the patients were followed up until January 2021. Clinically, all of the patients had different degrees of lower back pain before the operation, of whom 38 had pain or numbness in 1 or both sides of the lower limbs, and 6 patients had intermittent claudication symptoms when they changed position from sitting to standing and walking (Supplementary Table S1, Supplemental Digital Content, <http://links.lww.com/MD/I211>). All the patients underwent conservative treatment for >3 months before the operation, and the symptoms of lower back and leg pain were not significantly improved.

**3.2. Original lesion site and the maximal unbalanced space**

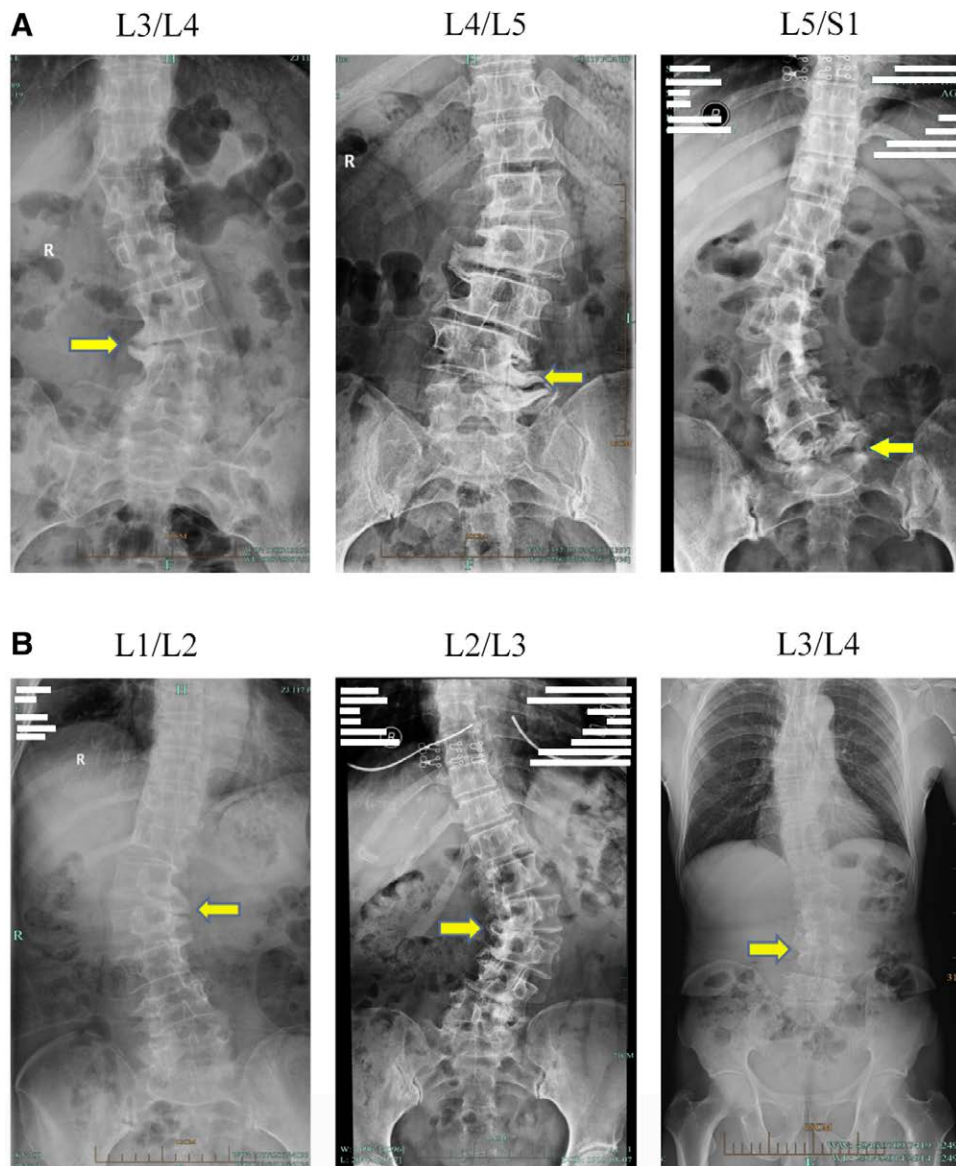
We found that the original lesion sites in adult degenerative scoliosis patients mainly included L3/4 rotary subluxation as well as tilted L4/5 and L5/S1 intervertebral degenerative discs, with L4/5 being the commonest site (Fig. 2A), and the maximal unbalance spaces mainly L1/2, L2/3, and L3/4 spaces, with L2/3 being the commonest space (Fig. 2B).

**3.3. Comparison of preoperative and postoperative JOA scores and Cobb angles**

In the follow-ups, the JOA scores of the 49 patients in the present study were found to significantly improve from  $9.45 \pm 3.33$  preoperatively to  $19.65 \pm 4.58$  postoperatively ( $P < .001$ ). The coronal Cobb angle was significantly improved from  $39.95^\circ \pm 9.04^\circ$  preoperatively to  $8.28^\circ \pm 4.21^\circ$  postoperatively ( $P < .001$ ) (Table 1).

**3.4. Preoperative and postoperative comorbidities and complications**

Supplementary Table S2, Supplemental Digital Content, <http://links.lww.com/MD/I212> shows the preoperative and postoperative comorbidities and complications of the patients in the present study compared to patients who underwent conventional methods for treating degenerative scoliosis between 2000 and 2013. In the present study, a total of 14 patients also suffered with hypertension, 7 with diabetes, 10 with severe



**Figure 2.** Original lesion sites and maximal unbalanced space in spines of adult patients with degenerative scoliosis. (A) Locations of the original lesion sites (yellow arrows). (B) Locations of the maximal unbalanced spaces (yellow arrows).



osteoporosis, 2 with bronchitis and mild pulmonary infection, and 3 with moderate gastric ulcers. After preoperative medical treatment, the patient’s blood pressure and blood glucose were controlled within the normal ranges and pulmonary infection, osteoporosis and gastric ulcer were significantly improved. There were no major complications such as epidural hematoma, which required revision surgery in the present study period. One patient suffered with superficial wound infection, and was successfully treated with antibiotics. Proximal junctional kyphosis occurred in 1 patient (Supplementary Table S2, Supplemental Digital Content, <http://links.lww.com/MD/I212>).

**3.5. Intraoperative outcomes**

The median operative time was 3 (2–5) hours and the median bleeding was only 350 mL (250–500 mL) in the present study, both of which were shorter and with less bleeding, respectively than conventional orthopedic interventions with a 5 (4–6) hour operation time and 650 mL (500–800 mL) blood loss (Supplementary Table S2, Supplemental Digital Content, <http://links.lww.com/MD/I212>).

**3.6. Case report**

A 58-year old female patient had suffered with back pain, progressive deformity and walking difficulty for 8 years. She

walked with a limp and could not walk >50 meters. Local tenderness and knocking pain of the lumbar dorsal muscle were obvious in the convex side. The straight-leg raise test was positive (50°) in her left leg. Preoperative X-ray images revealed degenerative scoliosis of the lumbar spine, and that the lumbar lordosis angle had disappeared. The preoperative JOA score and Cobb angle was 9° and 43.51°, respectively and she was diagnosed with moderate degenerative scoliosis and lumbar disc herniation. Intervertebral space release and unbalance correction combined with long-segmental fixation were carried out, and the lumbar scoliosis was significantly improved, lumbar lordosis was reconstructed and postoperative lumbar back pain was significantly relieved. The postoperative JOA score and Cobb angle were 20° and 4.87°, respectively (Fig. 3). The adult degenerative scoliosis patient was successfully treated with this novel intervertebral space release technique. Fusion was only performed at the original lesion site and the maximal imbalanced space, and the deformity correction was satisfactory at 7 years postoperatively.

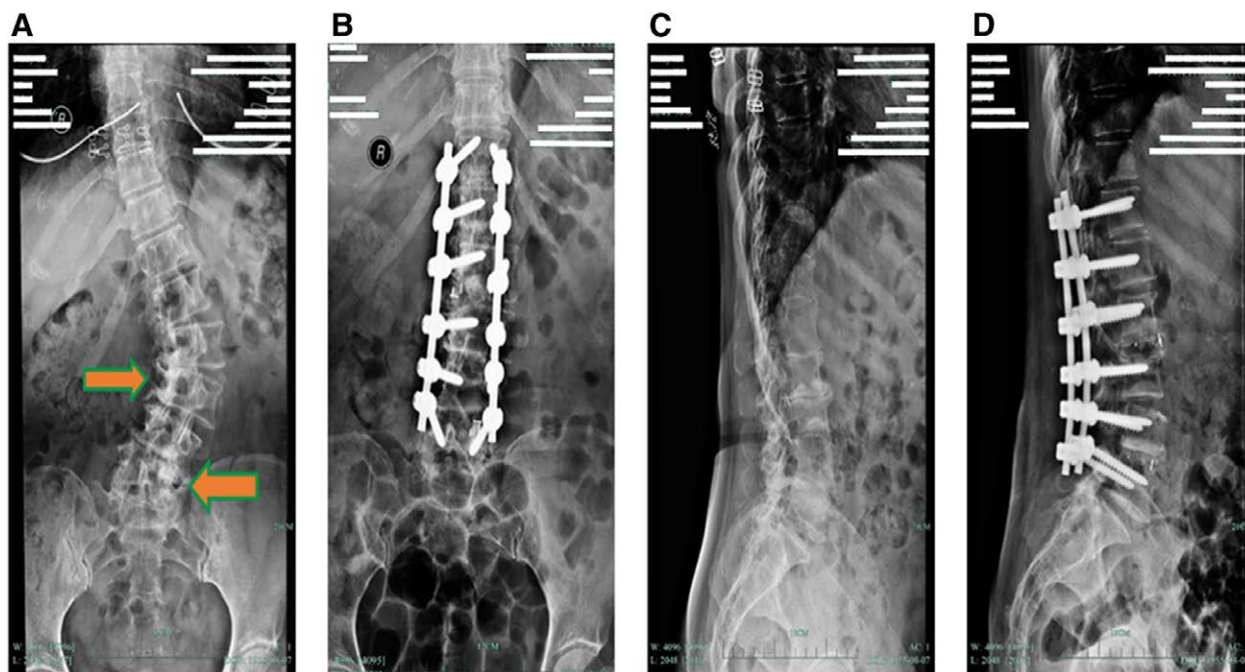
**4. Discussion**

In this study a novel intervertebral space release and unbalance correction without vertebral osteotomy to manage moderate to severe adult degenerative scoliosis was described. Our results suggested that this surgical technique showed promising clinical outcomes for spinal stability, deformity correction and symptoms improvement in the patient. Currently, surgical treatments on moderate to severe adult degenerative scoliosis commonly involve various osteotomies, mainly including Smith–Petersen osteotomy (SPO), Ponte osteotomy, pedicle subtraction osteotomy (PSO) and vertebral column resection (VCR). Among these osteotomies, SPO and Ponte have been used mainly to resect facet, lamina and ligamentum flavum, with limited effectiveness in deformity correction, so that it may be not suitable for moderate to severe adult degenerative scoliosis.<sup>[7,8]</sup> PSO osteotomy, which refers to the resection of bilateral facets, the lamina and ligamentum flavum with wedge-shaped component of the vertebral body and pedicles, can only generate 25° to 30° of

**Table 1**  
**Comparison of preoperative and postoperative JOA scores and Cobb angles.**

	Preoperative	Postoperative	P value
JOA score	9.45 ± 3.33	19.65 ± 4.58	<.001
Cobb angle	39.95° ± 9.04°	8.28° ± 4.21°	<.001

JOA = Japanese Orthopaedic Association.



**Figure 3.** X-ray images of a 58-year old female lumbar scoliosis patient. Anterior-posterior images showing lumbar scoliosis (yellow arrows) (A) before and (B) after surgery. Lateral images (C) before and (D) after the intervention.

correction<sup>[9]</sup>; VCR osteotomy refers to the complete resection of the vertebral bodies, the adjacent intervertebral disks and the associated posterior elements, and even the adjoining rib heads,<sup>[7]</sup> which can give a correction of 40° to 50° and has been more powerful in correcting the deformity than PSO. However, both PSO and VCR should be cautiously chosen for moderate to severe degenerative scoliosis treatment in elderly patients due to the higher rates of major complications associated with these procedures. In addition, these larger curves in moderate or severe adult degenerative scoliosis generally cause rigidity along the diseased spine, and thus could be a greater challenge to spine surgeons for correcting coronal and sagittal plane deformities. In our case series, special attention was paid to the original lesion site and the maximal unbalance space, and we found that releasing these 2 did soften the relatively rigid deformity and subsequent pedicle screws and rod fixation were less arduous to carry out. The coronal Cobb angle in our case series was improved from 39.95° ± 9.04° preoperatively to 8.28° ± 4.21° postoperatively, with an average Cobb angle change of 31.67°.

To the best of our knowledge, there are limited published literature on the effective treatment of severe adult degenerative scoliosis. Buell et al retrospectively analyzed in 22 patients the surgical outcomes of severe adult lumbar scoliosis with major curves ≥75°, with a minimum follow-up time of 2 years. Four patients with adult degenerative scoliosis were included and underwent TLIF at L4/5 or L5/S1, SPO or partial VCR, and posterior spinal instrumentation and fusion. In 22 patients, the authors reported major curve corrections up to 66% and significant improvements in global coronal and sagittal spinopelvic alignment.<sup>[10]</sup> All TLIF patients were conducted at L4/5 or L5/S1, which was similar to the reported original lesion sites in the present study, which mainly included L3/4 rotary subluxation, tilted L4/5 and L5/S1 intervertebral disc degeneration with L4/5 as the most common site. Thorough release at this site provided a basis for the subsequent correction of the deformity in our patients. Furthermore, special attention should also be paid to the maximal imbalanced space, which mainly included L1/2, L2/3, and L3/4 spaces, with L2/3 being the most common space.

In recent years, mini-invasive surgery (MIS) has been employed to manage adult degenerative scoliosis due to concerns about the major complications related to open surgery. Zhao et al retrospectively analyzed 22 patients with adult degenerative scoliosis, who had an average lumbar curve of 20.7° ± 7.0° preoperatively and 12.7° ± 7.1° at the 2-year follow-up. The authors concluded that MIS-TLIF can be employed for the treatment of patients with ALDS if the symptoms arose primarily from 1-level lumbar stenosis. Even though they achieved very favorable clinical outcomes and excellent fusion, with fewer complications and significantly less blood loss, the outcomes of the deformity corrections were not satisfactory.<sup>[11]</sup> In another comparison study on MIS versus open surgery for the correction of adult degenerative scoliosis, both types were found to produce comparable improvements in pain relief and enhanced patient functions. However, although MIS was associated with superior safety outcomes, open surgery produced a greater correction of the spinal deformity.<sup>[12]</sup> Therefore, MIS may not be an optimal technique for moderate or severe adult degenerative scoliosis with larger curves. Nevertheless, adult degenerative scoliosis patients often have various clinical manifestations, a minor, precise and individual treatment being advocated first to focus on the symptoms rather than the deformity.

No major complications occurred in our case series. Simon et al summarized the perioperative complications after surgery for adult degenerative scoliosis, which included adjacent segment failure, epidural hematoma, and postoperative paresis.<sup>[13]</sup> None of these complications were found in the present study, thus proving the safety profile of this novel intervertebral space release technique.

The major limitation of the present study was rooted in its retrospective nature with relatively small numbers of cases, disorganized long-term follow-ups, and the missing major objective parameters for thorough analysis. These facts downplay the significance of the present study, so a prospective study with a large patient cohort and better follow-up routines has been suggested to verify the clinical outcome and deformity correction of this novel intervertebral space release technique for the treatment of moderate to severe adult degenerative scoliosis.

## 5. Conclusion

A novel surgical technique that focused on intervertebral space release and balance correction at the original lesion and the maximum unbalanced site. It produced a promising clinical profile and may be considered as an alternative treatment for moderate to severe degenerative scoliosis.

## Author contributions

**Conceptualization:** Yonghong Yang.

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**Formal analysis:** Hang Yuan.

**Project administration:** Yonghong Yang.

**Supervision:** Yonghong Yang.

**Validation:** Hang Yuan, Yaming Xie, Jie Zheng, Yonghong Yang.

**Visualization:** Hang Yuan, Yaming Xie, Jie Zheng, Yonghong Yang.

**Writing – original draft:** Hang Yuan.

**Writing – review & editing:** Hang Yuan.

## References

- [1] Birknes JK, White AP, Albert TJ, et al. Adult degenerative scoliosis: a review. *Neurosurgery*. 2008;63(3 Suppl):94–103.
- [2] Sansur CA, Smith JS, Coe JD, et al. Scoliosis research society morbidity and mortality of adult scoliosis surgery. *Spine (Phila Pa 1976)*. 2011;36:E593–597.
- [3] Drazin D, Shirzadi A, Rosner J, et al. Complications and outcomes after spinal deformity surgery in the elderly: review of the existing literature and future directions. *Neurosurg Focus*. 2011;31:E3.
- [4] Cho SK, Bridwell KH, Lenke LG, et al. Major complications in revision adult deformity surgery: risk factors and clinical outcomes with 2- to 7-year follow-up. *Spine (Phila Pa 1976)*. 2012;37:489–500.
- [5] Lenke LG, Newton PO, Sucato DJ, et al. Complications after 147 consecutive vertebral column resections for severe pediatric spinal deformity: a multicenter analysis. *Spine (Phila Pa 1976)*. 2013;38:119–32.
- [6] Schwab F, Ungar B, Blondel B, et al. Scoliosis Research Society-Schwab adult spinal deformity classification: a validation study. *Spine (Phila Pa 1976)*. 2012;37:1077–82.
- [7] Bridwell KH. Decision making regarding Smith-Petersen vs. pedicle subtraction osteotomy vs. vertebral column resection for spinal deformity. *Spine (Phila Pa 1976)*. 2006;31(19 Suppl):S171–178.
- [8] Dorward IG, Lenke LG, Stoker GE, et al. Radiographical and clinical outcomes of posterior column osteotomies in spinal deformity correction. *Spine (Phila Pa 1976)*. 2014;39:870–80.
- [9] Bridwell KH, Lewis SJ, Rinella A, et al. Pedicle subtraction osteotomy for the treatment of fixed sagittal imbalance. Surgical technique. *J Bone Joint Surg Am*. 2004;86-A(Suppl 1):44–50.
- [10] Buell TJ, Chen CJ, Nguyen JH, et al. Surgical correction of severe adult lumbar scoliosis (major curves ≥ 75°): retrospective analysis with minimum 2-year follow-up. *J Neurosurg Spine*. 2019:1–14.
- [11] Zhao Y, Liang Y, Mao K. Radiographic and clinical outcomes following MIS-TLIF in patients with adult lumbar degenerative scoliosis. *J Orthop Surg Res*. 2018;13:93.
- [12] Lak AM, Lamba N, Pompilus F, et al. Minimally invasive versus open surgery for the correction of adult degenerative scoliosis: a systematic review. *Neurosurg Rev*. 2020.
- [13] Simon MJK, Halm HFH, Quante M. Perioperative complications after surgical treatment in degenerative adult de novo scoliosis. *BMC Musculoskelet Disord*. 2018;19:10.