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# Efficacy and safety of one-stage posterior hemivertebral resection for unbalanced multiple hemivertebrae: A more than 2-year follow-up

Yong Huang[1], Ganjun Feng[1], Yueming Song*, Limin Liu, Chunguang Zhou, Lei Wang, Zhongjie Zhou, Xi Yang

*Department of Orthopedic Surgery, West China Hospital, Sichuan University, No. 37 GuoXue Road, Chengdu, Sichuan, 610041, China*

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ABSTRACT

*Objective:* One-stage posterior hemivertebral resection has been proven to be an effective, reliable surgical option for treating congenital scoliosis due to a single hemivertebra. To date, however, no studies of treating unbalanced multiple hemivertebrae have appeared. This study evaluated the efficacy and safety of one-stage posterior hemivertebral resection for unbalanced multiple hemivertebrae.
*Patients and methods:* Altogether, we studied 15 patients with unbalanced multiple hemivertebrae who had undergone hemivertebral resection using the one-stage posterior approach with at least 2 years of follow-up. Clinical outcomes were assessed radiographically and with the Scoliosis Research Society-22 (SRS-22) score. Related complications were also recorded.
*Results:* The mean Cobb angle of the main curve was 62.4° (46°–98°) before surgery and 18.2° (9°–33°) at the most recent follow-up (average correction 73.3%). The compensatory cranial curve was corrected from 28.5° (11°–52°) to 9.1° (0°–30°) (average correction 70.0%). The compensatory caudal curve was corrected from 31.6° (14°–54°) to 6.9°(0°–19°) (average correction 79.1%). The segmental kyphosis/lordosis was corrected from 41.1° (−40° to 98°) to 12.3° (−25° to 41°) (average correction 65.5%). The mean growth rate of the T1-S1 length in immature patients was 9.8 mm/year during the follow-up period. Health-related quality of life (SRS-22 score) had significantly improved. Complications include one wound infection and one developing deformity.
*Conclusion:* One-stage posterior hemivertebral resection for unbalanced multiple hemivertebrae provides good radiographic and clinical outcomes with no severe complications when performed by an experienced surgeon. Longer follow-up to detect late complications is obligatory.

## 1. Introduction

Congenital scoliosis caused by malformations of the vertebrae is one of the most challenging spinal deformities in terms of prognosis and therapy. Hemivertebrae produced by complete failure of unilateral formation is the most common cause of congenital scoliosis [1]. With the exception of some incarcerated and balanced types, most hemivertebrae have growth potential and create a local wedge-shaped deformity that progresses during spinal growth. Such a local, wedge-shaped deformity could develop into spinal disorders such as congenital kyphosis and scoliosis if it is not addressed [2,3].

The natural history of congenital scoliosis has been well documented. The rate of deterioration and the ultimate severity of the spine deformity due to hemivertebrae depend on the patients' growth potential, type of the anomaly, size of the deformity, and the location at which it occurs [4–7]. Apart from some rarely equilibrated deformities induced by compensated and symmetrical hemivertebrae, multiple hemivertebrae disposed in a successive or intermittent manner generally develop into an unbalanced spinal deformity [8]. Unbalanced multiple hemivertebrae could be anticipated to lead to progressive scoliosis at a rate of 2°–5° per year, which is more rapid and higher than with a single hemivertebra (1.0°–3.5°) [4]. Based on observations over 1–10 years, Nasca et al. reported a variable rate of progression of 1.5°–12.0° per year [5]. Considering the notorious natural history of this deformity, surgical treatment is required in most cases.

Since the first case of hemivertebral resection was reported by Royle in 1928, the procedure has been proven reliable and effective for correcting this deformity and become the most frequently recommended correction technique for hemivertebrae to date [9]. Because of its good visualization for surgical manipulation and the need for less technical

* Corresponding author.
*E-mail addresses:* huangyongod@163.com (Y. Huang), gjfeng_hx@163.com (G. Feng), yuemingod_song@163.com (Y. Song), liuliminod@163.com (L. Liu), chunguang_zhou@163.com (C. Zhou), leiod_wang@163.com (L. Wang), zhouzjod@163.com (Z. Zhou), xiyangin88@163.com (X. Yang).
[1] These two authors contributed equally to this work.

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skill, a combined anterior and posterior approach using either a one-stage or two-stage operation was performed for hemivertebral resection during the early days [10–12]. With advances in surgical instrumentation, the one-stage posterior approach for hemivertebral excision has the advantage of being less invasive with a shorter postoperative recovery period and lower surgery-related morbidity while providing the desired correction rate [13]. In recent years, hemivertebral resection via a one-stage posterior-only approach has gradually become the preferred surgical option for hemivertebral deformities [14–23].

When dealing with deformity caused by unbalanced multiple hemivertebrae, two or more hemivertebrae should be removed, increasing the technical difficulty. In addition, more severe deformity and sophisticated structures may be confronted, posing an enormous challenge for the surgeon. Although hemivertebral resection using the one-stage posterior approach has been used extensively to treat scoliosis with a single hemivertebra, there have been no reports in the literature on treatment of unbalanced multiple hemivertebrae with this approach. The aim of this study was to evaluate the mid-term outcomes of one-stage posterior hemivertebral resection for unbalanced multiple hemivertebrae in 15 consecutive patients.

## 2. Materials and methods

The posterior-only approach has been used to treat congenital scoliosis with unbalanced multiple hemivertebrae in our department since 2010. For this study, we retrospectively reviewed 15 patients with a diagnosis of a congenital scoliosis due to unbalanced multiple hemivertebrae who underwent hemivertebral resection via the one-stage posterior approach during 2010–2015 at our institution. Each had been followed up for at least 2 years. The institutional review board of our hospital approved this study prior to data collection and analysis.

### 2.1. Patients

All operations were performed by one of the authors. The study group included 6 male and 9 female patients with a mean age of 11.9 years at the time of surgery (range 2–32 years). The details of patients, including sex, age at operation, resected hemivertebrae, associated abnormalities, and operative data, are shown in Table 1. Overall, two patients have undergone removal of the internal fixation hardware: at 3 years after the primary surgery in patient 1 and at 49 months after the primary surgery in patient 3. Before the surgery, all patients displayed trunk imbalance, which was the main reason for seeking treatment. No neurological compromise, radicular pain, motor weakness, abnormal reflex, or pulmonary insufficiency was apparent at their presentation.

Standard preoperative whole-spine plain radiography was applied to assess the deformities. Each of the deformities was caused by unbalanced multiple hemivertebrae, which was further confirmed and evaluated by whole-spine three-dimensional computed tomography reconstruction. Magnetic resonance imaging was used to exclude intraspinal anomalies. Renal and cardiovascular systems were also investigated for associated anomalies and syndromes. We reviewed operative reports to confirm the presence of any intraoperative complications and the patients' medical records to identify any complications during the perioperative and follow-up periods.

### 2.2. Radiographic assessment

Whole-spine standing posteroanterior and lateral radiographs were reviewed preoperatively, 1 month postoperatively, and at the most recent follow-up to assess deformity correction and spine balance and growth. The total main scoliosis curve, compensatory cranial curve, compensatory caudal curve, and coronal balance were measured in the coronal plane. Segmental kyphosis/lordosis, thoracic kyphosis, lumbar lordosis, and sagittal balance were measured in the sagittal plane. All curve parameters were measured by the Cobb method, as described by Ruf and Harms [14]. The coronal balance was measured according to the deviation of the C7 plumb line from the center of the sacral vertical line. The sagittal balance was measured as the distance between the C7 plumb line and the posterosuperior corner of S1. It was considered significant when the distance exceeded 20 mm. Segmental scoliosis, which is the parameter usually used for congenital scoliosis, was not adopted because the unbalanced multiple hemivertebrae, which were arranged irregularly (successive or intermittent, unilateral or bilateral), made it difficult to measure (and meaningless). The T1-S1 height was measured to assess spinal growth during the follow-up period.

### 2.3. SRS-22 questionnaire

Health-related quality of life was evaluated by the Scoliosis Research Society-22 (SRS-22) questionnaire, which has been validated in various populations. Patients were required to finish the questionnaire preoperatively, 1 month postoperatively, and at the last follow-up. If the patient was younger than 10 years or incapable of understanding the questions, the patient's parent(s) would complete the questionnaire. At follow-up, a standardized questionnaire was mailed to the patient with a stamped return envelope. To avoid missing answers,

**Table 1**
Demographic anatomical, and operative data.

| Case | Sex | Age[a] (years) | BMI | Resected hemivertebrae | Associated congenital abnormalities | Fused segments | Op time (min) | Blood loss (mL) | Follow-up (month) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | F | 5 | 15.38 | T11-R/L2, 3-L | atrial septal defect | T10-T12, L2-L3 | 305 | 600 | 72 |
| 2 | M | 6 | 22.73 | L1/L3-R | T1-R,T7-R,T9-R(incarcerated), Butterfly vertebrae T5 | T11-L4 | 260 | 400 | 66 |
| 3 | F | 2 | 15.62 | T12/L2-R | / | T11-L3 | 150 | 300 | 63 |
| 4 | M | 16 | 18.31 | T9/T10-L | Butterfly vertebrae T8 | T8-L2 | 215 | 800 | 59 |
| 5 | F | 11 | 21.70 | T12/L2-L | / | T10-L4 | 300 | 900 | 56 |
| 6 | F | 11 | 20.19 | T3-L/T9-R | Butterfly vertebrae T8 | T2-T12 | 325 | 1100 | 51 |
| 7 | F | 13 | 19.23 | T4-L/T7-R | / | T2-T9 | 310 | 1000 | 49 |
| 8 | F | 10 | 15.37 | L4-L/L6-R | / | L2-S1 | 250 | 500 | 42 |
| 9 | F | 12 | 17.60 | T11/T12-R | / | T8-L2 | 350 | 1000 | 39 |
| 10 | M | 32 | 18.42 | T11-R/L2-L | L5 spondylolysis | T8-L3 | 280 | 1200 | 34 |
| 11 | M | 13 | 19.74 | T7-R/T12-L | Butterfly vertebrae T1,Pectus excavatum, | T5-T9, T11-L1 | 295 | 1500 | 32 |
| 12 | F | 11 | 18.61 | T5-R/T9-L | / | T3-T11 | 330 | 800 | 28 |
| 13 | F | 9 | 19.20 | T12/L2-L | / | T9-L3 | 265 | 900 | 27 |
| 14 | M | 14 | 17.78 | T11/T13-L | / | T9-L2 | 320 | 500 | 25 |
| 15 | M | 12 | 16.20 | T2/T4-R | Butterfly vertebrae T6 | T1-T5 | 275 | 900 | 24 |

L: hemivertebrae located on the left side, R: hemivertebrae located on the right side.
[a] Age at time of surgery.