Hemivertebra Resection for the Treatment of Congenital Lumbar Spinal Scoliosis With Lateral-Posterior Approach

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Scoliosis and kyphosis that is secondary to a hemivertebra varies in severity and prognosis.1 The degree of scoliosis produced by a hemivertebra depends on the type, site, and number of hemivertebrae and the patient's age. Thoracolumbar and lumbosacral junctions are transitional areas between the mobile lumbar spine and the less mobile thoracic spine or sacrum. Hemivertebrae located in these two transitional areas lead to trunk shift. In the thoracolumbar and lumbar spine, progressive kyphosis may also occur. A single lumbar hemivertebra (between L2 and L4) can be expected to cause progression of scoliosis at a rate of 1.7°/yr if it is fully segmented and 1°/yr if it is partially segmented.2 Congenital scoliosis due to hemivertebra may progress after nonoperative and even after operative management.3 Many types of treatment have been proposed, the most radical being total excision of one or more anomalous structures.1,4–6 The aim of this study was to evaluate the results of lumbar hemivertebra resection and short-segment fusion through a lateral-posterior approach in a consecutive series of twenty-four patients who had congenital scoliosis due to single lumbar hemivertebra.

This report is an unselected, inclusive review of our early results after a follow-up of 5 to 94 months.

Materials and Methods

From December 1998 to December 2006, twenty-four children who had congenital scoliosis or kyphoscoliosis due to a lumbar hemivertebra had hemivertebra resection through a lateral-posterior approach and with the use of a short anterior convex-side fusion. The mean age of the patients at the time of surgery was 9.4 years (range, 6 years and 8 months–16 years and 9 months). The mean follow-up period was 43 months (5–94). There was a mean improvement of 61.5% in the segmental scoliosis curve from a mean angle of 45.2° before surgery to 17.4° at the time of the latest follow-up assessment, and a mean improvement of 60.9% in the total main scoliosis curve from 47.6° to 18.6° at the same periods. The mean final lordosis was within normal values. There were no major complications and no neurologic damage.

Conclusion. Excision of a lumbar hemivertebra through lateral-posterior approach is safe and provides stable correction when combined with a short-segment fusion.

Key words: congenital scoliosis, hemivertebra, excision.


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No funds were received in support of this work. No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.
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Operative Technique

The surgical technique involved complete excision of the hemivertebra with short segment fusion through a lateral-posterior approach. After general anesthesia has been administered, the patient is placed in a lateral decubitus position, with the convex side of the curve up. The flank is prepared and draped in the routine fashion. An L-shape lateral-posterior approach was chosen to expose the hemivertebra. Make a straight longitudinal incision about 3.5 cm lateral to the spinous process from one segment cephalad to one segment caudad to the hemivertebra, and then turn to the lateral. Carry dissection down to the lumbodorsal fascia and retract the skin and subcutaneous tissue on either side. Then make a fascial incision and pull the sacropinal muscle medially. Expose the lumbar transverse processes, facet joints, lamina and spinous process subperiosseously. After pulling psos major laterally, proceed with dissec-
tion directly anteriorly on the pedicle to the vertebral body. After segmental vessels have been ligated, the hemivertebra and the appendage, which have been identified radiographically, are exposed. The lamina of the hemivertebra is removed with its attached transverse process, facet joints, and the remaining portion of the pedicle and spinous process. The disc material on both sides of the hemivertebra is excised completely. Next, the vertebral epiphysial plates are removed. After this, the hemivertebra is removed, the dissection starts from the convex aspect to the concave aspect of the hemivertebra. If the dura has been exposed, a Gelfoam (gelatin sponge) is placed over it. The hemivertebal body removed is cut into morsels and is carefully laid, as a graft, in the gap that was created by the resection. Compression and stabilization on the convex side with a short-segmental instrumentation (Cotrel–Dubousset Horizon, Medtronic Sofamor Danek Co.) including vertebra cephalad and caudad to the hemivertebra were carried out anteriorly to correct the scoliosis deformity. The facets and the laminae cephalad and caudad to the hemivertebra are decorticated on convex side of the curve. Any bone that is removed during the laminectomy, and the remaining portion of the resected hemivertebra, is cut into morsels and is placed as graft material throughout the area extending from one vertebral cephalad to one vertebra caudad to the hemivertebra (Figures 1–6). Bleeding is controlled with thrombin-soaked Gelfoam. A thrombin-soaked Gelfoam are placed over the dural sac. The wound is closed in a routine manner. No wake-up test or evoked potential monitoring was used intraoperatively. Although the patient is still under anesthesia, radiographs are made to confirm the correction of the curve. After operation, a rigid brace was used to protect the instrumentation. It was worn full- or part-time for an average of 4 months (range, 3–6 months), depending on how soon the fusion appeared solid radiographically.

**Postoperative Assessment**

The effectiveness of the surgery was evaluated by a review of the radiographs taken before and after operation and at the most recent follow-up (Figures 7 and 8). All radiographs were measured according to Cobb’s method.\(^7\) The curves measured in the coronal plane were the segmental scoliosis curve, the total main scoliosis curve and trunk shift. The segmental scoliosis curve was measured between the two vertebrae immediately adjacent to the hemivertebra, whereas the total main scoliosis curve measured was the maximum scoliosis angle between the two most tilted vertebrae. The trunk shift is the distance between the middle of the sacrum and a line drawn from the middle of the T1 body and perpendicular to the biiliac line. The pelvic width is the distance between the two points of the iliac crests tangential to the biiliac line. The trunk shift was related to the pelvic width and was expressed as a percentage of the pelvic width to avoid errors due to radiographic enlargement. The curves measured in the sagittal plane were segmental kyphosis and lumbar lordosis. The segmental kyphosis was measured between the two vertebrae adjacent to the hemiver-

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Figure 1. Transverse section through the posterior abdominal wall to show lateral-posterior approach to lumbar spine.

Figure 2. Patient positioning and L-shape incision for lateral-posterior approach.

Figure 3. Hemivertebra and its appendage was exposed.

Figure 4. Hemivertebra and its appendage was resected.
tebra, and the global lordosis was measured between the super-
rior endplate of L1 and the superior endplate of S1. A kyphotic
curve is expressed as a positive angle value, whereas a lordotic
curve corresponds to a negative value.

**Statistical Analysis**
The results were analyzed statistically with use of the paired
Student t test, with the level of significance set at \( P \leq 0.05 \).

**Results**
The mean age of the 24 patients at the time of surgery
was 9.4 years (range, 6 years and 8 months–16 years and
9 months). The mean follow-up was 43 months (5–94).
The mean segmental scoliosis curve was 45.2° (35°–70°)
before operation, 15.6° (0°–23°) immediately after sur-
gery, and 17.4° (0°–26°) at the time of the latest fol-
low-up assessment. The total main curve was 47.6° (35°–
73°), 16.9° (0°–25°) and 18.6° (0°–28°) at the same
periods, respectively. This represents a mean 61.5% cor-
rection for the segmental curve and a mean 60.9% cor-
rection for the total main curve. These differences be-
tween preoperative and postoperative or between
preoperative and final follow-up were significant (\( P <
0.01 \)). The trunk shift improved from 23% (5%–40%)
before operation to 21% (4%–38%) after operation,
and to 10% (0%–32%) at the latest follow-up (\( P <
0.05 \)). In the sagittal view, the mean segmental lordosis
was \(-2.6° (-22° to +20°)\) before surgery, \(-4.9° (-27°
to +22°)\) after surgery, and \(-5.8° (-26° to +24°)\) at
final assessment. The mean global lordosis was \(-26°
(-49° to +15°), -22° (-40° to +29°)\) and \(-35.2°
(-55° to +31°)\) at the same periods, respectively. There
were no postoperative neurologic complications and no
breakages of implants. All patients achieved solid fusion
at the latest follow-up.

**Discussion**
Hemivertebrae are the most frequent cause of congenital
scoliosis. They have growth potential similar to normal
vertebra, creating wedge-shaped deformity that
progresses during further spinal growth. In congenital
scoliosis, progression of the spinal deformity occurs as a
result of unbalanced vertebral growth. Nonsurgical
treatments including bracing usually have been unsuccessful in preventing progression of the deformity, and surgical intervention is necessary for most cases with curve progression.10,11

The primary goal of surgical intervention of congenital scoliosis due to hemivertebra is to halt curve progression and deformity that might require a more extensive corrective procedure. Progression of the scoliosis is most rapid during the adolescent growth spurt and stops only at the point of skeletal maturity.12 It has been recommended2,6,13 that prophylactic treatment be administered before the spine begins to decompensate and before secondary curves become structural.

There are four basic procedures available to the surgeon treating congenital scoliosis: posterior fusion, combined anterior and posterior fusion, convex growth arrest (anterior and posterior hemiepiphysiodesis), and excision of the hemivertebra.11,14–20,21

Posterior spinal fusion alone has considerable limitations. The goal of posterior surgery is stabilization in order to prevent further progression rather than correction of the curve. Winter22 reported 290 patients with congenital scoliosis who had posterior fusion with or without Harrington instrumentation. Correction was limited to 28% in those fused without instrumentation and to 36% in those in whom Harrington implants were used. Instrumented distraction across the concavity was associated with the risk of paraplegia. Deformation of the fusion mass because of continued anterior growth, was observed in 40 patients (14%). The crankshaft phenomenon occurs in 15% of patients of all ages and in 36% of patients who are younger than 4 years old at the time of fusion23. Slabaugh et al24 compared hemivertebra excision with posterior fusion in situ for lumbosacral hemivertebrae and found better correction of the curve in the group who had excision.

Combined anterior and posterior fusion offers several advantages over posterior fusion. More substantial correction can be achieved by discectomies, the potential for a crankshaft effect is eliminated, and the occurrence of pseudarthrosis is reduced. Because this technique does not address the wedge deformity directly, the entire measured curve must be encompassed in the fusion, including normal segments. Fusion of multiple vertebral segments will result in a corresponding loss of spinal mobility and loss of future growth potential in every segment fused. Meanwhile, this technique may leave a residual curve, persistent deformity, and occasionally unacceptable cosmesis.

Convex epiphysiodesis of the spine was designed to arrest convex growth while allowing concave growth to correct the deformity. The surgery must take place when sufficient spinal growth remains, usually in children less than 5 years of age.16,18,20,25,26 Concave growth is, however, unpredictable and kyphosis in the region of the anomaly may develop as growth of the posterior elements continues. It is necessary to perform convex hemiepiphysiodesis across the entire measured curve, often including a normal segment above and below, in order to achieve a satisfactory improvement. The results of this procedure have been variable and unpredictable. Roaf27 described unilateral hemiepiphysiodesis in patients with spinal deformity, and proposed that further growth would correct the deformity. He achieved correction of more than 20° in 23% of patients, but less than 10° in 40%. Andrew and Piggott28 demonstrated mixed early results in a series of 13 patients treated by convex epiphysiodesis. Long-term follow-up of 33 patients from the same center showed correction of the curve in 23 (70%), with better results in patients treated at a young age.29 Winter and Moe11 reported early results in 10 children treated by convex hemiepiphysiodesis, with only two demonstrating significant correction at follow-up at 2 years. Long-term follow-up of a similar group of 13 patients showed arrest of the curve in 7 patients (54%) and improvement of more than 5° in 5 (38%).26

In contrast to the above techniques, hemivertebra excision has several distinct advantages. Directly removing the hemivertebra eliminates the potential for future curve progression and provides immediate correction of the existing clinical deformity, resulting in improved cosmesis. This leaves the remaining proximal and distal uninvolved segments mobile, fused, and available for continued normal growth. It is well established in the management of lumbosacral curves.14,24,29–32 Correction cannot be achieved reliably by other methods.

Excision of a hemivertebra was first reported in 1928 by Royle3 in Australia. Numerous authors have reported on series in which hemivertebra resection was performed through successseive or simultaneous anterior and posterior approaches or through the posterior approach alone. The rates of correction of the scoliotic curve in those studies ranged from 24.3% to 71.1%.33,34

Before the development of modern instrumentation systems, excision of hemivertebra was not commonly performed, as it did not provide significant correction, except for fusion effect on curves and ceasing of progression; it also had serious neurologic and systemic complications.13,35–37 Recently, Leatherman and Dickson30 popularized it again. In many subsequent studies, it has been reported that complete excision of hemivertebra at the same session at one or two steps leads to pronounced improvement as well as spontaneous correction.14,15,34,38 Bradford and Boachie-Adjei14 reported a 70% correction in Cobb angle. Only 1° of correction loss occurred after anterior-posterior hemivertebra excision simultaneously performed at a single step. King and Lowery,33 in their series with 7 patients, reported a 29.7° of final curve following 2 step excision and 18° curve with simultaneous single step intervention. Callahan et al reported the results of 10 patients with 67% correction in curves at 40°, and Shono et al reported 64% correction.39,40 Lazar and Hall41 improved preoperative curves from 47° to 14° in their series of 11 patients, while Hall et al41 improved it from 54° to 33°. Shono et al19 re-
ported an improvement in lateral body shift from 23 mm to 3 mm. in patients with hemivertebra excision. Similarly, Deviren et al reported an improvement from 35 to 11 mm.

The most common method is the excision of the hemivertebra body and disc in the form of Y, and subsequent excision of the posterior components, if present. According to Lubicky, excision of the posterior components first through posterior approach, and then the excision of anterior hemivertebra body and compression with Zielke or Dwyer operation is the other method. The most recent reports recommend the simultaneous performance of two procedures during the same session as this is more reliable and efficient. Several reports recommend the simultaneous performance of two procedures during the same session as this is more reliable and efficient. The authors of more recent studies have reported on hemivertebra excision from the posterior approach only. Ruf and Harms reported on twenty-eight hemivertebra resections in which convex compression by a screw-rod system was used. At a mean of 3.5 years, the mean correction of the scoliosis was 71.1% (from 45° to 13°). Complications included two pedicle fractures, three failures of instrumentation, two additional operations for curve progression, and one infection. Shono et al reported on hemivertebra resection through a single posterior approach in twelve patients, in whom the mean correction was 63.3% (from 49 to 18°).

To our knowledge, few reports have been reported describing a procedure consisting of one-stage lateral-posterior lumbar hemivertebra resection and correction of the deformity by segmental anterior instrumentation to date. In contrast to the above approaches, lateral-posterior lumbar hemivertebra excision has several distinct advantages. Directly removing the hemivertebra and its’ appended structures provides immediate correction of the existing clinical deformity in an approach. Stabilization were carried out anteriorly using a short-segmental instrumentation including only vertebra cephalad and caudal to the hemivertebra. This leaves the remaining proximal and distal uninvolved segments mobile, unfused, and available for continued normal growth. The sacrospinal muscle, vertebral canal and dura on the concave side were not exposed and disturbed.

Our mean rate of correction of the major curve in these 24 patients was 60.9%, similar to previously reported results for hemivertebra excision. The mean final lordosis was within normal values. In the present study, no neurologic deficit occurred.

The encouraging results of this study indicate that correction of progressive deformity due to a single hemivertebra can be satisfactorily achieved through a lateral-posterior approach. The operation was well tolerated by our patients, and it was not associated with any adverse complications. However, one should take into account the presence of compensatory thoracic or lumbar curves that may produce spinal imbalance if the curve is overcorrected. We recognize that a longer follow-up, preferably to the completion of growth, is necessary for a full assessment of the role of the technique in the overall management of these patients.

### Conclusion

Complete single hemivertebra excision carried out through a lateral-posterior approach is quite safe for lumbar regions of vertebral column. High correction and fusion rates can be achieved with short anterior segmental instrumentation. Minimal correction loss is observed at follow-up visits. Sagittal contours may be brought within normal physiologic ranges. Lateral trunk shift is considerably corrected and no additional imbalance or decompensation problem was observed.

### Key Points

- Congenital scoliosis or kyphoscoliosis due to a lumbar hemivertebra were managed by resection of the hemivertebra and fusion through a lateral-posterior approach.
- Use of a lateral-posterior approach in the surgical treatment of hemivertebrae has not been described previously in the literature.
- Excision of a lumbar hemivertebra through lateral-posterior approach is safe and provides stable correction when combined with a short-segment fusion.

### References

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