Excision of hemivertebrae in the management of congenital scoliosis involving the thoracic and thoracolumbar spine

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We present a study of ten consecutive patients who underwent excision of thoracic or thoracolumbar hemivertebrae for either angular deformity in the coronal plane, or both coronal and sagittal deformity. Vertebral excision was carried out anteriorly alone in two patients. Seven patients had undergone previous posterior spinal fusion. Their mean age at surgery was 13.4 years (6 to 19). The mean follow-up was 78.5 months (20 to 180). The results were evaluated by radiological review of the preoperative, postoperative and most recent follow-up films.

The mean preoperative coronal curve was 78.2° (30 to 115) and was corrected to 33.9° (7 to 58) postoperatively, a mean correction of 59%. Preoperative coronal decompensation of 35 mm was improved to 11 mm postoperatively. Seven patients had significant coronal decompensation preoperatively, which was corrected to a physiological range postoperatively. There were no major complications and no neurological damage.

We have shown that resection of thoracic and thoracolumbar hemivertebrae can be performed safely, without undue risk of neurological compromise, in experienced hands.

J Bone Joint Surg [Br] 2001;83-B:496-500.
Received 5 September 2000; Accepted 5 December 2000

The management of spinal deformity caused by a hemivertebra is controversial. The progression of the deformity is unpredictable and requires continuous evaluation. The location of the hemivertebra is an important factor in predicting the need for surgical treatment. When the lesion is in the lower thoracic or thoracolumbar region surgical treatment may be required to prevent deterioration of the curve.[1] The optimum method, however, for the management of a hemivertebra at these levels has yet to be determined.

Excision of a hemivertebra is a well-established procedure, although its use has been largely limited to the management of anomalies of the lumbar and lumbosacral spine.[2-9] In a classic description of the aetiology of scoliosis, MacLennan[10] described the technique of resection of a vertebral body through a posterior approach, followed by immobilisation in a cast. He reported "surprisingly little" correction, however, because of the rigidity of the retained posterior elements. Von Lackum and Smith[9] carried out a combined anterior vertebrectomy and posterior fusion in the management of a fixed lateral deformity, but concluded that the removal of thoracic vertebral bodies was impractical because of the risk of haemorrhage and shock. Wiles[11] reported progressive kyphosis in two patients after excision of a lumbar hemivertebra. Subsequent discussion revealed that follow-up of the earlier experience of Compere[12] and of Von Lackum and Smith[9] also demonstrated progressive kyphotic deformity.

Leatherman and Dickson[5] introduced the concept of a two-stage correction using a closing wedge osteotomy with shortening of the spinal column. Their results gave a mean correction of 43% at follow-up, with a transient neurological deficit in two patients.[5,6] Holte et al[3] described hemivertebral excision and wedge resection in 37 patients with congenital scoliosis, but reported eight neurological complications; six followed excision at L5 or S1, one after excision at T10 and one after excision at T9. Bradford and Boachie-Adjei[2] reported on single-stage, lumbar and lumbosacral hemivertebral excision in seven patients, aged from one to ten years, with a mean correction of 64% and no neurological compromise.

In spite of these reports showing effective correction with limited neurological hazard after excision of hemivertebrae, the technique has usually been used for lumbar and lumbosacral deformities only. Excision of a hemivertebra above the lumbosacral junction is controversial as deformity at this level has less impact on spinal balance, and the risk of neurological damage has been thought to be

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0301-620X/01/411699 $2.00

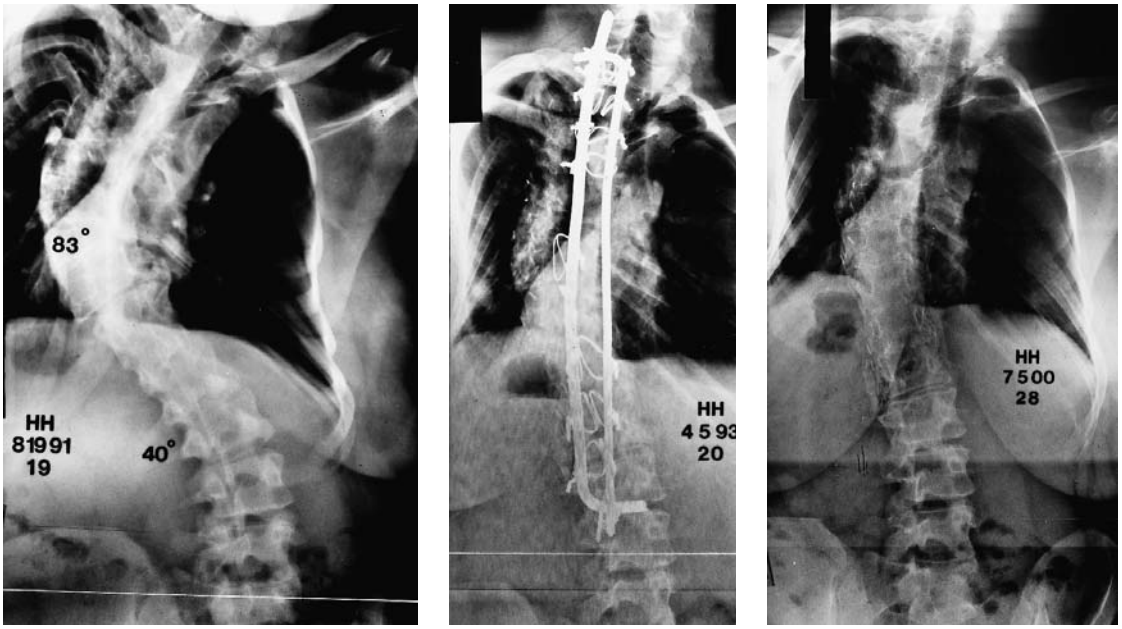

Fig. 1a Fig. 1b Fig. 1c

Posteroanterior radiographs of a 19-year-old woman with congenital scoliosis with hemivertebra at T8 to T9 a) before operation, b) after operation and c) at follow-up at nine years after removal of the internal fixation.

very high, especially above the level of the conus medullaris. Hemivertebral excision has a potential advantage over alternative techniques for the surgical management of congenital scoliosis by addressing the deformity directly and allowing immediate, better controlled and more predictable correction, particularly for coronally decompensated patients.[4,6,7,10]

Our aim is to review the outcome of hemivertebral excision in the treatment of congenital hemivertebrae of the thoracic and thoracolumbar spine.

Patients and Methods

From our database we identified all patients with the diagnosis of congenital spinal deformity and the records of patients who had had thoracic or thoracolumbar hemivertebral excision were reviewed. There were ten patients with a follow-up of at least two years. In seven, the procedure had been carried out for coronal deformity, and in three for both coronal and sagittal malalignment. The excision had been performed anteriorly in two patients, and through a combined approach in the remainder. Before this operation, seven patients had had posterior spinal fusion (Fig. 1).

Operative technique. Either a standard thoracic or retroperitoneal thoracoabdominal approach was used according to the level of the hemivertebra. Once the level had been exposed, the discs above and below were excised as far back as the posterior longitudinal ligament. The hemivertebra was then removed with a rongeur and curette, including the base of the existing single pedicle on the convex side. If the hemivertebra was located at the thoracic level, the head of the rib which articulated with the hemivertebra was removed to facilitate exposure and subsequent closure of the space remaining after hemivertebral excision. The space was loosely packed with autologous bone graft.

As a rule the remainder of the hemivertebra was excised posteriorly including the rest of the pedicle. Correction and stabilisation were carried out posteriorly using segmental instrumentation. The extent of the fusion was based on the preoperative assessment of the magnitude and location of the deformity, the rigidity of the curve and the presence of decompensation.[13]

Hemivertebral resection was carried out through an isolated anterior approach in two patients (one at L1 and the other at T12). In these cases, in addition to excision of the vertebral body, the convex pedicle, transverse process and other bone remnants were removed entirely through the anterior approach. The posterior elements were not developed substantially; these patients had had no previous surgery to the spine. They were stabilised by anterior instrumentation and fusion only.

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. Absolute measurements were made of the coronal and sagittal curves, trunk shift, coronal decompensation, thoracic kyphosis, and lumbar lordosis. Coronal and sagittal curves were measured according to Cobb's method.[14] Trunk shift was determined by relating the central point of the trunk to the central point of the pelvis. Coronal decompensation was defined as displacement of the T1 vertebra by more than 25 mm from the

Table I. Details of the ten patients with congenital scoliosis involving the thoracic and thoracolumbar spine

Case	Gender	Age (yrs)	Follow-up (mths)	Previous spinal operation*	Level of hemivertebra	Stage of surgery*	Estimated fusion level	Blood loss (ml)
1	M	15	30	No	L1	A	T12 to L2	700
2	F	9	72	PSF+HIS	L1	A+P	T4 to L4	3800
3	M	16	31	A+PSF	T11	A+P	T2 to L2	6500
4	M	15	63	No	T12	A+P	T10 to L3	4700
5	M	13	26	No	T12	A	T11 to L1	1200
6	F	19	106	PSF	T8 to T9	A+P	T1 to L3	1150
7	F	6	32	PSF	T10 to T11	A+P	T1 to L1	2800
8	F	14	132	PSF	L2	A+P	T1 to S1	3900
9	F	12	120	PSF	T7 to T8	A+P	T1 to L4	1175
10	M	15	180	PSF	T7 to T8	A+P	C7 to L4	1750
								2767

* PSF, posterior spinal fusion; HIS, Harrington instrumentation; A, anterior; P, posterior

Table II. Radiological measurements for the ten patients before and after hemivertebral excision for congenital scoliosis involving the thoracic and thoracolumbar spine

	Major curve (degrees)			Coronal T1 offset (mm)		Sagittal T1 offset (mm)	
Case	Preop	Postop	Correction (%)	Preop	Postop	Preop	Postop
1	36	11	*69*	22	6	70	35
2	74	37	*50*	50	40	28	42
3	78	34	*56*	0	10	10	30
4	47	7	*85*	18	2	0	10
5	37	10	*73*	10	0	10	20
6	83	50	*48*	50	10	30	20
7	97	50	*40*	30	0	40	30
8	115	42	*63*	60	25	30	0
9	105	58	*45*	55	20	30	30
10	110	40	*64*	60	0	10	40
		34	*59*	36	11	26	26

central line of the sacrum. Sagittal decompensation was defined as displacement of the T1 vertebra by more than 40 mm from the posterior superior sacral margin.

In addition to the radiological analysis, inpatient and outpatient records were reviewed. Data were recorded regarding the age at the time of surgery, the levels fused, the level of the hemivertebra, the type and level of instrumentation, estimated blood loss, complications and any additional surgery.

Results

The mean age of the ten patients at the time of surgery was 13 years (6 to 19). The mean follow-up was for 78 months (24 to 180). Seven patients had had previous surgery; five a posterior spinal fusion without instrumentation, one an anterior and posterior spinal fusion, and one a posterior fusion with Harrington fixation. Four patients had excision of two hemivertebrae each (Table I).

The mean size of the coronal curve was 78° (36 to 115) before operation, which improved to 34° (7 to 74) at follow-up, with a mean correction of 59% (45 to 85). The mean compensatory curve was 28° preoperatively and 11° at follow-up, giving a correction of 61%. Balance in the coronal plane improved from a mean offset of 36 mm (0 to 60) before operation to 11 mm (0 to 40) at follow-up. The mean trunk shift was 35 mm before operation and 9 mm at follow-up. Balance in both planes improved for all patients except one, in whom there was imbalance in both planes in the cervicothoracic region after operation (Table II). This patient underwent further surgery four years later for progressive deformity.

The mean thoracic kyphosis was 35° (-25 to 76) before and 42° (18 to 64) after operation. The mean lumbar lordosis was 65° (28 to 98) before operation and 52° (28 to 70) at follow-up. Three patients with congenital thoracolumbar kyphosis improved after surgery. The measurements of 80°, 50° and 32° before operation, improved to 32°, 18°

and 12°, after. Alignment in the sagittal plane was either maintained or improved in all patients.

Two patients required additional surgery during follow-up. One had transpedicular subtraction osteotomy for a fixed cervicothoracic congenital deformity and the other removal of the internal fixation because of pain. There were no postoperative neurological complications and no breakages of implants. All patients achieved solid fusion at the latest follow-up.

Discussion

When congenital deformity of the spine causes an imbalance of growth, progression of the deformity is rapid and relentless.[1,15-19] The development of a curve is variable depending on the location of the deformity and the growth potential of the bony elements involved. Thoracic and thoracolumbar deformities often have a poor prognosis and usually require surgical intervention.[2,20] 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.[2,3,15,19,21-25]

Posterior spinal fusion alone has considerable limitations. The goal of posterior surgery is stabilisation in order to prevent further progression rather than correction of the curve. Winter[26] 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%). Hall et al[22] reported a mean correction of the curve of 12% in posterior fusions without instrumentation, improving to 35% with Harrington instrumentation. Slabaugh et al[8] compared hemivertebral 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. Since this technique does not address the wedge deformity directly, the entire measured curve must be encompassed in the fusion, including normal segments.

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 five years of age.[15,21,23,27,28] 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. Roaf[29] 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 Piggott[20] demonstrated mixed early results in a series of 13 patients treated by convex epiphysiodesis. Long-term follow-up of 33 patients from the same centre showed correction of the curve in 23 (70%), with better results in patients treated at a young age.[27] Winter and Moe[24] reported early results in ten children treated by convex hemiepiphysiodesis, with only two demonstrating significant correction at follow-up at two years. Long-term follow-up of a similar group of 13 patients showed arrest of the curve in seven patients (54%) and improvement of more than 5° in five (38%).[28]

In contrast to the above techniques, excision of the hemivertebra addresses the deformity directly and allows reliable correction immediately. It is well established in the management of lumbosacral curves, which are responsible for pelvic obliquity, apparent leg-length discrepancy, and truncal listing.[2-5,8,9,13] Correction cannot be achieved reliably by other methods. In the thoracic and thoracolumbar spine, less imbalance is produced but even so, there is often considerable cosmetic deformity and continued spinal growth may cause the curves to progress. Hemivertebral excision allows more complete correction of the curve in these patients, producing improved cosmetic results and restoration of balance. Our mean rate of correction of the major curve in these ten patients was 59%, similar to previously reported results for hemivertebral excision, and much superior to the radiological results reported for hemiepiphysiodesis, anterior and posterior fusion, and posterior fusion alone.

Some authors have questioned the safety of such a procedure in the thoracic and thoracolumbar spine because of the risk of kyphosis and neurological deficit above the conus.[16] Our results suggest that hemivertebral excision involving the thoracic and thoracolumbar spine is not associated with an increased risk of kyphosis or neurological complications. In ten consecutive cases of hemivertebral excision did not encounter permanent neurological deficit or progressive kyphosis. Based on our experience, the correction and balancing of congenital thoracic or thoracolumbar curves are more effectively achieved by resection of the hemivertebra than by alternative treatments for patients with significant, rigid curves.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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