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Posterior Convex Wedge Resection in the Management of Advanced Congenital Scoliosis Caused by Hemivertebra

Surya Prakash Rao Voleti, MS, Dnb

Department Of Orthopaedics, Nizam's Institute Of Medical Sciences, Hyerabad, India

Abstract

Study Design and Objective: To study the early results of posterior convex wedge resection in patients with advanced congenital scoliosis using a single stage posterior approach

Background Data: The treatment of advanced congenital scoliosis is a surgical challenge. If hemivertebra is a cause of the deformity, excision is ideal for obtaining good correction. Several authors have used a staged or single staged anterior and posterior surgery for tackling these deformities.

Material and Methods: Ten consecutive cases of advanced congenital scoliosis with hemivertebra were treated with 'posterior convex wedge resection and segmental spinal instrumentation. Transpedicular decancellation along with the curettage of the adjacent discs was performed to facilitate correction. Wide resection of the posterior elements was done to prevent laminar impingement over the dura while correcting focal segmental kyphosis. A convex rod was applied first and the reduction maintained. Bonechips were placed into the residual defect of the hemivertebra after the correction and spinal fusion. Preoperative and postoperative radiographs and patient records were evaluated.

Results and Observations: Mean age was 14.1 yrs (range 10-20 years). Mean follow up was six months (three to 12 months).Segmental main scoliosis curves had improved from a preoperative mean of 64 to 37 degrees (42% correction) and kyphosis from 47° to eight degrees (83% correction). Total scoliosis curve improvement was from 59° to 23° (42% correction) which was maintained at the last follow up. On an average 6.8 segments were fused (five to nine). We had one hemivertebra each at T9, T11 and L3 , two hemivertebrae each at T12, and L1 and three hemivertebrae at L2 in this series. There were seven right and three left sided curves. All patients are neurologically preserved postoperatively

Discussion and Conclusions: Posterior resection of hemivertebra is a promising procedure for correction of deformity in both of the planes. The presence of associated kyphosis, vertebral rotation and shifting of the cord on to the concave side makes the approach to hemivertebra easier. As all the patients in this group were older, most of them had well-developed secondary structural curves. This could be the reason for better correction in the sagittal plane than in the coronal and for the longer levels of instrumentation. Being a convex shortening procedure, there is less neurological risk. Pedicle screw instrumentation gives good stability. As the anterior surgery can be avoided, this 'posterior only approach' is much less morbid than the classical anterior and posterior approach.

Keywords: posterior convex wedge resection, hemivertebrectomy, congenital scoliosis

Introduction

Hemivertebrae are a common cause of congenital scoliosis. Depending on their location and the magnitude of the resultant deformity, they may be asymptomatic or require treatment. In the past, treatment has focused on prevention of deformity progression in growing children. Little has been written about congenital scoliosis presenting late. Because the aging of the spine is a kyphosing process and hemivertebrae often present with a local segmental kyphotic alignment, this can become symptomatic. Excision of hemivertebrae is well established as a safe and effective procedure when treatment is required. Initially this was conducted via a combined anterior–posterior approach. Recently some authors have indicated that in the lumbar spine hemivertebra resection can safely and effectively be achieved via a single posterior transpedicular approach.We present 10 consecutive cases of advanced congenital scoliosis with hemivertebra which were treated with posterior convex wedge resection and segmental spinal instrumentation. Transpedicular decancellation along with the curettage of the adjacent discs was performed to facilitate correction. A good correction of the deformity was achieved. There were no neurological complications. All the patients were spared an anterior ap-

proach (thoracotomy or lumbotomy or thoraco phreno lumbotomy) and no chest tubes were required.

The location and type of vertebral anomaly can affect the severity and prognosis of congenital scoliosis.(1-4) When a large deformity is present at an early age, surgical treatment is necessary. Surgical correction of congenital curves is generally more successful when high-risk curves of a smaller magnitude are treated early.(5,6) In cases in that present later in life, treatment is more challenging to the clinician. There are a number of surgery-related options available for the management of congenital scoliosis.

This is because of the secondary structural curves which develop in the due course. The cases included in this series are the ones with established secondary curves and hence the condition is considered 'advanced' congenital scoliosis.

Historically these options have included posterior spinal fusion with or without instrumentation, anterior and posterior fusion in situ, hemiepiphysiodesis and fusion following hemivertebra excision via combined anterior–posterior approach.(5-11) In single-stage hemivertebra excision deformity correction is advantageously combined with a short-segment fusion. Hemivertebra excision was first reported in the early 20th century(12) The potential for neurological injury led Leatherman and Dickson (10) to recommend a staged sequential anterior–posterior hemivertebra resection. In subsequent reports by Bradford and Boachie-Adjei (8) and others(5,9,11) the authors reported the safety and efficacy of single-stage combined anterior–posterior excision. These series included children who ranged in age from one to greater than 10 years. Callahan and coworkers(5) suggested that results might be improved if surgery was performed at a younger age. The purpose of this report is to present our experience with a posterior-only transpedicular lateral extracavitary hemivertebra excision (posterior convex wedge resection) in patients with congenital scoliosis presenting late.

Material and Methods

Ten consecutive cases of advanced congenital scoliosis with hemivertebra were treated with posterior convex wedge resection and segmental spinal instrumentation. These included eight girls and two boys. The mean age at the time of surgery is 14.1 years (range 10-20 years). The average follow up is six months (range four to 12 months). All the patients were screened with Magnetic Resource Imaging (MRI) to rule out any neural axis anomalies. The hemivertebrae involved thoracic and lumbar regions. We had one hemivertebra each at T9, T11 and L3, two hemivertebrae each at T12, and L1, and three hemivertebrae at L2 in this series. There were seven right and three left sided curves. Of the hemivertebrae, five are fully segmented and five are semi segmented vertebrae.

All the patients in this series exhibited focal segmental kyphosis. The pre- and postoperative angle of the main scoliosis curve, the total scoliosis curve and the focal kyphosis angle on the standing films are evaluated for all the patients. The main scoliosis curve is the curve made by the anomalous vertebra without considering the transitional vertebrae above and below the anomaly which contributed to the total scoliotic curve in the patient.

Operative Procedure

After the induction of Endotracheal anesthesia, the patients were placed prone on bolsters to avoid pressure on the abdomen.After preparation a longitudinal skin incison was placed in the midline centering the hemivertebra. Paravertebral muscles were resected and spine exposed to the tip of the transverse process on either side. The hemivertebra was identified.

Pedicle screws were placed on the vertebrae above and below the hemivertebra under fluoroscopic guidance. The hemivertebra are usually deviated to a posterior lateral position and the pedicle of the hemivertebra is usually thicker than usual. The pedicle of the hemivertebra was identified and transpedicular decancellation along with the curettage of the adjacent discs was performed with curettes. No resection of the posterior elements was done until a sufficient amount of the vertebral body was curetted out. In cases of the semi segmented hemivertebra, partial curettage of the vertebrae above and below the hemivertebra was performed.

After sufficient body is curetted, the anterior cortex of the hemivertebra was weakened with gentle tapping on an osteotome which was placed through the pedicle. At this juncture, the posterior elements of the hemivertebra along with the wedge of the cranial and caudal lamina were resected. Wide resection of the posterior elements is done to prevent laminar impingement over the dura while correcting focal segmental kyphosis. The controlled correction of the deformity was achieved by compressing the convex side and by application of the precontoured rod, and levering it into the top loading mono axial pedicle screws. This closed the posterior triangular gap and crushed the anterior cortical shell of the hemivertebral body. The incompletely resected concave part of the disc and vertebral body shell acted as a hinge which prevented translation of the osteotomy. The concave rod was then applied and the reduction stabilized. Bonechips were placed into the residual defect of the hemivertebra. The realignment of the spine checked under the C-arm image intensifier. The epidural bleeding was controlled by cotton patties and Gelfoam sponges. At the end of the procedure, laminar impingement over the dural sac was checked and if required an additional part of the adjacent laminae resected. An intraoperative wake-up test was performed at the end of the correction of the deformity and instrumentation to check spinal cord integrity. Posterior elements of the spine along the entire length of the construct were decorticated and bone graft applied. Patients were mobilized after the surgery in a brace according to how they tolerated the pain.

Table 1. Patient data

Serial number	Age	Gender	Follow-up (months)	Scoliosis main curve before surgery	Scoliosis main curve after surgery	Segmental kyphosis before surgery	Segmental kyphosis after surgery	Scoliosis total curve before surgery	Scoliosis total curve after surgery
1	16	f	12.00	79.00	48.00	0.00	-17.00	64.00	20.00
2	20	f	8.00	54.00	50.00	30.00	-3.00	60.00	28.00
3	17	m	7.00	110.00	81.00	68.00	20.00	80.00	30.00
4	12	f	6.00	50.00	20.00	40.00	20.00	50.00	12.00
5	10	f	5.00	40.00	40.00	50.00	0.00	36.00	18.00
6	15	f	5.00	48.00	24.00	20.00	-5.00	40.00	20.00
7	14	m	5.00	60.00	30.00	85.00	10.00	70.00	50.00
8	11	f	4.00	40.00	20.00	60.00	20.00	38.00	10.00
9	12	f	4.00	90.00	20.00	80.00	25.00	70.00	26.00
10	14	f	4.00	70.00	45.00	40.00	10.00	70.00	20.00
Mean	14.1		6.0	64.10	37.80	47.30	8.00	57.80	23.40

Results and Observations

Average blood loss in this procedure is around 1,000 ml (range 600-1300 mL). The volume of the blood transfusion done is around three units. The operative procedure took around 300 minutes. Because of the associated problems of hypothermia and blood loss, five of the patients were electively ventilated and postoperatively. Segmental main scoliosis curves improved from a preoperative mean of 64° to 37° (42% correction) and kyphosis from 47° to 8° (83% correction). Total scoliosis curve improvement was from 59° to 23° (42% correction) which was maintained at the last follow-up. On average 6.8 segments were fused (five to nine). All patients are neurologically preserved postoperatively (**Tables 1 and 2**).

Discussion

The natural history of congential scoliosis has been reported in many studies. The rate of progression is related to the type of anamoly and rate of the growth. Among all the variants of congenital scoliosis, fully segmented hemivertebrae can have significant unbalanced growth potential.(1-4) Patients presenting with a high-magnitude curve at a very young age are at substantial risk for deformity progression. In these patients, there is usually a significant acute kyphotic angulation at the site of the hemivertebra. With the aging process, the spine becomes progressively more kyphotic, primarily through loss of disc height. Because the discs can no longer compensate for the structural osseous anomalies, degenerative spurring can occur and the secondary structural

Table 2. Surgical data

Serial Number	Level and side of hemivertebra	Type of hemivertebra	Number of vertebrae fused in surgery	Number of levels fused
1	L2 R	semisegmented	T11 to L4	6
2	L2 R	semisegmented	T11 to L4	6
3	L1 R	fully segmented	T10 to L5	8
4	T11 L	fully segmented	T8 to L2	7
5	T12 L	fully segmented	T9 to L1	5
6	L2 R	semisegmented	T11 to L4	6
7	L3 L	semisegmented	T12 to L4	5
8	T9 R	semisegmented	T6 to L1	8
9	L1 R	fully segmented	T9 to L4	9
10	T12 R	fully segmented	T8 to L3	8
			Mean	6.8

changes become quite severe Though most authors agree than these are to be treated by surgery, the approach for surgical treatment remains controversial. Treatment options include posterior spinal fusion alone, anterior–posterior fusion, hemiepiphysiodeses, or single or two-stage hemivertebra excision and fusion. Posterior spinal fusion with or without anterior spinal fusion will arrest progression of the curve and may, with the use of instrumentation, obtain curve correction.(6)Using this method, Winter and Moe(12) together and with Lonstein(13) reported their extensive experience in young children and adolescents. They found that in some children undergoing posterior spinal fusion alone, "bending of the fusion mass" occurred (or what is now called crankshaft phenomenon) in up to 14% of cases. Bending of the fusion mass was associated with some loss of spinal alignment correction. In both studies, however, they did not correlate the eventual bending of the fusion mass with posteriorly tethered anterior growth. They believed that an associated anterior fusion was not necessary. In a similar population, Hall et al(6) reported that with the use of Harrington instrumentation a greater degree of correction was maintained. Hemiepiphysiodeses was originally described in 1963. Bradford (7) reported on hemiepiphysiodeses in 1982. This procedure was an attempt to arrest curve progression through partial convex anterior hemiarthrosis while achieving a slow curvature correction with further spinal growth. Hemiepiphysiodeses was also an attempt to limit the restriction of growth that occurs after posterior spinal fusion. When used in congenital scoliosis, results of this procedure were mixed.(7)

In the past, hemivertebra excision was considered to be an aggressive treatment. Leatherman and Dickson (10) expressed concern about the neurological risk associated with the single-stage hemivertebra excision. Despite their concern, they suggested that two-stage hemivertebra excision might pose less danger of neurological injury than instrumentation-augmented posterior spinal fusion because hemivertebra excision shortens the spine while correcting the deformity. Subsequently Bradford and Boachie-Adje (8) reported that this procedure could be conducted safely in a single stage. The results of a number of other studies of heterogeneous groups of children and adolescents have supported their results.(4 5 6 11) It is unclear whether this decrease in complications is caused by an improvement in surgical or anesthetic technique. It is likely that the combination of these advances has contributed to a safer procedure than that originally reported by Leatherman and Dickson.

A one-stage hemivertebra resection via the posterior approach has been previously described.(14,15,16,17) Ruf and Harms (14) reported on 21 cases (age range 15–167 months) with a two-year follow-up period. In all cases a posterior only approach was used for the placement of transpedicular instrumentation and hemivertebra resection. The mean preoperative Cobb angle of the main curve was 41°; postoperatively it was 14° and at the latest follow-up assessment it was 15°. The angle of kyphosis was 24° before surgery but improved to 11° after surgery. Shono et al(15) reported on 12 patients (age range eight to 24 years) in whom hemivertebra resection was performed via a one-stage posterior approach. This article is close to our series. All patients harbored a single nonincarcerated hemivertebra at T-9 (one patient), T-10 (two patients), T-11 (two patients), T-12 (four patients) and L-1 (three patients).(12) The mean preoperative scoliosis was 49° and was corrected to 18° and preoperative kyphosis of 40° was corrected to 17°. No intraoperative complications were noted in their patients. We had very good correction of the deformity especially in correction of kyphosis which is up to 83% and scoliosis up to 42%. As all the patients in this group were older, most of them had well-developed secondary structural curves. This could be the reason for better correction of kyphosis than scoliosis. As these patients were older with well-developed secondary structural curves and the instability caused by the procedure is quite high, patients in our series needed longer levels of instrumentation (mean =6.8) (range five to nine segments). In the first report, the authors were treating very young children and in the second report the authors have concentrated on the adolescent population (14,15) and the patient population is very similar to this series. Though hemivertebrectomy was classically described for the treatment of lumbosacral hemivertebrae with fixed truncal translation, we had no patients in the lumbosacral hemivertebrae in the series. David W. Polly, et al(16) described two thoracic hemivertebra excisions in adults via a posterior only approach. This procedure is done in adults for complaints of pain rather than deformity.

Similar procedures, ie, transpedicuar eggshell osteotomies with correction of deformities associated with congenital scoliosis, were reported by Mark R Milkles and Graziano GP.(18) They used stereotactic guidance for the proceure and especially for the placement of pedicle screws in the cases of congental scoliosis after correction of the deformity. We have used C-arm guidance satisfacrorily for the placement of pedicle screws though the use of navigatory systems aid and improved the accuracy of the screw placement.

Posterior convex wedge resection of hemivertebra is an effective procedure for correction of deformity in both the planes. The presence of associated kyphosis, vertebral rotation and shifting of the cord on to the concave side makes the approach to hemivertebra easier. As all the patients in this group were older, most of them had well developed secondary structural curves. This could be the reason for better correction in the sagittal plane than in the coronal plane and for the longer levels of instrumentation. Because this is a convex shortening procedure, there is less neurological risk. Pedicle screw instrumentation gives good stability. As

the anterior surgery can be avoided, this 'posterior only approach' is much less morbid than the classical anterior and posterior approach.

Conclusions

Posterior convex wedge resection in the management of advanced congenital scoliosis caused by hemivertebra is a promising procedure. The presence of associated kyphosis, vertebral rotation and shifting of the cord on to the concave side makes the approach to hemivertebra easier and the resection safe at even at a spinal cord level. The use of pedicle screw fixation gives strength and stability to the construct and helps in early postoperative mobilization.

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Reviewer's Comments

The author reported the feasibility of the "posterior only" technique for correction of congenital scoliosis caused by hemivertebra. Wide laminectomy along with transpedicular decancellation allowed adequate and safe convex wedge resection. The study population was mainly adolescent with advanced deformities which led to long span of instrumentation and fusion. Even with the limit number of cases and short follow up time, the deformities were well corrected, especially in the sagittal plane. Though the long-term maintenance of curve correction has to be verified, this "avoid anterior" surgical strategy was found to be sufficient.

-Visit Vamvanij, MD