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Single-Stage Posterior Hemivertebra Resection with Transpedicular Instrumented Fusion for Correction of Congenital Scoliosis

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Abstract

Background Data: Congenital scoliosis may be caused by failure of formation, failure of segmentation, or by a combination of these 2 factors, resulting in a mixed deformity. Complete failure of formation results in a hemivertebra. There is a debate on the method of treatment and whether operate with or without fusion. Nevertheless there is no debate about the early treatment. Congenital scoliosis due to hemivertebra is difficult to control and may progress after non-operative and even after operative management. Hemivertebra resections in older children often require a long fusion segment because of secondary structural curves that may be avoided with early management.

Purpose: Assessment of surgical intervention in congenital scoliosis by posterior approach with transpedicular instrumentation.

Study Design: Retrospective clinical case study.

Patients and Methods: Thirty five consecutive cases of congenital scoliosis in young children were operated on by hemivertebra

resection by a posterior-only approach with transpedicular instrumentation. Mean age at time of surgery was eight years. The mean follow-up was 26 months.

Results: Mean Cobb angle of the main curve was 55.8° before surgery, and 13° at latest follow-up. On average three segments were fused. There was one infection, two pedicle fractures, and three implant failures. In two patients additional operations were performed because of new developing deformities.

Conclusion: Correction surgery of congenital scoliosis should be performed early, before the development of severe local deformities and secondary structural changes, especially in patients with expected deterioration. Posterior resection of the hemivertebra with transpedicular instrumentation allows for early intervention in young children. Excellent correction in the frontal and sagittal planes, and a short segment of fusion allows for normal growth in the unaffected parts of the spine. (2016ESJ115)

Keywords: Congenital scoliosis, surgical treatment, posterior hemivertebra resection.

Introduction

A hemivertebra (HV) is considered the most common cause of a congenital scoliosis. This spine anomaly occurs during the first 8th to 12th weeks of fetal development due to failure of formation. Where HV is formed only of a partial vertebral body, a corresponding pedicle, and a corresponding hemilamina. HV may be further classified on the basis of the presence or the absence of fusion to the vertebral bodies above and/or below. HV can be fully segmented, semisegmented, unsegmented, or incarcerated. HV may occur at ipsilateral adjacent levels of the spine, which produces significantly asymmetrical spine growth, or may be counterbalanced by a HV on the contralateral side of the spine in the same region, separated by 1 or several healthy vertebrae (this is termed a hemimetameric shift).[7,8,13,15,17]

The rate of progression and the severity of the curve depend on type of HV, the size of the deformity, the age of the patient, and the location of the vertebral anomaly.[4,14] Curve progression is caused by unbalanced growth of one side of the spine relative to the other. Radiographically, definable discs signify the presence of vertebral growth plates, and when it is asymmetrical or more present on one side of the spine than on the other, then it have the potential for asymmetrical growth in that area of the spine. Thus, fully segmented HV with healthy, definable discs above and below have much more potential to cause curvature compared with an unsegmented HV, which is fused to the vertebra above and below.[13] Curve progression occurs more rapidly during the first 5 years of life and, again, during the adolescent growth period of puberty; these 2 periods represent the most rapid stages of spine growth.[6]

Anomalies at the cervicothoracic and lumbosacral junctions produce more visible deformities than those seen at other areas of the spine. The anomaly most probable to produce the most severe scoliosis is the unilateral bar with contralateral HV, followed by a unilateral bar, a HV, a wedge vertebra,

and finally, the most benign of all anomalies- the block vertebra.[14]

As it varies in severity and prognosis, the goal of treatment of congenital scoliosis secondary to a HV is early diagnosis and treatment. There is a debate on the method of treatment whether surgical or non-surgical, and the surgical ones whether with fusion or without. Nevertheless, there is no debate about the early treatment as congenital scoliosis due to HV is difficult to control. The curve may progress after non-operative and even after operative management.[3] The surgical technique varies from staged anterior and posterior procedures to isolated posterior wedge resections based on the experience and preference of the surgeon.[11,16]

This study is one of the ongoing efforts to minimize the surgical duration by avoiding the anterior approach with all its morbidity. This is done by using only single stage posterior hemivertebrectomy, with achieving good correction and stability post-operative by using short segment transpedicular screws fixation.

Patients and Methods

At Alexandria Sporting Children Hospital, 35 children who had congenital scoliosis due to a HV had one-stage posterior vertebral convex wedge resection and segmental spinal instrumentation. These included 16 boys and 19 girls. The mean age at the time of surgery was 8 years (range 5-12 years). All the patients were screened with Magnetic Resource Imaging (MRI) to rule out any neural axis anomalies. The HV involved thoracic and lumbar regions. It affected levels from third thoracic vertebra to the fourth lumbar, thoracolumbar region was the most commonly affected, with L1 the most common level with seven cases (Figure 2). All the patients had one HV. There were 22 right and 13 left sided curves. All the HV were fully segmented vertebrae (Table 1).

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:

We used general anesthesia using hypotensive technique to minimize blood loss. Then, the patients were placed prone on bolsters to avoid pressure on the abdomen. After thorough disinfection using betadine then sterelium, longitudinal skin incision was placed in the midline centering the HV. Paravertebral muscles were dissected and spine exposed to the tip of the transverse process on either side. The HV was identified, we confirm the level using intraoperative fluoroscopy in the antero-posterior view, with marking the HV with a kirschner wire (Fig. 3). Pedicle screws were placed on the vertebrae above and below the HV under fluoroscopic guidance. The HV are usually deviated to a posterior lateral position and the pedicle of the HV is usually thicker than usual. The pedicle of the HV 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. After sufficient body is curetted, the anterior cortex of the HV was weakened with gentle tapping on an osteotome which was

placed through the pedicle. At this juncture, the posterior elements of the HV 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 pre-contoured 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. Bone chips were placed into the residual defect of the HV. The realignment of the spine checked under the C-arm. The epidural bleeding was controlled by bipolar 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 lamina 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.

Following surgery the patients visit the out-patient clinic after 2 weeks for wound assessment, and do his first plain X-ray. Then radiological follow up, is done after 6, 12, 24 months to minimize radiation exposure.

Results

The operative time of the procedure ranged between 100-240 minutes with a mean 155.7±39.2 minutes. Because of the associated problems of hypothermia and blood loss, five of the patients were electively ventilated postoperatively.

Blood loss in this procedure ranged from 200-1000, with a mean 500±222 ml. The volume of the blood transfusion ranged from 0-1000 ml, with a mean 391.4±212 ml. The mean follow up was 25.97±10.5 months. According to Cobb Methods, the mean preoperative angle was 55.7±12.2°, with a range between 31° and 85°. The mean post-operative angle was 55.7±13.4°, with a range between 6 and 25°. Total scoliosis curves improved from a mean preoperative of 55.8° to 13° post operatively (76.8% correction), which was maintained at the last follow-up.

Number of level fixed ranged between two to five levels with a mean 2.8±1 levels, which were the same number of level fused. We used only autogenous bone graft, from the HV resected and lamina above or below. We applied on lay posteriorly after lamina decortication (Table 1).

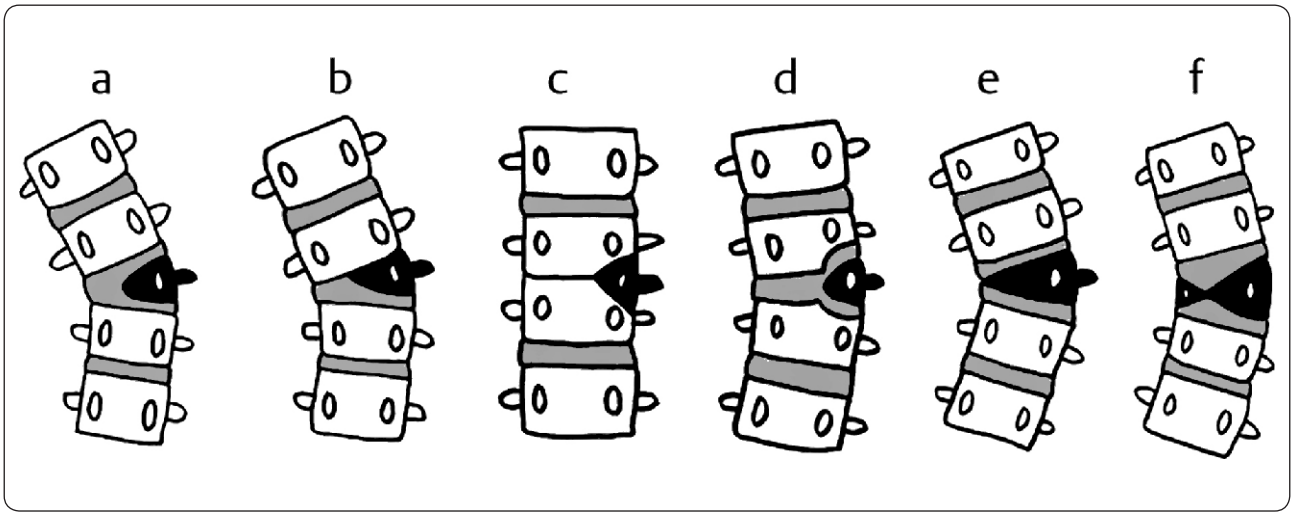

Figure 1. Schematic representation of hemiveretebra due to failures of formation (a,fully segmented hemivertebra; b, semisegmented hemivertebra; c, unsegmented hemivertebra; d, incarcerated hemivertebra; e, wedge vertebra; f, asymmetric butterfly vertebra).[15]

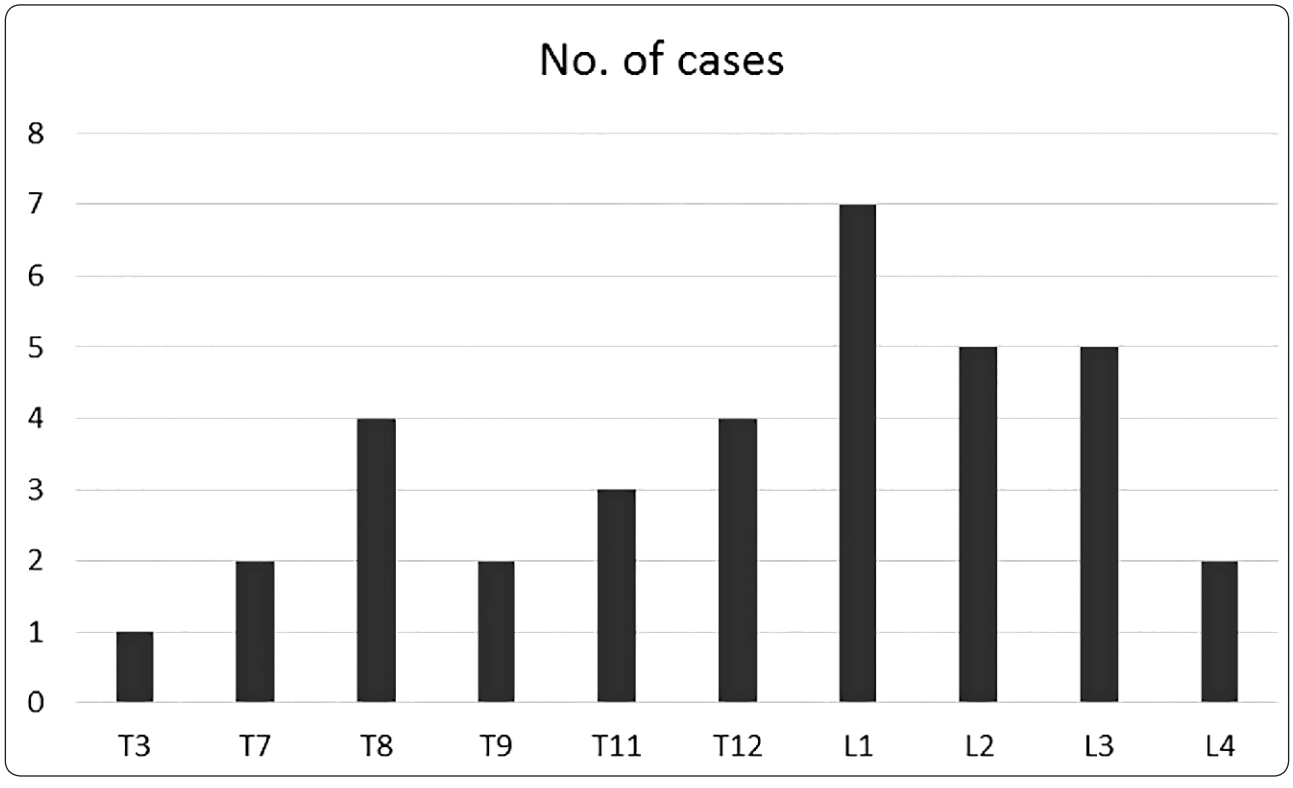

Figure 2. Bar chart showing the hemivertebra levels included in this study, T: thoracic vertebra, L: Lumbar vertebra.

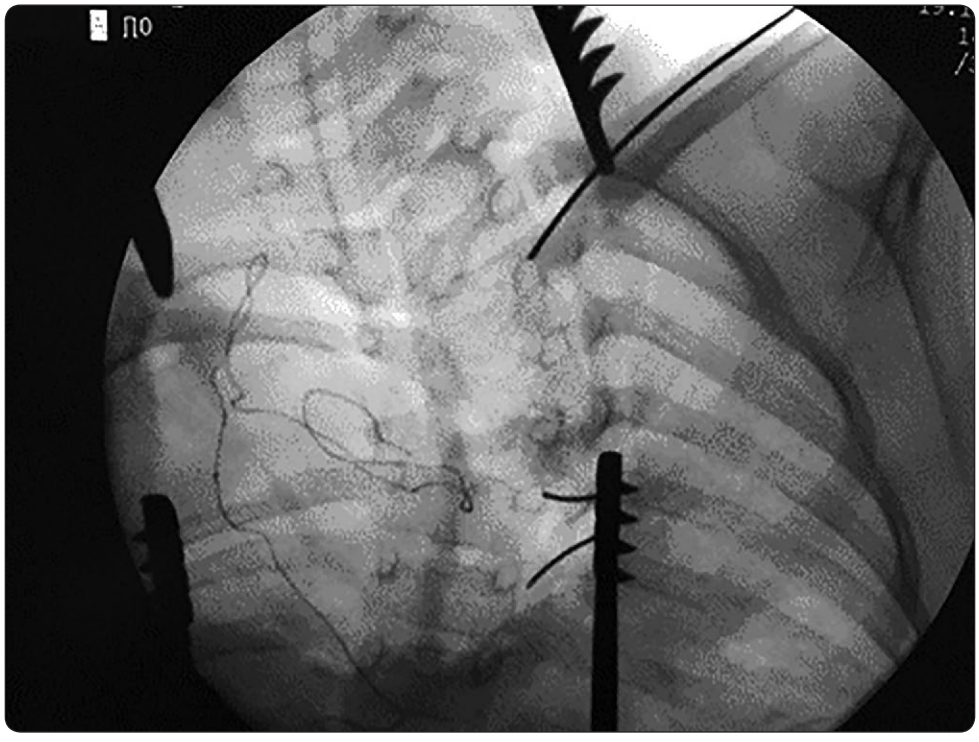

Figure 3. Intraoperative fluoroscopy using C-arm, in an AP view, marking the levels to be fixed and confirming the hemivertebra level.

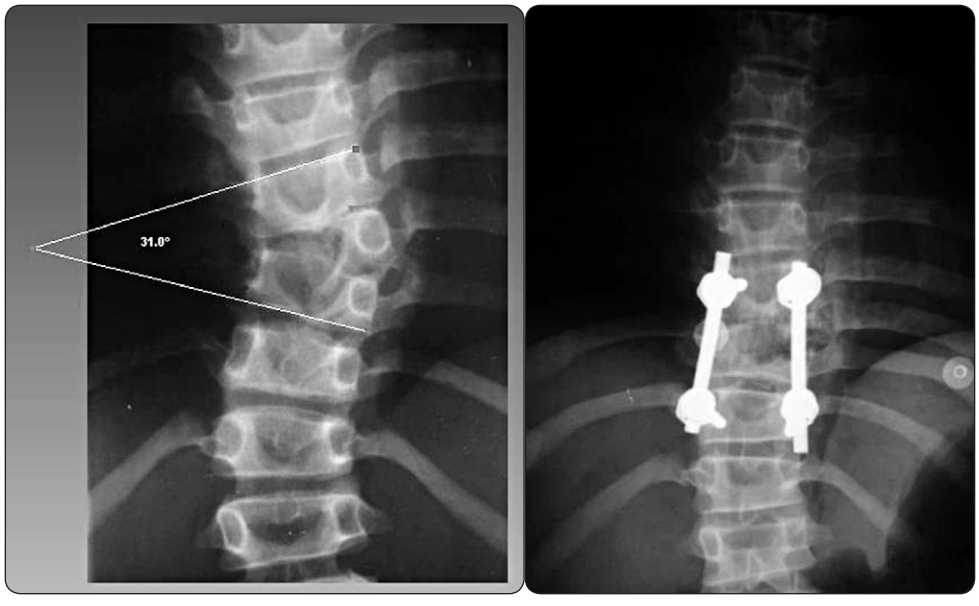

Figure 4. A: Preoperative AP view X-Ray of seven years old boy complaining of left scoliotic curve with main curve 31 degrees due to congenital T9 hemivertebra. B:Postopetrative AP view X-Ray after hemivertebra excision and fixation of T8-T11 result in correction of the curve to become 6 degrees only after 3 years follow up.

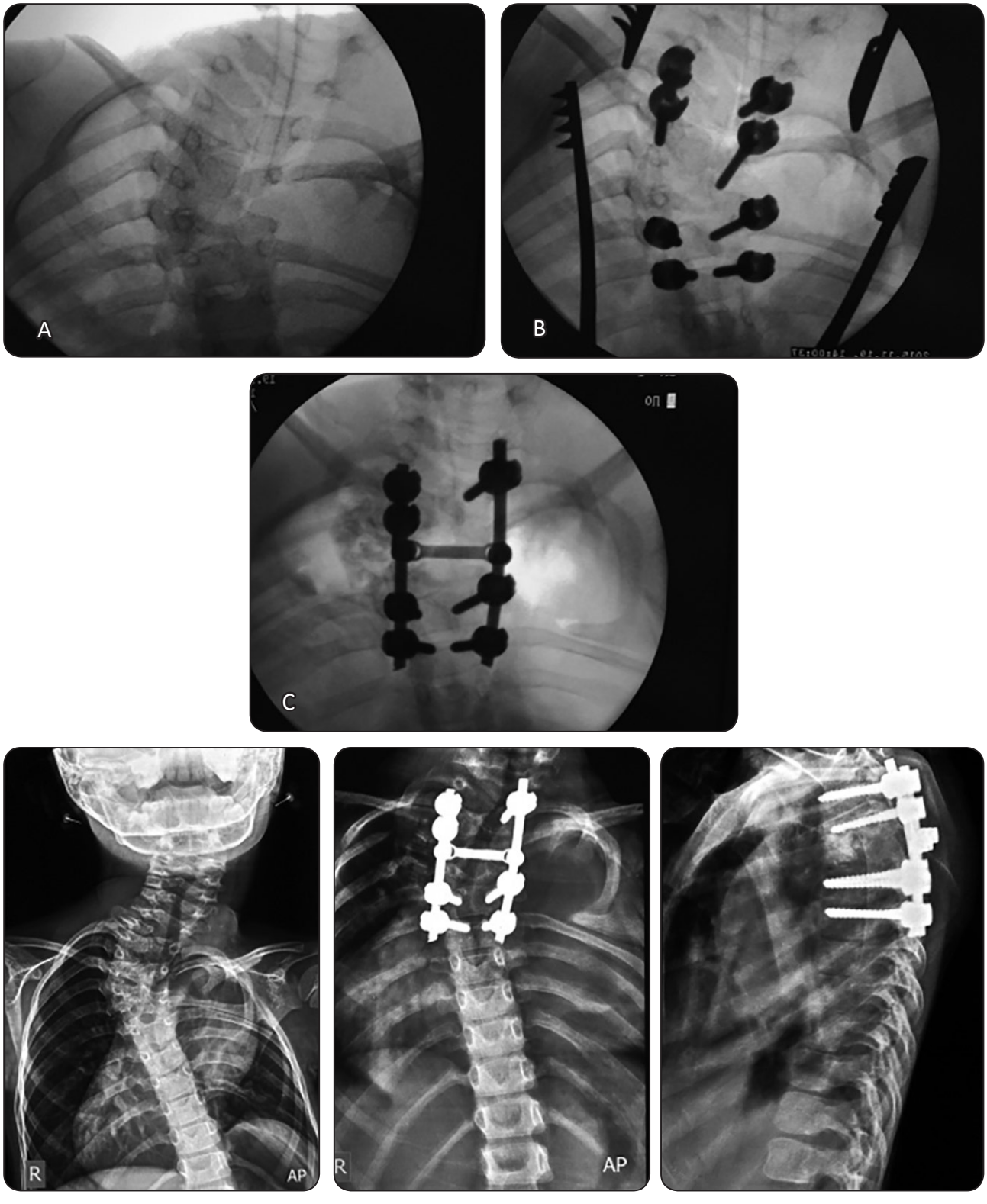

Figure 5. five years old girl complaining of right scoliotic curve with main curve 42 degrees due to congenital T3 hemivertebra. A-C operative AP fluoroscopic images, D: Peroperative AP view R-Ray showing T3 hemivertebra. E,F Postoperative X-Ray images after hemivertebra excision and fixation of T1-T6 result in correction of the curve to become 16 degrees only after one year follow up.

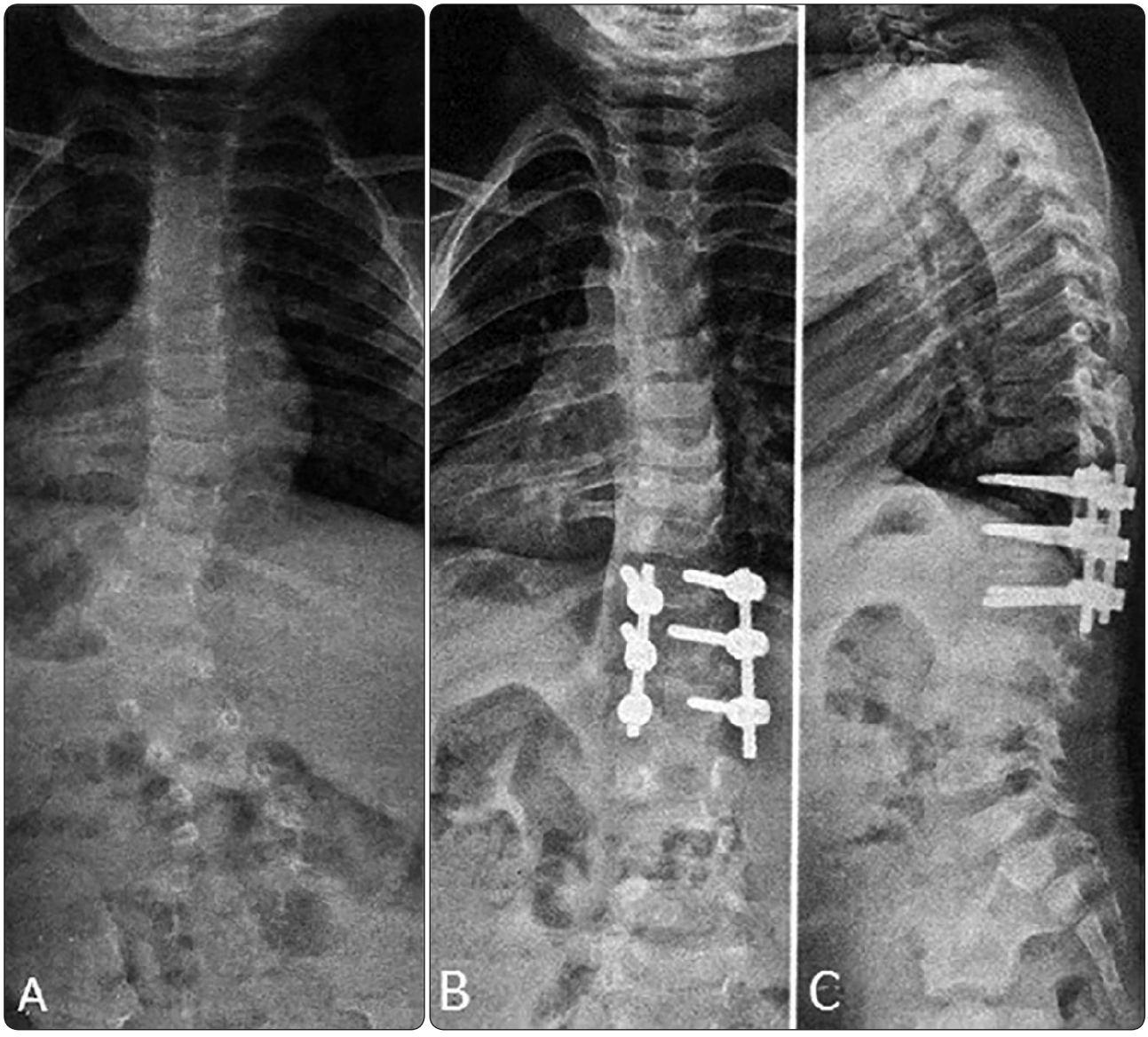

Figure 6. A: Preoperative AP view X-Ray of four years old boy complaining of right scoliotic curve with main curve 34 degrees due to congenital L1 hemivertebra. B,C: Postoperative X-Ray images of hemivertebra excision and fixation of T11-L2 result in correction of the curve to become 6 degrees only after 18 months follow up.

Table 1. Summary of Data Base of Reported Patients (N=35) in this Series

Case	Sex	Age	Side	HV Level	PreOp Cobb	Follow-up/mo	PostOp Cobb	Correction %	Level fixed & Fused	No. of Levels	Blood loss/ml	Blood Tran	Op time /min
1	M	5	Right	L3	50	15	10	80%	L2-L4	2	200	250	100
2	F	7	Right	L4	58	24	12	79%	L3-L5	2	500	500	120
3	M	10	Right	T8	55	24	15	73%	T7-T9	2	700	500	200
4	M	8	Left	L1	45	18	10	78%	T12-L2	2	300	250	110
5	M	8	Right	T8	63	45	14	78%	T6-T9	3	400	250	140
6	F	5	Left	L4	53	15	13	75%	L3-L5	2	400	400	120
7	M	6	Right	L3	55	26	9	84%	L2-L4	2	300	250	100
8	F	5	Right	T11	47	42	14	70%	T10-L1	3	500	500	140
9	M	9	Left	L3	44	36	10	77%	L2-L4	2	600	500	120
10	M	6	Right	L2	50	28	14	72%	T12-L3	3	500	500	120
11	F	8	Left	L1	45	18	12	73%	T12-L2	2	400	250	120
12	M	6	Right	T12	55	15	10	82%	T11-L1	2	300	200	140
13	M	5	Left	T9	31	18	6	81%	T8-T11	3	300	250	150
14	M	7	Right	L2	58	24	15	74%	T12-L3	3	400	250	180
15	F	9	Left	L1	48	28	8	83%	T12-L2	2	200	0	100
16	F	5	Right	T3	42	12	16	62%	T1-T6	5	500	500	150
17	F	6	Left	T12	55	16	6	89%	T11-L1	2	400	250	150
18	M	11	Right	T7	79	35	25	68%	T5-T9	4	900	500	200
19	F	8	Right	L1	65	24	15	77%	T10-L2	3	500	500	180
20	F	5	Left	T11	45	36	10	78%	T10-L1	3	500	500	150
21	M	12	Left	L2	80	37	20	75%	T11-L4	5	900	750	210
22	F	10	Right	L2	60	44	15	75%	T12-L4	4	800	500	180
23	F	4	Right	L1	34	18	6	82%	T11-L2	3	600	700	180
24	M	10	Right	T11	70	24	18	74%	T9-L2	5	700	500	200
25	F	8	Right	T12	55	28	12	78%	T11-L1	2	400	250	150
26	M	11	Left	L2	67	18	13	81%	T12-L3	3	700	500	180
27	F	7	Right	L3	50	15	14	72%	L2-L4	2	300	250	120
28	F	9	Left	T9	50	38	15	70%	T8-T10	2	400	250	150
29	F	9	Right	T8	57	42	17	70%	T6-T9	2	300	150	140
30	M	10	Left	L3	54	48	10	81%	L2-L4	2	400	250	120
31	F	11	Right	T8	65	26	15	77%	T6-T10	4	800	500	220
32	F	11	Right	L1	76	24	20	74%	T11-L3	4	900	750	240
33	M	8	Right	T12	48	24	10	79%	T11-L1	2	200	0	150
34	F	7	Left	L1	56	15	10	82%	T12-L2	2	300	250	180
35	F	12	Right	T7	85	12	15	82%	T6-T9	5	1000	1000	240
Mean		7.94			55.71	26.06	12.97	76.77%		2.83	500	391.43	155.71
SD		2.29			12.22	10.41	4.15	0.05		1.04	222.29	212.65	39.20
t test					5.7264E-30								

Discussion

In this study we reported 35 patients with congenital scoliosis due to HV including 16 boys and 19 girls, with mean age 8 years. All had posterior HV resection, fixation, and fusion. Average number of fixed and fused levels were three levels. Blood loss in average was 500 ml. Average operative time was 155 minutes. Previous reported series [1,4,5,16,18,19] were more or less similar to ours. However, there is variable data in relation to age of surgery, studies are done at very young age,[1,16] and this is supported by Chang et al,[4] study that recommend surgery better result when done at age six or younger. On the other hand, other studies[5,23] showed same results at older patients.

According to Winter's classification, vertebral anomalies are divided either failure of formation (type I) or differentiation (type II), or mixed (type III). Formation failures are subdivided into wedge vertebrae (incomplete failure) or hemivertebrae (complete failure), which is subclassified as fully segmented, partially segmented and unsegmented according to the presence or absence of disc spaces or bony fusion to adjacent vertebrae.[8] If there's more than one HV at ipsilateral adjacent levels of the spine, this will cause significant asymmetrical spine growth, on the other hand a HV may be counterbalanced by a HV on the contralateral side of the spine in the same region, separated by one or several healthy vertebrae (this is termed a hemimetameric shift). [17] Wedge vertebrae have bilateral pedicles but are hypoplastic, producing height asymmetry. Segmentation failures produce either bars (unilateral) or block vertebrae (bilateral) with bars tethering spinal growth. The combination of a unilateral bar and contralateral hemivertebrae is particularly deforming. Overall, failures of formation represent nearly two-thirds while failures of differentiation comprise approximately one-third of vertebral anomalies.[8]

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 HV.[2,3,5,10,12,22] HV excision remains a safe and effective tool for treating an isolated HV that produces curve progression and causes truncal imbalance. The options of in situ fusion and convex epiphysiodesis have been shown reliable at obtaining a growth arrest and stopping curve progression; however, they afford no correction of deformity and truncal imbalance.[20,21] The optimal indication for HV resection remains the same: a patient younger than 5 years with a thoracolumbar, lumbar, or lumbosacral HV and associated truncal imbalance.[11,16] However in our study, because of parents' ignorance and fear of surgery, the age in some cases were older than five years old but achieved good results.

Anterior and posterior exposure of the spine may be performed as sequential procedures under a single anesthetic. Although this affords excellent visualization, the operative time tends to be longer, given the magnitude of the surgery and the need to reposition and drape the patient.[1] Anterior and posterior exposure has been shown effective for HV excision when performed as simultaneous procedures. Hedequist et al,[9] reported on their series of 18 patients treated by means of simultaneous exposures with excision and instrumentation. The average age of the patients was 3 years, with an average curve correction of 70%. There were no neurological complications, and all patients obtained fusion from the index operation.

On the other hand, Posterior-only HV excision in growing children has recently been reported with successful results.[16,18] We have found

the ideal indication to be the HV located at the thoracolumbar junction or in the lumbar spine, with some associated kyphosis. Ruf and Harms[16] reported their results on HV excision using posterior-only approach and segmental transpedicular instrumentation. They reported excellent results in patients younger than 6 years, with an average Cobb measurement of 45 degrees. At 3.5 years follow-up, the Cobb measurement had been maintained at 14 degrees, with no patient having a neurological complication. Shono et al,[19] reported on their experience involving 12 patients treated with HV excision and segmental instrumentation during adolescence. Their correction rate was 64%, with all patients obtaining fusion and no patient having a neurological deficit.

A multicenter study[23] comparing the outcomes of three surgical treatments for congenital spinal deformity due to a HV, showed that posterior HV resection in younger patients resulted in better percent correction than either hemiepiphysiodesis/ in situ fusion or instrumentated fusion without resection, although it has a higher complication rate. So, the posterior resection of HV is a demanding procedure that may be performed safely by experienced hands with good correction rate and minimal neurological risk.

Conclusion

Early management is preferable and two staged surgery may be considered in too young children. In majority of patients single posterior approach may decrease morbidity (duration of surgery, avoid thoracotomy, and minimize blood loss) and obtain even better results than the two stage operation. Good correction in coronal and sagittal planes with short segment fusion allow for normal growth in the unaffected parts of the spine.

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الملخص العربي

تصحيح الجنف الخلقي باستئصال النصف فقرة في مرحلة واحدة بالتدخل الخلفي مع تثبيت الفقرات باستخدام الاعمدة و المسامير

البيانات الخلفية: قد يكون الجنف الخلقي بسبب فشل تشكيل، عن طريق فشل تجزئة، أو عن طريق مزيج من هذه العوامل ، مما أدى إلى تشوه مختلط. الفشل الكامل في التشكيل ينتج عنه نصف فقرة فقط. على الرغم من أنه قد يكون هناك نقاش حول طريقة العلاج سواء الجراحية أو غير الجراحية، والجراحية منها سواء مع الالتحام العظمي أو بدون. ولكن ليس هناك نقاش حول العلاج المبكر. كما الجنف الخلقي بسبب النصف فقرة من الصعب السيطرة ويمكن أن يتطور سواء بعد العلاج الجراحي او التحفظي. وغالبا ما يتطلب استئصال الفقرة المشوهة في الأطفال الأكبر سنا شريحة اندماج طويلة بسبب المنحنيات الهيكلية الثانوية التي يمكن تجنبها مع التدخل المبكرة.

الغرض: تقييم التدخل الجراحي في الجنف الخلقي عن طريق النهج الخلفي باستخدام الاعمدة و المسامير.

تصميم الدراسة: دراسة بأثر رجعي مع التقييم السريري لاستئصال الفقرة المشوهة بالتدخل الخلفي باستخدام الاعمدة و المسامير في الأطفال الصغار الذين يعانون من الجنف الخلقي.

المرضي و الطرق: تم اجراء العملية الجراجية المذكورة ل٣٥ حالة متتالية من الجنف الخلقي في الأطفال الصغار جدا على استئصال الفقرة من خلال نهج الخلفي فقط. وكان متوسط العمر في وقت الجراحة ثماني سنوات. ودرسوا بأثر رجعي بمتوسط متابعة لمدة ٢٦ شهرا.

النتائج: متوسط زاوية كوب من المنحنى الرئيسي كان ٥٥,٨ درجة قبل الجراحة، و ١٣ درجة في آخر متابعة. في المتوسط تم دمج ثلاثة فقرات. كان هناك عدوى واحدة، وكسور في فقرتين، وثلاثة حالات فشل في التثبيت. في اثنين من المرضى أجريت عمليات إضافية بسبب التشوهات النامية الجديدة.

الاستنتاج: ينبغي إجراء جراحة تصحيح الجنف الخلقي في وقت مبكر، قبل تطور التشوهات المحلية الشديدة والتغيرات الهيكلية الثانوية، وخاصة في المرضى الذين يعانون من تدهور متوقع. استئصال الخلفي للفقرة المشوهة بواسطة أعمدة و مسامير, يسمح بالعلاج المبكر في الأطفال الصغار. و ينتج عنه تصحيح ممتاز في المستوى الأمامي والسهمي، مع استخدام جزء قصير في الانصهار يسمح للنمو الطبيعي في الأجزاء غير المتضررة من العمود الفقري.