



Long-segment posterior instrumentation and fusion with freeze-dried allograft in congenital scoliosis

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Objective: The aim of this study was to evaluate the effectiveness of long-segment posterior instrumentation and allograft application in obtaining fusion in congenital scoliosis.

Methods: Twenty-one patients with congenital scoliosis who were treated with long-segment posterior instrumentation (>6 levels) and freeze-dried allograft and followed up for more than 24 months were reviewed. Six patients were excluded from the study due to anterior procedures. Fifteen patients with congenital scoliosis (13 females, 2 males; mean age: 12.2±3 years, range: 7-17 years) were retrospectively reviewed. Mean follow-up time was 30.9±9.4 (range: 24 to 48) months. Six patients had laminectomy either due to previous posterior surgeries or to address intraspinal pathologies during the posterior fusion procedure. Preoperative, postoperative and final follow-up anteroposterior and lateral spine X-rays were reviewed. Fusion was graded according to the classification reported by Bridwell et al.

Results: Two patients were graded as 'no fusion' (pseudarthrosis), four patients as 'probably fused', and nine patients as 'definitely fused'. The major curve was corrected from an average of 68±18.6 to 39.3±12.2 degrees (p<0.001). Mean correction lost in the major curve was an average of 4.5±5.2 degrees in the latest follow-up. There was significant correction in the compensatory curve (preoperative 37.9±13.2 degrees, postoperative 20.2±6.6 degrees; p=0.001). Preoperative and postoperative global thoracic kyphosis were 39.5±13.3 and 32.3±7.9 degrees, respectively (p=0.018). Preoperative and postoperative global lumbar lordosis was 36.3±7.4 and 36.1±8.9 degrees, respectively (p=0.883). Successful fusion was detected in %86.7 of patients in the final follow-up.

Conclusion: The usage of allograft alone to achieve fusion increases the rates of pseudarthrosis while additional anterior procedure decreases the pseudarthrosis rate in patients with congenital scoliosis that require long-segment posterior instrumentation. Further studies should be performed to assess the efficacy of the usage of polysegment pedicle screw instrumentation

Key words: Allograft; congenital scoliosis; fusion; posterior instrumentation.

Congenital spinal deformities are progressive curvatures of the spine that are formed due to intra-uterine vertebral anomalies. They can engender excessive deformities and are quite difficult to treat. Treatment strategies are

complex and controversial in stiff curvatures. Non-operative treatment is usually ineffective.^[1] Surgical fusion is known to be the most effective method to control progression in these progressive curves.

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Decortication and application of autograft after achieving correction of the curve with or without instrumentation is considered the gold standard. Additional morbidity caused by graft harvesting and the absence of adequate graft source in the majority of the patients leads to the search for alternative graft sources.^[2-5] The utilization of allografts in spinal surgery to achieve fusion is gradually increasing with the advances in allograft technology. Various articles regarding the utilization of allografts in idiopathic and neuromuscular scoliosis exist in the literature.^[6-15] However, there is limited data about the usage of allograft in congenital scoliosis surgery.

The aim of this study was to evaluate the safety and the efficacy of long-segment posterior instrumentation and fusion using freeze-dried allograft in congenital scoliosis.

Patients and methods

The Spinal Surgery Database of our clinic was reviewed to determine patients. One hundred and twenty-three patients with congenital scoliosis were treated at our institute between 1997 and 2005. Patients treated with long-segment posterior instrumentation (>6 segments) and freeze-dried allograft and followed-up for at least 24 months were included in the study.

Data, including patient age, sex, neurologic status at admission and postoperative period, complications, surgical technique, amount of bleeding, type of graft, presence or absence of previous operations, (if applied) type of osteotomy, and accompanying other system anomalies were reviewed.

Deformities were assessed using whole spinal anteroposterior and lateral X-rays. Congenital anomalies were grouped as formation, segmentation and mixed anomalies. Vertebral anomalies not involving the main curve were excluded. Measurements were made using preoperative, postoperative and follow-up radiographs. The Cobb method was used to assess the magnitude of the main and compensatory curves in the coronal plane. Global thoracic kyphosis (T5-T12) and lumbar lordosis (L1-S1) were measured in the sagittal plane. Further sagittal assessment was performed in the anomalous segment measuring the regional Cobb angle.

Three dimensional computerized tomography (3D-CT) and magnetic resonance imaging (MRI) were obtained in all patients to evaluate the morphology of the vertebral anomalies and presence of intraspinal pathologies. Intraspinal anomalies were identified in 16 patients.

Fusion was evaluated in the anteroposterior and lateral (and oblique when needed) radiographs in the final follow-up, as described by Bridwell et. al.^[15] Bridwell et. al. evaluated fusion using radiographs, amount of loss of correction, implant failure, visible pseudarthrosis, and local back pain. The presence of trabeculation throughout the fusion is classified as 'definitely fused'. 'Probably fused' refers to cases in which trabeculation is not visible in all segments due to implant overlapping or other reasons where loss of correction is less than 10 degrees and implant failure is absent. The presence of back pain, implant failure, loss of correction of more than 10 degrees or visible pseudarthrosis is described as 'no fusion/pseudarthrosis'.^[15]

Hybrid systems of pedicle screws, hooks, sublaminar and spinous process wiring were used for posterior instrumentation. Distraction was avoided and translation and cantilever maneuvers were used to obtain correction. After local bone decortications, freeze-dried allografts were applied to the area to be fused. The Stagnara wake-up test was used in all patients.^[16]

Results

Twenty-one patients met the inclusion criteria. Patients with additional anterior procedures were excluded from the study due to the difficulty in evaluating fusion. Among the remaining 15 patients, 11 had intraspinal pathologies, 3 had skin abnormalities and one had caudal regression. One patient had lipomeningocele. Five patients with split cord malformation had a tethered cord, one had hydromyelia and one intraspinal lipoma. One patient had isolated syringomyelia whereas another patient had intraspinal lipoma and tethered cord. Split cord malformations were classified according to Pang.^[17] Laminectomy and neurosurgery was performed in six patients in this context. Mean age of the 12 girls and 3 boys was 12.2±3 (range: 7 to 17) years and the mean follow-up was 30.9±9.4 (range: 24-48) months.

Radiographic evaluation revealed 4 formation, 5 segmentation and 6 mixed-type vertebral anomalies. Polysegmental chevron osteotomy was performed in 4 patients to achieve posterior release. A mean of 80 (range: 60 to 90) cc freeze-dried allograft was used after decortication. Mean surgical time was 242±50 minutes and mean blood loss was 923±243 ml.

Preoperative, postoperative and follow-up measurements of global thoracic kyphosis, lumbar lordosis and the major and compensatory curves in the coronal plane are listed in Table 1. Mean correction was 42.4% and 46.7% in the main and the compensatory curves, respectively (Table 1). Clinically significant correction was

Table 1. Follow-up details of the patients.

No. of patients	15			
Sex (M/F)	3/12			
	Preoperative (°)	Postoperative (°)	Correction rate	Final follow-up (°)
Main curve	68 (48-114)	39.3 (20-62)	42.4%	43.8 (22-70)
Compensatory curve	37.9 (24-64)	20.2 (12-30)	46.7%	24.3 (14-42)
Global kyphosis	39.5 (18-68)	32.7 (18-56)		34.5 (20-52)
Global lordosis	36.3 (22-50)	36.1 (22-58)		36.6 (22-54)

obtained in all patients. The preoperative and postoperative changes in kyphosis, lordosis, main and compensatory curves in the coronal plane were compared using the paired t-test. Improvements in the main curve ($p < 0.001$), compensatory curve ($p = 0.001$) and kyphosis ($p = 0.018$) were statistically significant whereas pre and postoperative lordosis did not change ($p = 0.883$). In the follow-up period, a mean of 4.5 ± 5.2 degrees of loss of correction was observed in the main curvature. One patient had an early superficial infection. No patients had late or deep infection or neurological deficits.

According to Bridwell's criteria,^[15] 9 patients were 'definitely fused' (Fig. 1) and 4 were 'probably fused' (Fig. 2). One patient with a broken rod (Fig 3.) and one patient with a loss of correction of more than 10 degrees were acknowledged to have pseudarthrosis (Table 2). The patient with implant failure underwent revision surgery while the other patient with asymptomatic loss of correction was observed. Fusion was detected in 86.7% of patients and 13.3% had pseudarthrosis. Pseudarthrosis was not observed in the patients with additional anterior procedures.

Discussion

Congenital scoliosis presents at earlier ages than idiopathic scoliosis, and in many cases the curvature is too rigid to treat conservatively.^[1,18-20] The aim of the treatment is to obtain a straight spine at the end of the growth period with the least possible compromise of growth potential. Although several surgical techniques

that preserve the growth potential have been described, congenital scoliosis patients may require posterior instrumentation and fusion in neglected cases.^[18-20]

In our study with posterior instrumentation and freeze-dried allograft, the rate of definite and probable fusion was 86.7%. This rate increases to 90% when patients who underwent anterior procedures are included. Pseudarthrosis was identified in two patients (13.3%), one of which did not require revision surgery because the patient was asymptomatic and the curvature did not progress. Mean correction rate was 42.4% and 46.7% in the main and the compensatory curves, respectively. There was clear clinical improvement of deformities in all patients. Global kyphosis decreased in all patients while no change was observed in lordosis. Sagittal plane curves were within normal range in all patients. In the follow-up period, a mean of 4.5 ± 5.2 degrees of loss of correction was observed in the main curvature. However, the clinical status of the patients did not worsen. One patient had an early superficial infection which was treated with oral antibiotic treatment. No patients had late or deep infection or neurological deficits.

Fusion is required in spinal deformity surgery to maintain the correction throughout the patient's lifespan. Techniques used to obtain fusion include facet joint excision, decortication and grafting with bone grafts or bone graft-like substances. Autograft harvested from the iliac crest is, to date, considered to be the gold standard in obtaining fusion. Potential complications of

Table 2. Details of fusion of the patients.

		Patient	Percent (%)	Total
Fusion	Definite	9	60	13 (86.7%)
	Probable	4	26.7	
Pseudarthrosis	Implant failure	1	6.65	2 (13.3%)
	Loss of correction	1	6.65	
Total		15	100	15 (100%)

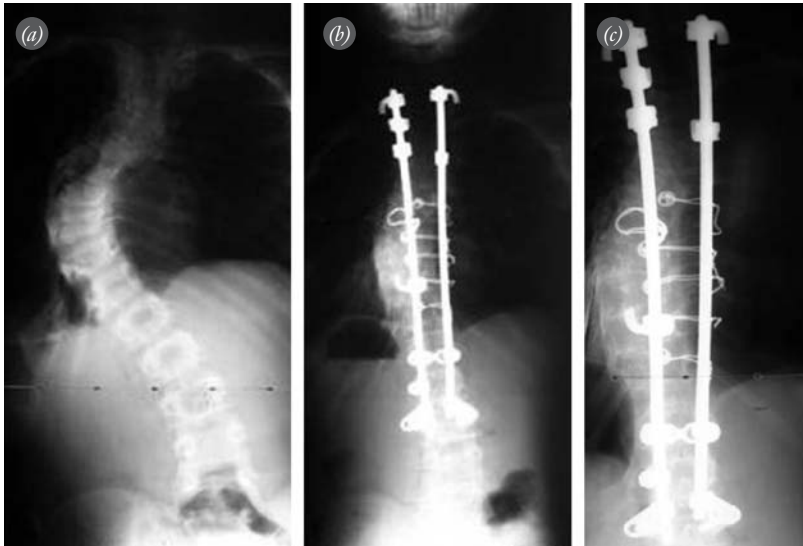


Fig. 1. (a) Preoperative, (b) early postoperative and (c) follow-up X-rays of a 13-year-old boy who was previously operated for intraspinal pathology. He was pain-free clinically and loss of correction of more than 10 degrees or implant failure or pseudarthrosis was not present. Trabeculation was visible especially in the apex. The patient was evaluated as 'definitely fused'.

autograft harvesting, however, increased the need for alternative grafts. Cancellous allografts are used to achieve fusion with reported good results.

Although autografts are considered the gold standard in achieving fusion, their usage is not without drawbacks. Studies show that donor site pain becomes chronic in 19 to 31% of patients in 2 to 4 years of follow-up.^[21,22] Prolonged anesthesia, increased bleeding and transfusion rate, chronic donor site pain, donor site infection, nerve palsies, iliac fractures and prolonged wound drainage are some of the reported complications of autograft usage.^[3-5,23] The complication rate seems to increase with the amount of graft taken. Kessler et al. reported that complications occurred only when the graft volume exceeded 17 cm³.^[24] Complication risk

increases in long-segment posterior instrumentation as fusion requires the use of more graft than this threshold.

Allografts have been used to avoid the complications inherent in autograft harvesting and to achieve fusion in more segments. Reported fusion rates in adolescent idiopathic scoliosis surgery are 92.7 to 100%^[6,12,25] and 92.5 to 100% in neuromuscular and paralytic scoliosis.^[13-15] Fusion rates with allografts are very close to those of autografts, especially in idiopathic scoliosis.^[6-11] Knapp et al. reported 2.7% of pseudarthrosis and 5.9% of loss of correction in their study of 11 idiopathic scoliosis patients with a minimum of 5 years of follow-up.^[12] Bridwell et al. reported only 3 cases of pseudarthrosis in 40 paralytic scoliotic patients who received allograft application with a mean follow-up of 3 years and 9

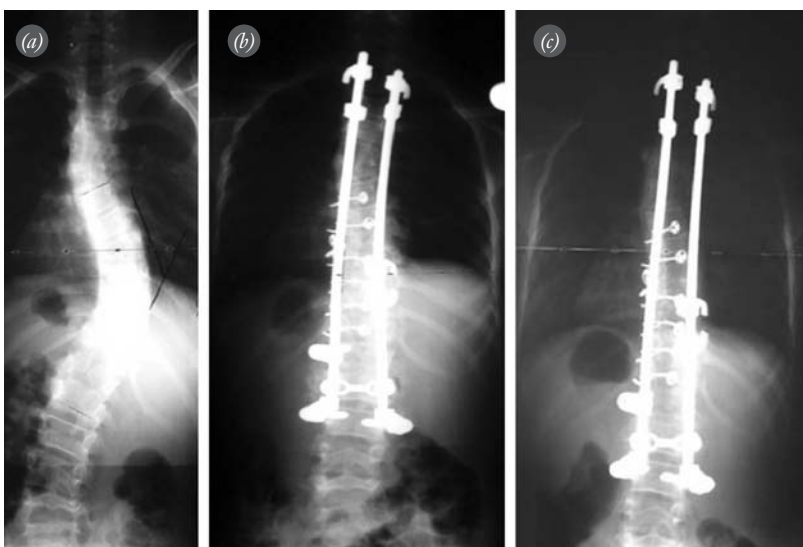


Fig. 2. (a) Preoperative, (b) postoperative and (c) follow-up X-rays of a 13-year-old girl who was previously operated for intraspinal pathology. She was pain-free clinically and loss of correction of more than 10 degrees or implant failure or pseudarthrosis was not present. Trabeculation was not visible due to implant overlapping. The patient was evaluated as 'probably fused'.

months.^[15] Yazici and Asher reported 2 cases of pseudarthrosis in 40 neuromuscular scoliosis patients.^[14] On the other hand, pseudarthrosis rates using autograft with or without instrumentation is reported to be 10 to 17% in congenital scoliosis.^[19,26] Although there is no evidence regarding the diminished bone healing potential in congenital curvatures, this difference in pseudarthrosis rates may be due to insufficiency of the bone stock (either congenital or iatrogenic due to previous surgeries) or inability to establish strong fixation due to anatomic malformations.

Only one study exists in the literature that investigates the usage of allografts in congenital scoliosis. In this retrospective study, Hedequist et al. analyzed 107 patients with a mean follow-up of 44 months.^[27] Pseudarthrosis criteria were similar to our study: implant failure, radiographic appearance of pseudarthrosis and loss of correction of more than 10 degrees. The mean curvature in the final follow-up was 19° which was equal to the early postoperative mean. Pseudarthrosis rate was reported as 2.8%. Superficial infection, another well-known complication of allograft application, was 0.9%. Hedequist et al., however, reported the results of short-segment, long-segment fusion and hemivertebrectomy together. The forces on the implant alter in short- and long-segment fusions. Furthermore, when hemivertebrectomy is performed, the osteotomized bone is used as an autograft. Therefore, extrapolating this high percentage of fusion to allograft itself is doubtful.

Pseudarthrosis rate was 13.3% in our study. This rate was higher than reported rates in idiopathic, neuromuscular and congenital scoliosis.^[27] However, it should be kept in mind that Hedequist's study included different treatment modalities whereas our study consisted of long-segment instrumentation and fusion only. It is obvious that the utilization of allograft has potential disadvantages in this patient group whose bone quality is weak with a higher risk of nonunion. Furthermore, 6 patients who underwent previous laminectomy for intraspinal pathologies had a smaller area to apply the graft which may make achieving fusion more difficult.

Although not included in the study group, it was an interesting finding that no pseudarthrosis was observed in patients with additional anterior procedures. Additionally, all patients in this study were operated before 2005 using hooks and wires, the standard implants at that time. Similar patients today are operated with all pedicle screw systems which offer a more stable and rigid fixation. There is no report, however, on the results of allograft use in a similar patient population with all (or by a majority) pedicle screw instrumentation. Nevertheless, it can be presumed that improvements in

Fig. 3. Follow-up X-ray of a 10-year-old boy demonstrating implant failure. Both rods are broken. He was evaluated as 'pseudarthrosis'



spinal surgery and newer implants will also positively affect congenital scoliosis treatment.

In conclusion, the usage of allograft alone to achieve fusion increases the rates of pseudarthrosis while additional anterior procedure decreases the pseudarthrosis rate in patients with congenital scoliosis that require long-segment posterior instrumentation. Further studies should be performed to assess the efficacy of the usage of polysegment pedicle screw instrumentation.

Conflicts of Interest: No conflicts declared.

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