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ORIGINAL ARTICLE

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Surgical management of the spinal deformity in Ehlers-Danlos syndrome type VI

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This study was conducted at the Kadir Has University, School of Medicine, Department of Orthopaedic Surgery and Traumatology in Istanbul, and at Istanbul University, Istanbul School of Medicine, Department of Orthopaedic Surgery and Traumatology.

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Abstract Five patients with Ehlers-Danlos syndrome type VI were surgically treated for their spinal deformities. All of them were female. All but one had a double-major thoracic and lumbar curve. One had a mild scoliotic curve but severe thoracic lordosis. Anterior discectomy and fusion and posterior instrumentation was performed in a single stage in two patients, while two had anterior and posterior surgery performed in two stages. The remaining patient underwent posterior surgery only, because of the relative mildness of the deformity and adequate flexibility. Two serious vascular complications were confronted. One patient experienced avulsion of segmental arteries and rupture of iliac artery and vein during anterior surgery. Another patient had avulsion of superior gluteal artery, which happened during subperiosteal dissection to harvest iliac bone graft. Fortunately, we did not see any temporary or permanent neurological complications. The spinal fusions appeared solid radiographically, with no implant failure and loss of correction after an average follow-up of 4 years.

Keywords Ehlers-Danlos syndrome · Scoliosis · Spinal fusion

Introduction

Ehlers-Danlos Syndrome (EDS), so designated from descriptions made by Ehlers in 1901 and by Danlos in 1908, is an inherited disorder of collagen biosynthesis. Hyperelasticity and fragility of skin, hyperlaxity of joints and bleeding diathesis characterize this syndrome. It is a group of related entities that share the same complex of clinical abnormalities. Clinical findings vary widely, depending on specific gene mutation and resultant phenotype. But kyphoscoliosis is a hallmark of type VI EDS, named oculoscoliotic type, and scoliosis occurs in up to 50% of type III EDS [1, 5]. We could find only two re-

ports [6, 9] in the orthopaedic literature dealing with spinal deformities in EDS. We report the results and complications of scoliosis surgery in five patients with EDS.

Materials and methods

Five adolescent patients with EDS were surgically treated for scoliosis during the past 6 years. The activity of lysyl hydroxylase was present at a reduced level in fibroblasts cultured from the patients' skin. All of the patients were female. Progression of the deformity was like that of adolescent idiopathic scoliosis in pubertal growth phase, and mean age at the time of operation was 14 years and 2 months (range, 8–20 years). Four of five patients (80%) had double-major thoracic and lumbar curves. One had a mild scoliotic thoracic curve, but severe thoracic lordosis of –70°. All five patients had a failed previous conservative treatment with various braces at our institutions or elsewhere. In four patients we performed magnetic resonance imaging (MRI) for intramedullary anomalies and found no abnormalities. Thorough cardiovascular examination was performed preoperatively and echocardiography revealed mild insufficiency of the tricuspid valve in one patient. Two had previously undergone multiple operations for unstable hips, and one patient had undergone multiple ligament reconstruction and osteotomy of the distal femur for knee instability.

All surgeries were carried out by the senior author (A.H.). Anterior discectomy-fusion and posterior instrumentation and fusion were performed as single procedures in two patients. Two others underwent anterior and posterior surgery in two stages. The remaining patient underwent posterior surgery only, because of relatively mild deformity and adequate flexibility. Traction was not applied in any form with staged surgeries. There was abnormal capillary oozing during surgery in all cases, but this could have been controlled by hypotensive anaesthesia, and electrocautery instead of sharp dissection and wound packing when needed. No spinal cord monitoring was done during the procedures, but a wake-up test was performed to ensure that all the patients were neurologically intact.

Case histories

Case 1

An 11-year-old girl presented with joint laxity, skin hyperelasticity and kyphoscoliosis. Her initial treatment had been carried out elsewhere and she had undergone several operations for an unstable left hip. Conservative treatment was tried for 2 years, but was not successful. She had a right thoracic curve from T5 to T9, measuring 42°, and a left thoracolumbar curve from T9 to L4, measuring 90°. A thoracolumbar junctional kyphosis of 70° was also present preoperatively. MRI showed no intramedullary abnormalities. This patient had a mild tricuspid insufficiency with no clinical findings. At age 13 years, she underwent anterior release and interbody fusion from T9 to L3 through a left thoraco-abdominal approach. During the anterior discectomy, segmental arteries were avulsed from the lower aorta and common iliac vein, and artery rupture occurred. The aorta and iliac artery were repaired with gortex graft and the common iliac vein was ligated. Posterior fusion was performed 2 months later, with single-rod Cotrel-Dubousset instrumentation and sublaminar wiring. Minor wound healing problems after posterior surgery resolved uneventfully with wound care. Six years postoperatively, the lumbar curve was 35° and thoracic curve was 38°, without any significant loss of correction since the operation. Sagittal profile was also improved to 38°.

Case 2

A girl was diagnosed with the oculoscoliotic form of EDS at the age of 1 year, and her scoliosis was treated conservatively. At age 8 years, she had a right thoracic curve from T4 to T11 measuring 45° and a left thoracolumbar curve from T11 to L4 measuring 38°; both curves showed documented progression at follow-up. MRI of the spinal canal revealed no abnormalities. Cardiac evaluation did not show any pathology. No sign of joint instability was detected. She underwent two-stage anterior and posterior surgery at 8 years of age. Third-generation pedicle screw posterior instrumentation was used between T4 and L4 for correction 15 days after the right thoracotomy and left lumbotomy for anterior fusion. Anterior fusion was performed to prevent crankshaft deformity following posterior fusion alone. Neither vascular nor neurological complications were observed. Postoperatively, the upper curve measured 18°, and the lower curve measured 17°. The preoperative thoracolumbar junctional kyphosis of 40° was also improved to 5°, a much more physiologic angle. No significant loss of correction was detected in the follow-up of 2 years and 7 months.

Case 3

A girl presented with subluxated hips, joint laxity, sensori-neural type loss of hearing and scoliosis. She had undergone several operations at another hospital for her lax right hip joint and knee instability. No cardiac pathology was detected. Preoperatively, she had a left thoracic curve from T2 to T9 measuring 82° and a right thoracolumbar curve from T9 to L4 measuring 106°. Whole-spine MRI scans revealed no abnormality. She was treated with anterior lumbar discectomy and fusion through a right thoraco-abdominal approach between T11 and L3 and posterior spinal fusion from T2 to L5 using third-generation pedicle screws at lumbar levels and hooks at thoracic levels at the same setting. Her age at operation was 20 years. No vascular or neurological complications were experienced. Postoperatively, the thoracic curve measured 73° and the lumbar curve 70°, and the correction has been very well maintained for 2 years. The sagittal thoracolumbar junctional balance also improved, from 50° to 17° (Fig. 1).

Case 4

Patient 4 was a girl with EDS characterized by significant joint laxity, skin hyperelasticity, sensori-neural type loss of hearing, failure to thrive and a mild right thoracic scoliosis of 25°, but severe thoracic lordosis of –70°. Cardiac evaluation did not reveal any pathology. Her chief complaint was exercise-induced dyspnea due to marked thoracic lordosis. Pulmonary function test revealed severe restriction of ventilation with a vital capacity of 960 ml (35% of normal). MRI revealed no intramedullary abnormalities. At 17 years old, anterior discectomy and fusion and posterior instrumentation between T2 and L2 were performed in one setting without any complications. A pedicle screw-hook system was augmented with bilateral sublaminar wires at each level for reversing the severe lordosis. She was able to be weaned from respiratory support on the day after the operation. The severe thoracic lordosis of –70° was converted to a physiologic thoracic kyphosis of 26°, and there was no measurable curve in the coronal plane (Fig. 2). Repeat pulmonary function test at the last follow-up of 4 years and 10 months postoperatively showed a vital capacity of 1699 ml (62% of normal).

Case 5

The fifth patient was a girl manifesting significant joint laxity, skin hyperelasticity and scoliosis. No cardiac pathology was noted. She was 13 years old. She had a left thoracic curve from T6 to T11 measuring 38° and a right thoracolumbar curve from T11 to L4 measuring 45°. No sagittal imbalance was noted. She underwent only a posterior spinal fusion with Cotrel-Dubousset instrumentation because of the relative mildness of the deformity, flexibility

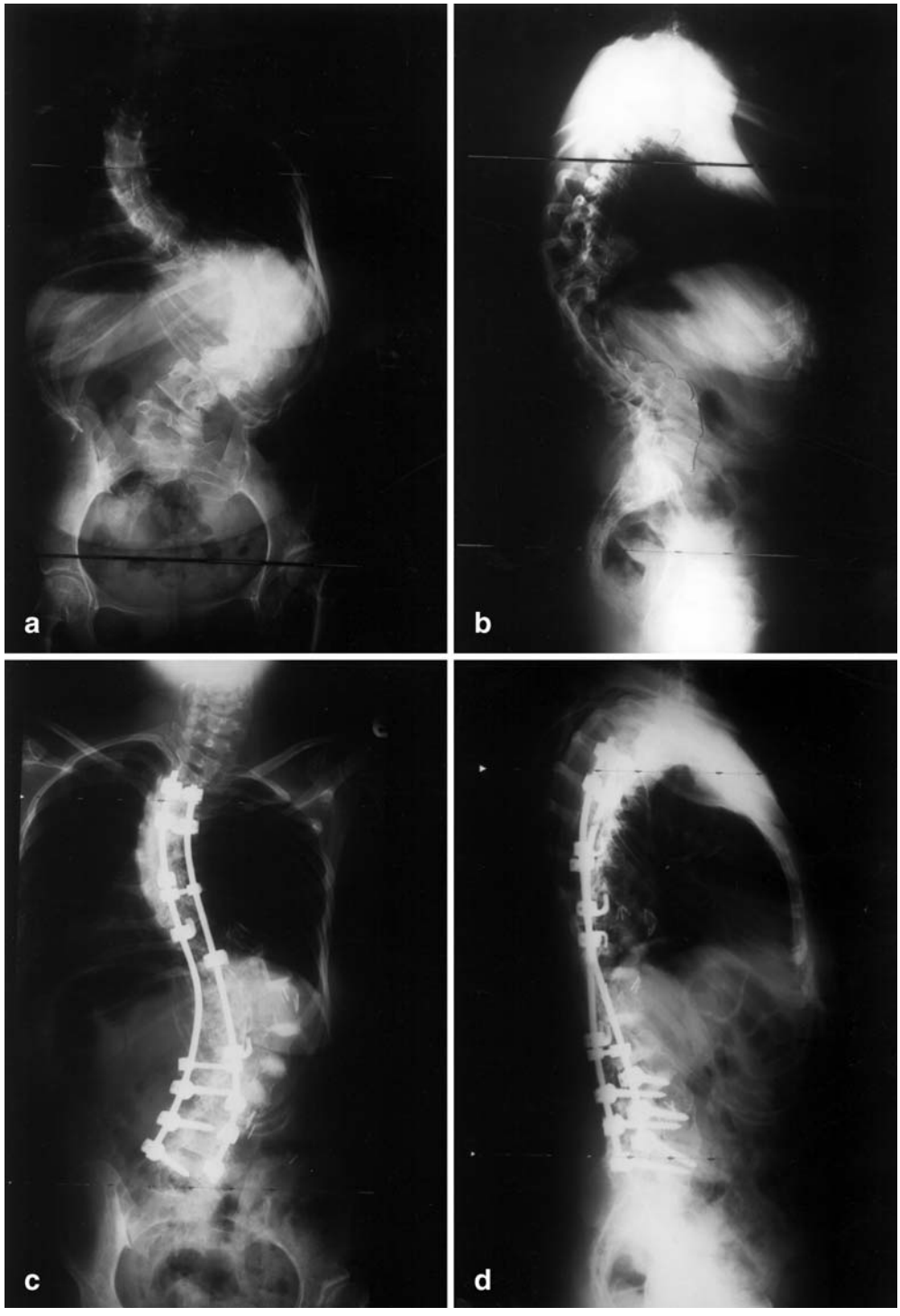

Fig. 1A–D Radiographs of a girl who presented with a severe right lumbar curve of 106° between T9 and L4, a severe left thoracic curve of 82° between T2 and T9 and thoracolumbar junctional kyphosis of 50°. **A** Anteroposterior and **B** lateral views at presentation, and **C** anteroposterior and **D** lateral views at most recent follow-up evaluation. Postoperatively, the lumbar curve was 70°, the thoracic curve was 73° and the kyphosis was reduced to 17°

on bending radiographs and a good sagittal contour. Postoperatively, the lumbar curve measured 10° and the thoracic curve 5°. The superior gluteal artery had been injured while harvesting iliac bone graft, and it was ligated. No neurologic complications developed. No loss of correction was detected in 4 years and 7 months of follow-up.

Results

During anterior lumbar surgery in one patient, two segmental arteries were avulsed from the lower aorta, and the iliac vein and artery were ruptured due to blunt dissection for exposure. The aorta and iliac artery were grafted and the common iliac vein was ligated in this case, which

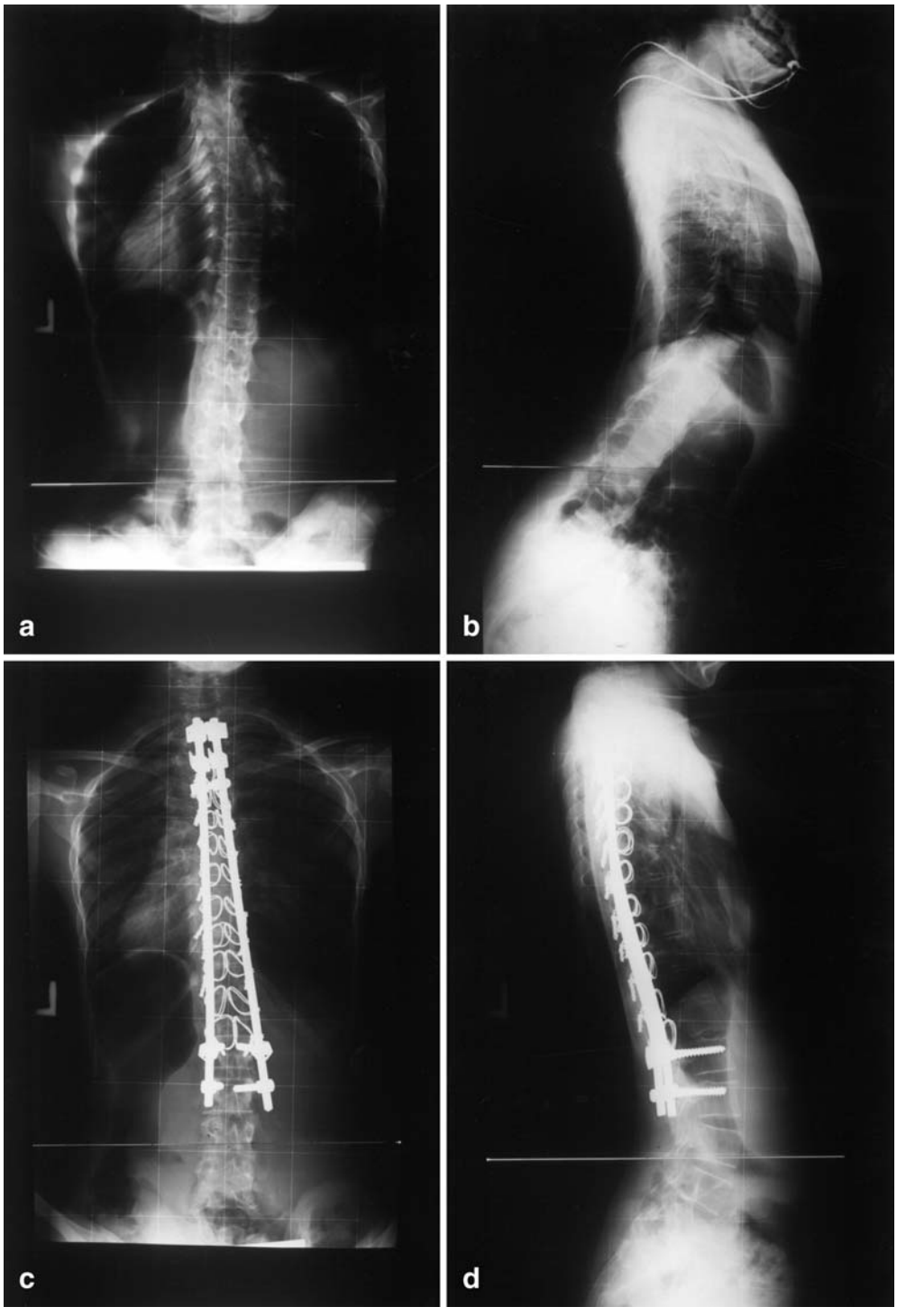

Fig. 2A–D Radiographs of a 17-year-old girl with a mild right thoracic curve of 25° between T3 and T10 and severe thoracic lordosis of –70° between T4 and T12. **A,B** Preoperative anteroposterior and lateral views; **C,D** postoperative anteroposterior and lateral views. Postoperatively, there was no frontal plane deformity and physiologic thoracic kyphosis of 26° was restored

worked out well, with no major problems. In another patient, we experienced avulsion of the superior gluteal artery, which happened during subperiosteal dissection to harvest iliac bone graft. It was successfully ligated. The mean perioperative bleeding was 1764 ml (1240–2800 ml).

A spine balanced over the pelvis was achieved in all patients. The central sacral line fell within 2 cm of the centre of C7 on postoperative radiographs, as was also the case preoperatively. Corrections in the frontal and sagittal planes were satisfactory (Table 1, Table 2). All patients wore a thoraco-lumbar-sacral orthosis (TLSO) for an average of 6 months postoperatively. We did not perform any secondary suture or surgical wound revision, but had some minor wound healing problems. All the wounds

Table 1 Preoperative and postoperative magnitude of lumbar and thoracic curves

	Mean	Max	Min
Lumbar curve (n=4)			
Pre-op.	69.7°	106°	38°
Post-op.	33°	70°	10°
Correction rate	52.6%	33.9%	73.6%
Thoracic curve (n=5)			
Pre-op.	46.4°	82°	25°
Post-op.	26.8°	73°	0°
Correction rate	42.2%	10.9%	100%

Table 2 Pre- and postoperative thoraco-lumbar junctional kyphosis between T12 and L2 in patients 1–3

	Mean	Max	Min
Pre-op.	53.3°	70°	40°
Post-op.	20°	38°	5°
Correction rate	62.4%	45.7%	87.5%

healed with tissue-paper scarring. At follow-up after an average of 4 years (range, 2–6 years), the spinal fusions appeared solid radiographically, with no implant failure or significant loss (>10°) of correction.

Discussion

Type-VI EDS is characterized by a deficiency of lysyl hydroxylase, and the major clinical manifestations are muscle hypotonia, skin hyperextensibility, moderate joint laxity, severe kyphoscoliosis, and vascular fragility [8]. MacFarlane [5] and Coventry [2] reported cases of EDS with thoracolumbar kyphoscoliosis and wedge-shaped deformity of the vertebral bodies. Sussman et al. [8] described two sibs with EDS, one of whom was shown to have hydroxylysine-deficient collagen. These patients had severe scoliosis and fragility of ocular tissues leading to rupture of the globe or retinal detachment. Neither wedging nor eye problems were seen either in the present study or in McMaster's [6] series.

Little has been reported about the surgical treatment of spinal deformity in EDS [3, 6,9]. Leatherman and Dickson [3] suggested that surgery should be avoided, presumably because of the risks of bleeding and poor soft tissue healing capacity. McMaster [6] reported on five EDS patients with severe spinal deformity. Three had a double structural scoliosis of the thoracic and lumbar region, one had a single thoracic scoliosis and one had a thoracic kyphosis. All these curves deteriorated rapidly at the onset of the adolescent growth spurt, requiring surgery at a mean age of 11 years and 9 months for major curves of a mean size of 88° (range, 66°–115°). Major corrective surgery with posterior fusion was performed. A number of different surgical techniques were used; all provided an acceptable improvement in the frontal plane (mean 58%; range, 35–78%). Although wound haematoma and dehiscence requiring repeated aspiration and secondary suture was often noted, satisfactory fusion was achieved.

Patients with EDS may be at high risk for neurological and vascular complications consequent to scoliosis surgery. Vogel and Lubicky [9] reported on four patients with neurological and vascular complications due to scoliosis surgery in EDS. Three patients (75%) developed neurological complications. Two developed paraplegia, and one developed unilateral foot and ankle weakness with transient neurogenic bladder. The other patient experienced avulsion of segmental arteries during anterior spinal surgery, which necessitated repair of the aorta with a pericardial patch. In contrast, in one paper from Russia by Pozdnikin and Ryzhakov [7], no neurologic complications were reported in eight patients with EDS.

All of our patients experienced progression of their spinal deformities in the pubertal phase, similar to adolescent idiopathic scoliosis, but all were unresponsive to brace treatment. Therefore, the patients required surgical management at a mean age of 14 years and 2 months, with mean preoperative curve magnitudes of 69.7° (range, 38°–106°) and 46.4° (range, 25°–82°) respectively, for the lumbar and thoracic curves. A spine balanced over the pelvis was achieved in all our patients. Mean corrections in the frontal plane of 52.6% (lumbar) and 42.2% (thoracic), and in the sagittal plane of 62.4% were satisfactory. We did not note any implant pullout or failure due to increased laxity of the vertebral column after initial stabilization, as described in the literature by Ainsworth and Aulicino [1]. All fusions were solid and no significant loss of correction was detected during an average follow-up of 4 years.

Vascular fragility is inherent in EDS, and therefore iatrogenic vascular injury may prove to be inevitable, especially while performing anterior lumbar surgery. This is something we experienced in our cases, as did Vogel and Lubicky in theirs [9]. This potentially fatal complication in one of our patients required vascular surgery with grafting of the aorta and the common iliac artery. We would like to point out some technical details here, which we applied and found helpful for minimizing excessive bleeding and avoiding possible vascular injury during anterior surgery in patients with vascular fragility like EDS:

1. Use of hypotensive anaesthesia, as needed in every spinal procedure, may minimize bleeding and the time taken to stop it.
2. Blunt dissection should be avoided for exploration of the vessels, because it may cause avulsion or laceration.
3. Using electrocautery may minimize the oozing capillary blood from soft tissues.
4. In the lumbar region, contrary to classical anterior scoliosis surgery, segmental arteries have to be carefully

and completely isolated and ligated as far from the aorta as possible.
5. Discectomy should not be as extensive as in idiopathic scoliosis, but it can be performed far away from the vascular structures.

The 0.7% reported incidence of iatrogenic paralysis in scoliosis patients undergoing spine surgery [4] is of course not applicable to patients with EDS. Vogel and Lubicky [9] argued that the combination of vascular fragility, which by unapparent or obvious damage leads to infarction of the spinal cord, and ligamentous laxity was responsible for the high percentage of neurologic deficits (75%) in their four patients. McMaster [6] did not report any neurologic complications in his five posteriorly corrected patients, who had a mean frontal correction rate of 58%. Fortunately, we did not see any neurological complications in our five patients, who had a mean frontal plane correction of 52.6%, similar to McMaster's, and mean sagittal plane correction of 62.4%. We carried out neuroimaging in four out of five patients with MRI, to rule out any spinal cord anomalies – an investigation that was not carried out in Vogel and Lubicky's series of patients. To avoid neurological complications, we suggest that surgeons must restrain their understandable desire to fully correct the deformity. Instead they should restrict the correction to that achieved on preoperative bending or traction films [10], such a correction being most often possible because of the hyperelasticity.

In conclusion, major corrective surgery for the spinal deformities in patients with EDS may be necessary, and satisfactory correction can be obtained in the frontal and sagittal planes with solid spinal fusion. There is a high risk of vascular complications during anterior surgery, which may be minimized by adhering to the suggestions outlined above. Neurologic complications were not experienced by our EDS patients.

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