

Complications of Scoliosis Surgery in Prader-Willi Syndrome

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Study Design. Retrospective case series of 16 consecutive patients.

Objective. To evaluate the results of scoliosis surgery in Prader-Willi syndrome (PWS) with special emphasis on the complications and their risk factors.

Summary of Background Data. PWS is a rare genetic disorder characterized by obesity, hypotonia, and frequent scoliosis. The literature dealing with scoliosis surgery in PWS consists of only few case reports. Surgical treatment was reported to be difficult with frequent and severe complications.

Methods. Sixteen patients (3 males, 13 females) in 63 presenting scoliosis and PWS were operated on between 1974 and 2004. Preoperative, postoperative and last follow-up clinical and radiologic data were analyzed. Complications, treatment, and outcome were investigated.

Results. Mean age at scoliosis diagnosis was 6.2 years (range 0.5–13.5). Mean age at surgery was 12.3 years (range 5–15). Mean follow-up was 5.4 years (range 2–18). There were 9 major complications (4 severe kyphosis above fusion, 2 deep infections, 1 transient paraplegia, 1 pseudarthrosis, 1 delayed wound healing). The 4 kyphosis required reoperation, 3 of which were complicated with permanent spinal cord injury. Minor complications affected 6 patients.

Conclusion. Scoliosis surgery is frequently necessary in PWS and is associated with high rate of complications. These are often related to specific features of this syndrome the surgeon should recognize and consider.

Key words: scoliosis, Prader-Willi syndrome, surgery complications, child. **Spine 2008;33:394–401**

Prader-Willi Syndrome (PWS) is a rare genetic disorder first described in 1956 and characterized by short stature, obesity, hypotonia, hyperphagia, intellectual disability, behavioral problems, and typical facial features. Consensus clinical diagnosis criteria were published by Holm *et al* in 1993.¹ The prevalence of PWS is thought to be 1 in 10,000 to 1 in 25,000 with a male: female ratio of 3:1. Most of the cases arise sporadically. PWS results from the loss of the paternal copy of chromosome 15 q11.2-13. More than 70% of patients have a deletion of

the paternal copy and approximately 25% of patients have a maternal uniparental disomy for chromosome 15. The remaining patients have a translocation or another structural alteration of chromosome 15. Patients with deletion genotype exhibit a more severe phenotype. Most manifestations including hyperphagia, sleep disorders, deficient growth hormone secretion, and hypogonadism seem to be related to hypothalamic dysfunction.

Musculoskeletal manifestations are frequent and include scoliosis, kyphosis, ligamentous laxity, osteoporosis, and various lower limb anomalies. Spinal deformities are considered supportive criteria with no direct impact on the diagnostic score established by Holm *et al*.¹ Scoliosis is of a high prevalence in PWS, ranging from 45% to 86% in the latest studies.^{2–4} PWS is associated with a deficit in growth hormone (GH); therefore GH therapy has been indicated with satisfactory results. Still, the influence of such a treatment on the occurrence and progression of spine deformities remains controversial. Scoliosis is reported to require active treatment in 15% to 20% of cases and to behave as an idiopathic scoliosis, with high risk of progression during adolescence.⁴ The literature dealing with scoliosis surgical treatment in PWS is scarce and consists of a few case reports.^{5–8} However, operative treatment was reported to be difficult with frequent and severe intraoperative and postoperative complications resembling those met in neuromuscular and dystrophic scoliosis.^{5,7}

We retrospectively analyzed the results of surgical management of scoliosis in 16 PW patients with particular concern for the complications and risk factors.

Materials and Methods

The following information was recorded from the medical records: definitive diagnosis of PWS, walking age, age of the patient at scoliosis diagnosis and at the time of operation, age adjusted body mass index (BMI) and Risser sign (1–5 grading system for ossification of the iliac crest apophysis) at the time of operation, fusion procedure, type of instrumentation, length of postoperative immobilization, and complications from the operation. Review of lateral and anteroposterior standing radiographs provided information regarding the curve pattern, magnitude of the main curve, kyphosis, and the vertebral levels fused. The coronal and sagittal components of the spinal deformity were measured by the Cobb method on full spine preoperative, postoperative, and last follow-up standing radiographs. Kyphosis angle was measured between T4 and T12. Complications were divided into minor and major according to their effect on the course of recovery in hospital and on their potential life, limb, or function threatening effect. The complications that were rated as major, necessitated further general anesthesia, significantly prolonged the hospital stay and/or affected the final surgical outcome of the patients.⁹

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The device(s)/drug(s) is/are FDA-approved by corresponding national agency for this indication.

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

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Table 1. Preoperative Data

Case	Sex/Age at Scoliosis Diagnosis	Age/Risser Score at Surgery	BMI/Age Adjusted BMI Score at Surgery	Mental Disorders	Scoliosis Pattern	Associated Orthopaedic Anomalies
1	♂/0.5 y	5 y/0	25.7/9.2	Slight retardation	TL	Hip dysplasia
2	♀/6 y	14.5 y/0	28.2/3.4	Moderate retardation Impulse control disorder	DM	Bilateral pes calcaneo-valgus
3	♀/9y	12 y/1	30.9/6.7	Severe retardation	TL	—
4	♀/—	11 y/0	18/0.5	Slight retardation	DM	—
5	♀/13.5 y	13.5 y/0	24.5/2.1	Slight retardation	DM	—
6	♀/—	13 y/1	14.3/—1.88	Severe retardation Oppositional defiant Impulse control disorder	DM	—
7	♀/—	12 y/3	25.1/3.9	Moderate retardation	DM	Chiari I malformation
8	♂/1y	11 y/0	27.4/3.7	Slight retardation	DM	—
9	♀/4.5 y	14 y/0	39.4/8	Slight retardation Self mutilating	DM	—
10	♀/—	11 y/1	36.2/6.12	Moderate retardation Depressive Oppositional defiant Obsessive/compulsive	L	—
11	♀/10y	15 y/1	37.3/7.17	Moderate retardation Depressive	TL	Genu valgum Left clubfoot
12	♀/4.5y	10 y/0	30/2.2	Moderate retardation Oppositional defiant Obsessive/compulsive	DM	Hip dysplasia
13	♀/9 y	13 y/3	30.9/5.7	Moderate retardation Attention deficit/hyperactivity Impulse control disorder	DT	Bilateral clubfeet
14	♂/—	13.5 y/1	25.1/3.3	Slight retardation	DM	Genu valgum
15	♀/—	15 y/1	49.5/11.6	Moderate retardation Attention deficit/hyperactivity Oppositional defiant	TL	—
16	♀/4 y	14 y/1	31.3/4.15	Slight retardation Depressive/Self mutilating	T	—

T indicates thoracic; L, lumbar; TL, thoraco-lumbar; DT, double thoracic; DM, double major.

■ Results

A total of 16 patients (3 males, 13 females) among 63 presenting a scoliosis associated with PWS were operated on consecutively between 1974 and 2004 and then observed at one of our two university hospitals. Most of the patients showed marked obesity (mean age adjusted BMI 4.74, range -1.88 to 11.6) and delayed walking age (mean 29 months, range 16–40 months) (Table 1). Mean age at scoliosis diagnosis was 6.2 years (range 0.5–13.5) and primary treatment consisted of bracing in all but one cases of late scoliosis diagnosis. Indication for surgery was progressive scoliosis superior to 40° and/or kyphosis superior to 40°. Seven patients had received GH therapy before surgery. Mean age at surgery was 12.3 years, (range 5–15). Five patients underwent combined anterior–posterior fusion (mean 41 days between the 2 stages, range 14–141) and 11 patients underwent posterior fusion alone. The type of instrumentation used depended on the time of surgery and is displayed in Table 2. An average of 11.5 vertebral levels was fused (range 6–14). Intraoperative neuromonitoring consisted of Stagnara Wake up test before 1993 and then Somatosensory Evoked Potentials (associated with Neurogenic Motor Evoked Potentials in 1 on the 2 institutions since 1999), when reliable responses were available. Postoperative immobilization with bracing was prescribed in 8 cases for an average duration of 6 months (range 3–12).

Mean follow-up was 5.4 years, (range 2–18). The mean preoperative magnitude of the main curve was 72°, 31° immediately after surgery and 44° at final follow-up. The mean preoperative kyphosis angle was 59°, 33° immediately after surgery and 43° at final follow-up (Table 3).

There were 9 major complications in 7 patients (56%), including 4 postoperative severe progressive cervical-thoracic kyphosis above fusion. All 4 required a

Table 2. Surgical Strategy

Case	Fusion Procedure	Fusion Level	Instrumentation Type/ Year of Surgery
1	Anterior/posterior	T7–L3	Anterior plate + Dwyer instrumentation + Harrington/1974
2	Posterior	T2–L3	Harri-Luque/1983
3	Posterior	T4–L4	Luque/1985
4	Posterior	T2–L4	Harrington/1985
5	Posterior	T4–L3	CD/1994
6	Posterior	T4–L4	CD/1996
7	Posterior	T3–L5	CD/1996
8	Posterior	T2–L3	CD/1998
9	Posterior	T3–L4	CD/1998
10	Posterior	T10–L4	CD/2000
11	Posterior	T4–L1	SCS/2002
12	Anterior/posterior	T4–L4	SCS/2002
13	Anterior/posterior	C7–L2	Moss Miami/2003
14	Anterior/posterior	T3–L3	PASS/2004
15	Anterior/posterior	T3–L4	Moss Miami/2004
16	Posterior	T3–L3	SCS/2004

Table 3. Radiographic Data

Case	FU (years)	Primary Curve Magnitude (°)			Kyphosis Magnitude (°)		
		Preoperative	Postoperative	Final	Preoperative	Postoperative	Final
1	18	85	30	35	50	40	35
2	17	60	33	43	55	26	34
3	2	115	55	65	60	42	63
4	2	70	32	40	60	10	15
5	3	40	15	28	20	14	22
6	2	60	30	50	55	35	44
7	3	75	45	48	40	15	15
8	8	88	88	90	87	87	88
9	7	90	50	55	90	48	55
10	6	55	5	5	45	35	40
11	4.5	41	26	31	62	48	60
12	3	70	40	45	40	28	30
13	3.5	60	20	40	90	51	51
14	3	72	16	52	90	26	35
15	2	95	42	42	60	48	49
16	2	76	30	36	40	30	50

Table 4. Complications, Treatment, and Outcome

Case	Progressive Deformity	Infection	Spinal Cord Injury	Instrumentation Failure
1	—	—	—	—
2	—	—	—	<i>Early T2 hooks dislodgement. No treatment</i>
3	—	Early deep wound infection. Irrigation, debridement, antibiotherapy. Full recovery	—	<i>Prominent proximal rod. No treatment</i>
4	—	—	—	—
5	—	—	—	—
6	—	Early deep wound infection. Irrigation debridement, antibiotherapy. Full recovery	—	<i>L4 hook dislodgement. No treatment</i>
7	Stiff kyphosis. Revision for anterior release after 2 mo	—	Complete and definitive ischemic paraplegia after revision surgery	—
8	—	—	Transient postoperative paraplegia Instrumentation removal	Lumbar pseudarthrosis. Uneventful revision with circumferential fusion 4 yr later
9	Severe kyphosis above the instrumented segment. Revision for C3–D1 posterior fusion and instrumentation 6 yr after primary correction	1. Delayed healing of tibial graft wound 2. Early deep wound infection after revision surgery. Irrigation, debridement and antibiotherapy	Definitive tetraplegia after revision surgery Instrumentation removal	—
10	—	—	—	—
11	—	—	—	<i>L1 hook dislodgement. No treatment</i>
12	—	—	—	—
13	Severe kyphosis above the instrumented segment. Revision for circumferential fusion and proximal extension of the instrumentation to C3, 2 yr later	<i>Early pneumonia and Clostridium difficile colitis. Antibiotherapy</i>	—	—
14	124° kyphosis above the instrumented segment. Subsequent T3 posterior osteotomy 2 yr later	<i>Superficial wound infection. Antibiotherapy. Complete healing</i>	Peroperative complete and definitive paraplegia after revision surgery	—
15	—	—	—	—
16	—	<i>Superficial wound infection. Local cares. Complete healing</i>	—	—

Bold indicates major complications; Italic indicates minor complications.

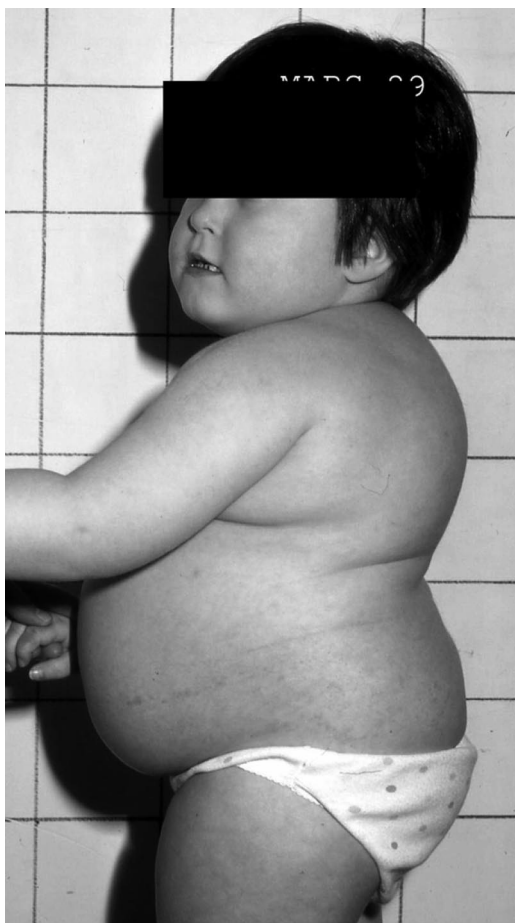


Figure 1. Case 9. 4.5-year-old girl presenting PWS and kyphoscoliosis.

complementary fusion with extension to the cervical spine, 3 of which were complicated with permanent spinal cord injury. Minor complications affected 6 patients (37%) (Table 4).

■ Case Studies

Case 9

A 4.5-year-old girl was diagnosed as having PWS and marked kyphoscoliosis. She was short and obese with hypotonia (Figure 1). Initial treatment consisted of Milwaukee bracing with preceding stage of halo-gravity traction at the age of 5. Spine deformities worsened despite bracing up to 90° left thoracic scoliosis and 90° thoracic kyphosis. Surgery was indicated at the age of 14. The patient was still obese with age adjusted BMI of 8.03 and presented slight mental retardation. Preoperative halo-gravity traction was applied for 2 months to achieve progressive correction. Uneventful T1–L4 posterior fusion was performed with pediatric CD instrumentation and tibial stick bone graft (Figure 2). The tibial wound failed to heal despite adequate treatment and eventually seemed to be related to automutilating behavior through scar scratching (Figure 3). Eventually, a skin graft was necessary for complete closing up 6 years after the graft had been harvested. The spinal segment above the instru-

mentation evolved progressively into severe unstable cervicothoracic kyphosis (Figure 4). Corrective surgery was thought to be indicated because of the pain, the bad tolerance of the permanent cervical collar and the risk of acute tetraplegia. The patient was placed in halo-gravity traction for 8 weeks. Then she underwent an extension of the posterior instrumentation to C4 with fusion and iliac bone graft when she was 20 years old, 6 years after initiating fusion. Two pediatric CD rods were linked to the primary instrumentation and secured to the spine via sublaminar hooks. Kyphosis was partially corrected and the procedure was uneventful. Immediate postoperative tetraplegia was diagnosed with respiratory failure. Immediate reoperation consisted of complete removal of the instrumentation and C1–C4 laminectomy along with widening of the magnum foramina that revealed severe narrow vertebral canal. Early deep infection developed and necessitated reoperation 3 weeks after surgery and prolonged intravenous antibiotherapy. The patient did not recover from tetraplegia and is still respiratory dependant and bound to wheelchair.

Case 13

A girl was diagnosed as having PWS at the age of 4. She presented bilateral stiff clubfeet, which necessitated operative correction at the age of 2. GH therapy was initiated when she was 7. Right thoracic kyphoscoliosis was diagnosed when she was 9 and was treated with TLSO brace. The major coronal curve progressed despite bracing and the patient required operative treatment at the age of 13. Preoperative standing radiographs demonstrated a 60° major coronal curve with a 90° thoracic kyphosis (Figure 5). Age adjusted BMI was 5.68 and Risser sign was 3. She exhibited impulse control disorder and attention deficit as well as moderate mental retardation. Circumferential spinal fusion was performed with anterior release and 2 weeks later posterior fusion from T1 to L2 with Moss Miami instrumentation. Major coronal curve was corrected to 20° and kyphosis to 51° after surgery (Figure 6). Recovery was marked by a pneumonia and subsequent *Clostridium difficile* diarrhea, which both resolved after adapted medical treatment. The patient developed cervicothoracic kyphosis above fusion within 3 months after surgery and her head rapidly had to be maintained in a cervical collar. This deformation kept in deteriorating, exhibiting C7–T1 collapse (Figure 7). The patient was then referred to our institution for reoperation 3 years after primary surgery. We extended the posterior instrumentation and fusion to C3 after prior anterior release 4 days before. Recovery was uneventful, cervical collar was interrupted after 6 months and a 20° loss of correction on the major coronal curve was noted at 2 years follow-up (Figure 8).

■ Discussion

Only a few articles report on the results of scoliosis surgery in PWS and exclusively through case reports.^{5–7,10} It has been said that in PWS, the presentation, curve pat-

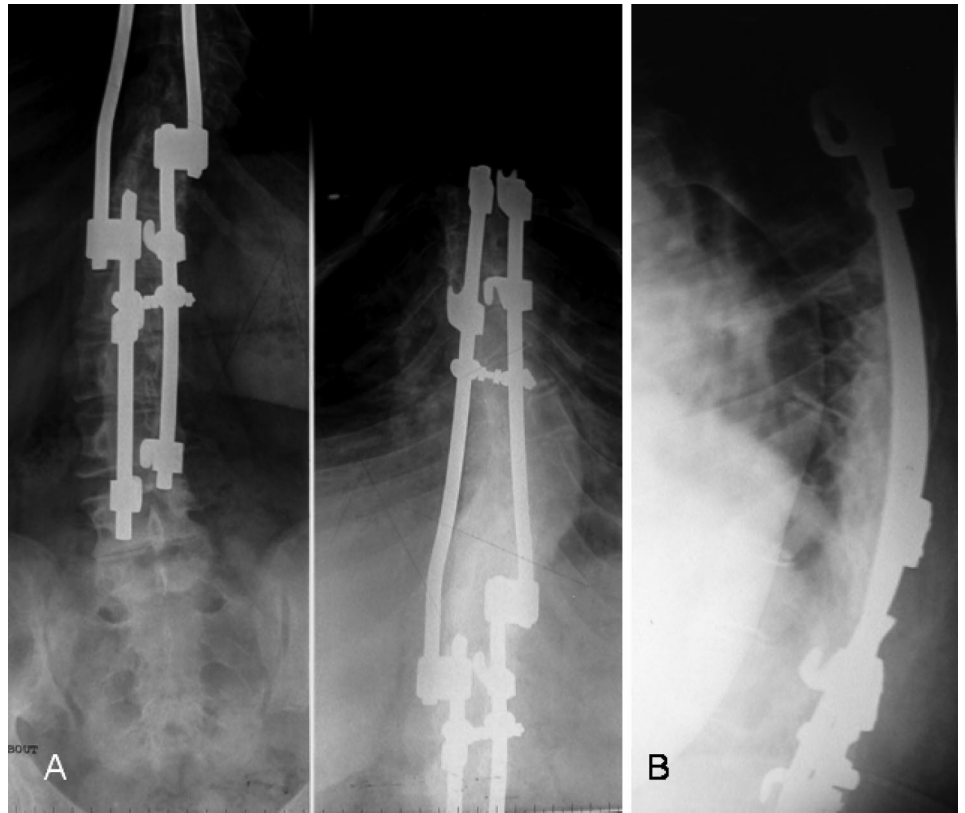


Figure 2. Case 9. Postoperative radiographs. **A:** AP view, **B:** lateral view.

tern, course of progression, guideline for treatment, and surgical indications resemble adolescent idiopathic scoliosis.² Nonetheless, scoliosis in PWS has several features in common with neuromuscular and dystrophic scoliosis and surgical treatment is subjected to severe and frequent

complications likewise. There is no definite consensus regarding indication for surgical correction and instrumentation in PWS scoliosis. Like in idiopathic scoliosis, unbalanced and progressive curves represent indications



Figure 3. Case 9. Left leg sore due to scar scratching.

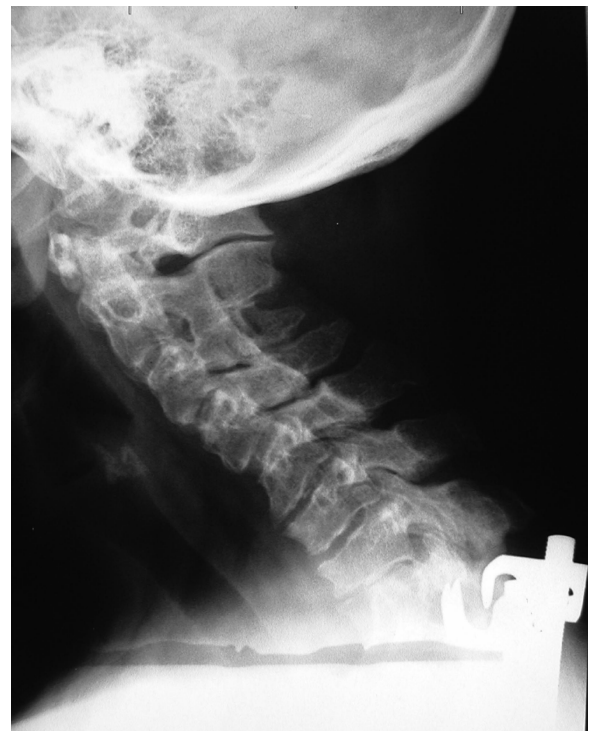


Figure 4. Case 9. Cervical-thoracic collapse above instrumented segment.

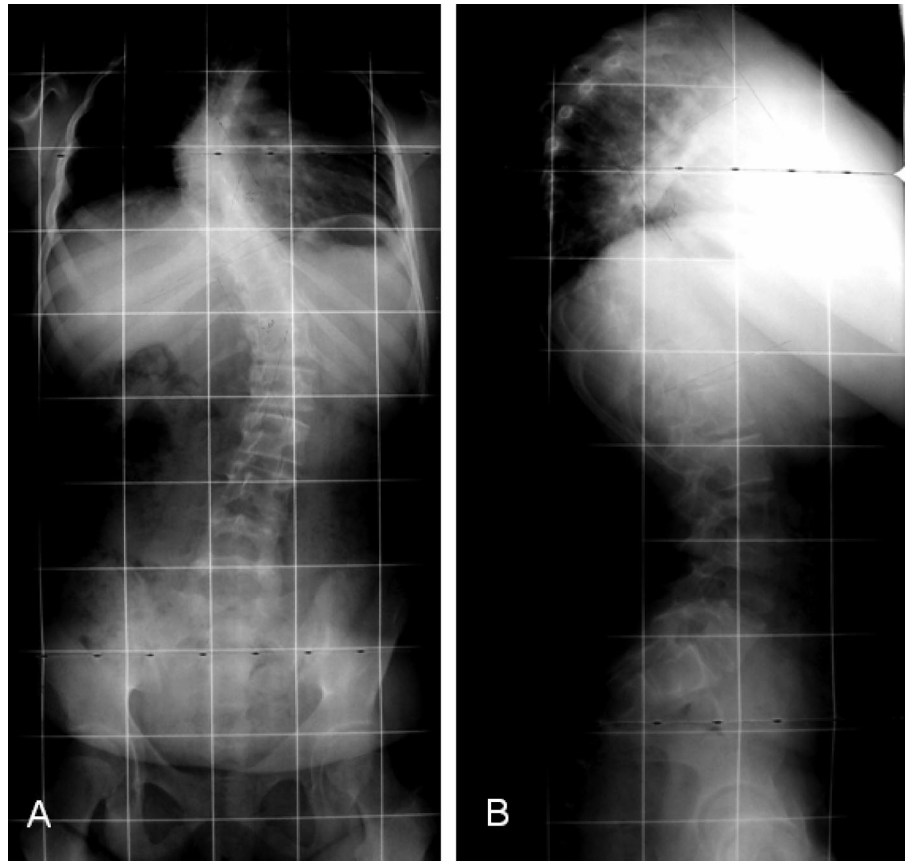


Figure 5. Case 13. Preoperative radiographs. **A:** AP view, **B:** lateral view.

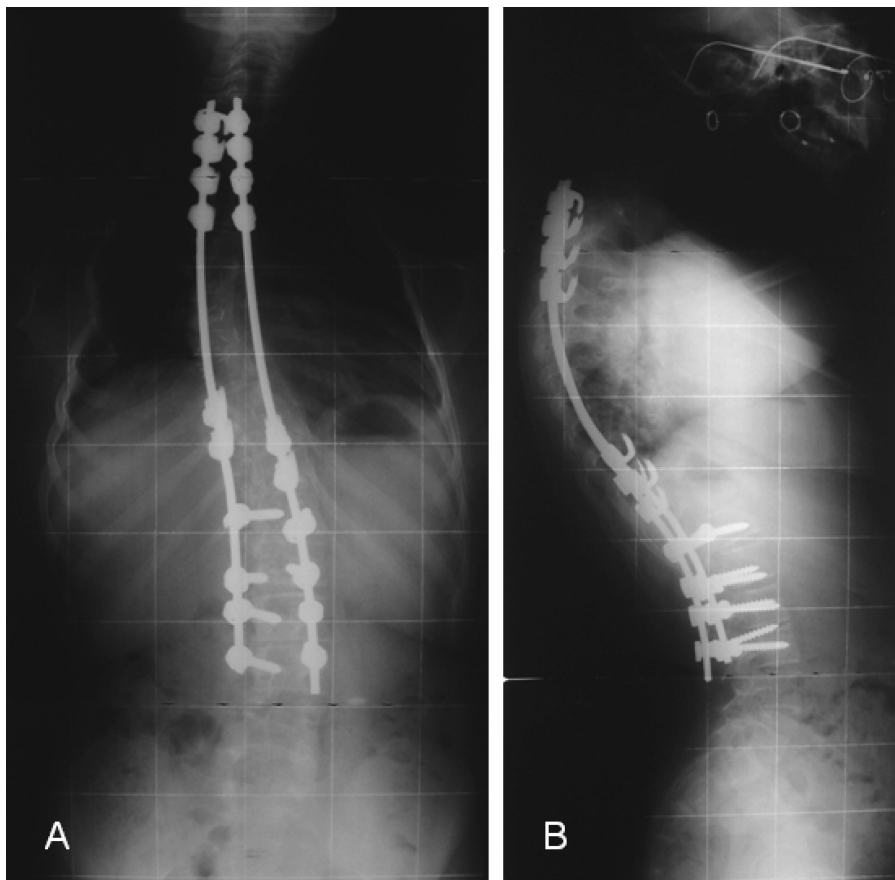


Figure 6. Case 13. Postoperative radiographs. **A:** AP view, **B:** lateral view.

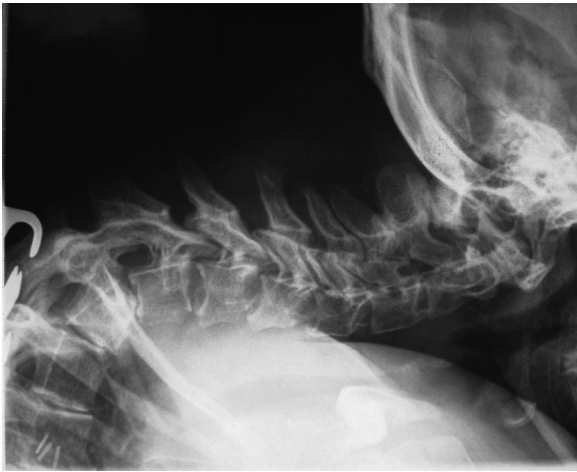


Figure 7. Case 13. Cervical-thoracic collapse above instrumented segment.

for surgery. However, bracing is often less efficient than in idiopathic scoliosis in halting curve progression because of patients obesity and frequent lack of compliance,² thus increasing the need for surgical treatment.

The limitations of the present study include the retrospective design and the variety of instrumentations used due to their evolution through the years (1974–2004). In the current series, 4 patients (25%) developed severe postoperative cervical-thoracic collapse that eventually required reoperation. This complication has never been reported before in PWS. It could be related to several

features of PWS, such as muscle weakness, ligamentous laxity, and natural tendency to a “head forward posture”.² Moreover it could be promoted by prolonged and excessive halo traction or long period of Milwaukee bracing, thus both should be avoided in PWS patients. This condition must be considered carefully when planning operative treatment. Preoperative lateral radiographs must be carefully analyzed to choose the right upper instrumented level. We were not able to isolate statistically any risk factor for this complication in this series.

Spinal cord injury affected 4 patients (25%). One transient paraplegia occurred during posterior primary instrumentation and fusion (case 8). The other 3 neurologic complications arose during reoperations: 1 ischemic permanent paraplegia during anterior fusion (case 7), 1 permanent paraplegia during posterior T3 vertebral osteotomy (case 14) and 1 permanent tetraplegia after extension of posterior instrumentation and fusion (see case 13 study). Such a high incidence of neurologic complications has not been previously reported in the literature. Patients with cervical kyphosis should be checked for narrow cervical spinal canal and spinal cord compression using MRI before surgery.¹¹ The use of spinal cord monitoring during surgery is highly recommended likewise.¹²

Wound infection affected 5 patients, 3 of whom required additional surgery for debridement and irrigation, which did not affect final fusion. Mental disorders frequently associated with PWS such as skin picking or

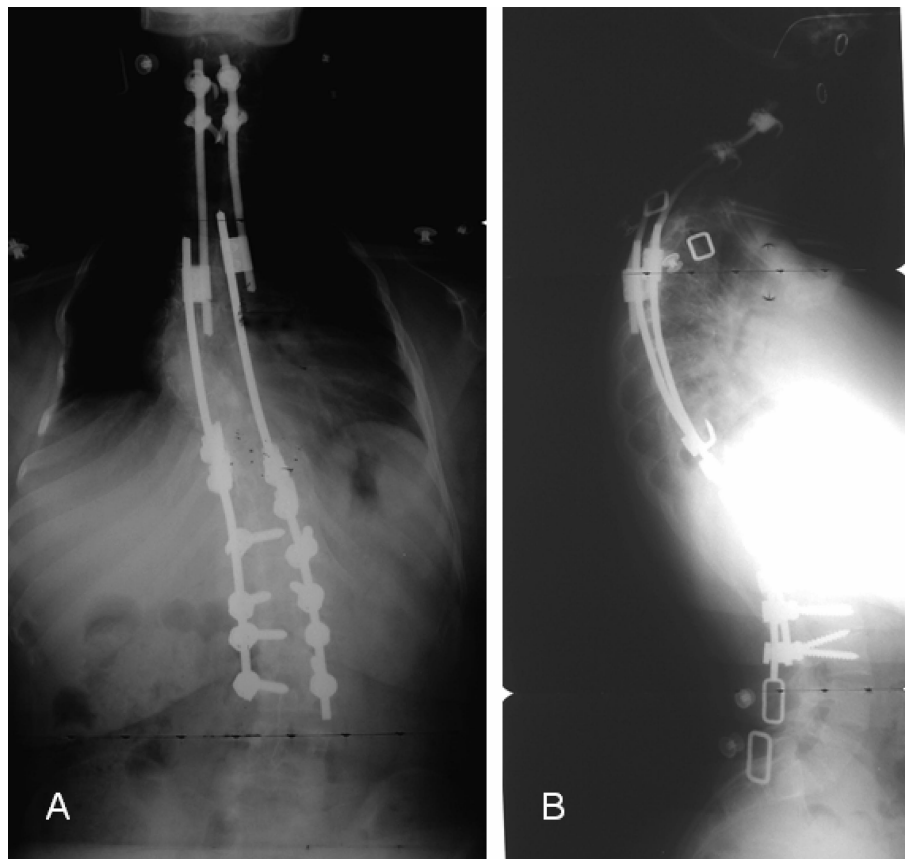


Figure 8. Case 13. Follow-up standing radiographs with extended instrumentation and fusion. **A:** AP view, **B:** lateral view.

self mutilating behaviors may facilitate such complications and surgical wounds should be carefully protected.² Respiratory function must be checked before surgery because obesity, muscle weakness, and short stature may reduce its performance.^{5,7} We noted 3 cases of hook dislodgement in this series. This could be related to frequent osteopenia,¹⁰ obesity, and hypotonia. Multiple points segmental fixation is mandatory as well as preoperative bone mineral density evaluation and adapted treatment accordingly.

Scoliosis is a frequent condition in PWS and must be screened systematically early in childhood. Surgical correction and fusion is frequently necessary and is associated with a high rate of complications. These are often related to specific features of PWS the surgeon should recognize and consider.

■ Key Points

- Scoliosis is of a high prevalence in PWS.
- Scoliosis correction and fusion in PWS presents a high rate of complications.
- Risk factors should be early recognized and considered throughout surgical management.

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