LONG-TERM RESULT OF MAJOR SPINOPELVIC ARTHRODESES IN SCOLIOSIS. IMPORTANCE OF AGE, WALKING ABILITY AND TYPE OF ILIAC FIXATION

RESULTADO A LONGO PRAZO DAS GRANDES ARTRODESES ESPINOPÉLVICAS EM ESCOLIOSE. IMPORTÂNCIA DA IDADE, DA CAPACIDADE DE MARCHA E DO TIPO DE FIXAÇÃO ILÍACA

RESULTADO A LARGO PLAZO DE LAS FUSIONES LARGAS ESPINOPELVICAS EN ESCOLIOSIS. IMPORTANCIA DE LA EDAD, LA CAPACIDAD DE MARCHA Y EL TIPO DE FIJACIÓN ILÍACA

Carlos Eduardo De la Cabada[1], Jesús Burgos[1], Carlos Barrios[2], Pablo Vera[2], Eduardo Hevia[3], Ignacio Sanpera[4], Gabriel Pizá[4], Pedro Domenech[5], Luís Miguel Anton[1], Vicente Garcia[6], Pedro Cortes[7]

ABSTRACT

Objective: To determine the factors that influence lumbosacral instrumentation failures following spinopelvic fusions. Methods: A retrospective study of patients diagnosed with scoliosis who underwent spinopelvic fusion via posterior, from T2 or T3 proximally to iliac crest, using pedicle and iliac screws. Instrumentation failures were analyzed, and the association of this complication with different parameters was studied. Results: We present 44 patients, with an average age of 24 years, with different etiologies. The mean value of the largest preoperative major curve was 74.2°, and in the final review, it was 67%. The anterior-posterior imbalance, pelvic tilt, thoracic kyphosis, lumbar lordosis and lateral imbalance were significantly improved in the final review. There were instrumentation failures in 41% cases, all at the lumbosacral level. A significant association was found between increased instrumentation failures in patients over 17 years and in patients with independent walking ability. In 24 patients, a bilateral single iliac screw was used and in 20 patients, two or more screws were used. Both groups had a similar incidence of failures. In the group with two or more screws, only rod breakages occurred, without detachment or screw lysis. There was lower instrumentation failure incidence in the patients who underwent L3-S1 interbody fusion or a third rod attached with sublaminar compression hooks. Conclusions: This series had 41% instrumentation failures, all located at lumbosacral level. There were significant more instrumentation failures in patients with independent walking ability and those aged over 17 years. There was lower instrumentation failure incidence in the patients who underwent L3-S1 interbody fusion or a third rod attached with sublaminar compression hooks.

Keywords: Scoliosis; Spinal fusion; Bone screws; Treatment outcome.

RESUMO

Objetivo: Compreender os fatores que influenciam as falhas instrumentais lombossacrais depois de fusões espinopélvicas grandes. Métodos: Estudo retrospectivo de pacientes com diagnóstico de escoliose, tratados cirurgicamente com fusão espinopélvica por via posterior, realizada de T2 ou T3 até o ilíaco, com parafusos pediculares e ilíacos. As falhas instrumentais foram analisadas, além de sua associação com diferentes parâmetros clínicos e radiológicos. Resultados: Apresentamos 44 pacientes com média de idade de 24 anos, com diferentes etiologias. O valor médio da curva pré-operatória maior foi 74,2 graus, e na revisão final foi de 67%. O desequilíbrio anteroposterior e a inclinação pélvica, a cifose torácica, a lordose lombar e o desequilíbrio lateral melhoraram significantemente na revisão final. Houve falhas de instrumentação de 41%, todas na região lombossacral. Verificou-se associação significante com mais falhas instrumentais em pacientes com mais de 17 anos e nos que tinham deambulação independente. Em 24 pacientes, utilizou-se um único parafuso ilíaco bilateral e em 20 pacientes, foram usados dois ou mais. Os dois grupos tiveram incidência de falhas semelhante. No grupo de dois ou mais parafusos ocorreram apenas quebra de hastes, sem perda da ancoragem ou lise. Os implantes intersomáticos de L3 a S1 ou amarrias sublaminares com uma terceira haste diminuíram a incidência de fracassos. Conclusões: Nesta série ocorreram 41% de falhas instrumentais, todas localizadas na região lombossacral. Os pacientes com capacidade de marcha independente e com mais de 17 anos tiveram significantemente mais falhas instrumentais. Nos pacientes submetidos à fusão intersomática de L3-S1 ou com uma terceira haste com amarrias sublaminares, a incidência foi reduzida.

Descritores: Escoliose, Fusão vertebral, Parafusos ósseos, Resultado do tratamento.

RESUMEN

Objetivo: Conocer los factores que influyen en los fracasos instrumentales lumbosacros después de fusiones espinopélvicas largas. Método: Estudio retrospectivo de pacientes diagnosticados con escoliosis, tratados quirúrgicamente por vía posterior, realizándo se fusión espinopélvica de T2 o T3 a ilíaco, utilizando tornillos pediculares e ilíacos. Se analizaron los fracasos instrumentales y su asociación con diferentes parámetros clínicos y radiológicos. Resultados: Se presentan 44 pacientes con edad promedio de 24 años, con diferentes etiologías. El valor promedio preoperatorio de la curva mayor era de 74,2º, y en la revisión final la corrección promedio fue 67%. El desequilibrio anteroposterior y la inclinación pélvica, la cifosis torácica, la lordosis lumbar y el desequilibrio lateral mejoraron significativamente en la revisión final. Hubo 41%

1. Orthopedic Surgery and Traumatology, Hospital Universitario Ramón y Cajal de Madrid, Spain.
2. Orthopedic Surgery and Traumatology, Universidad Católica de Valencia, Spain.
3. Spinal Surgery Unit, Hospital La Fraternidad Muprexpa de Madrid, Spain.
4. Traumatology and Pediatric Orthopedics Service, Hospital Universitario Son Espases de Palma de Mallorca, Islas Baleares. Spain.
5. Pediatric Traumatology and Orthopedics Unit, Hospital General Universitario de San Juan de Alicante, Valencia, Spain.
6. Orthopedic Surgery and Traumatology, Hospital de Alcazar de San Juan, Ciudad Real, Spain.
7. Vertebral Spine Unit, Hospital Virgen de la Candelaria de Santa Cruz de Tenerife, Spain.

Study conducted at the Orthopedic Surgery and Traumatology, Hospital Universitario Ramón y Cajal de Madrid. Spain.
Correspondence: Hospital Universitário Ramón y Cajal Carretera de Colmenar Viejo km. 9100 2803. Madrid. Spain.

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de fracasos de instrumentación, todos a nivel lumbosacro. Se encontró asociación significativa con más fracasos instrumentales en mayores de 17 años y en los que tenían deambulación autónoma. En 24 pacientes, se utilizó un solo tornillo ilíaco bilateralmente y en 20 pacientes, dos o más. Los dos grupos tuvieron una incidencia similar de fracasos. En el grupo de dos o más tornillos solo existieron roturas de barras sin desanclajes, ni lisis. El uso de implantes intersomáticos de L3 a S1 o cerclajes sublaminares con una tercera barra disminuyó la incidencia de fracasos. Conclusiones: En esta serie se presentaron un 41% de fracasos instrumentales, todos localizados a nivel lumbosacro. Los pacientes con capacidad de deambulación autónoma y mayores de 17 años presentaron significativamente más fallas instrumentales. En los que se realizó fusión intersomática L3-S1 o una tercera barra con cerclajes sublaminares, disminuyó la incidencia.

Descriptores: Escoliosis; Fusión vertebral; Tornillos óseos; Resultado del tratamiento.

INTRODUCTION

Initial attempts at spinopelvic fusions without instrumentation have failed[1] due to the poor quality of sacral fixation and to the great mechanical stresses that exist at this level. After confirming the poor results of instrumented fusions ending in the sacrum, instrumented inclusion of the pelvis in long spinal fusions[2] became more common, achieving a more rigid fixation and improving correction of imbalance and pelvic tilt.[3]

With the aim of achieving a solid spinopelvic fusion, *numerous techniques have been developed and currently continue to be proposed*.[4-6] The existence of so many techniques reflects the lack of a single pelvis anchor system that can satisfy the high mechanical requirements of these fusions, preventing instrumentation failures and losses of correction, which are not uncommon in these long assemblies with great mechanical stresses.

Initially the Galveston system was widely used, but it was shown that it caused an unacceptable number of pseudoarthroses and its use was is longer recommended.[7] Currently, the most widespread and most widely used technique for spinopelvic fusion is the bilateral iliac screw, and numerous biomechanical and clinical studies demonstrate the superiority of this distal anchorage system when compared to previous techniques, especially the Galveston system.[8-12] Iliac screws are easier to place, but lysis[13,14] and implant failures in the spinopelvic connection[15,16] are not uncommon. Classically, the literature presents a high percentage of non-fusion following long spinopelvic fusions[17] and these percentages have not been significantly reduced by the use of iliac screws, so that nowadays it continues to be a surgical technique that involves a high number of reinterventions, both in primary and revision fusions.[18]

There have been few studies analyzing the long term results of long spinopelvic assemblies using pedicle and iliac screws. In this study, we analyze the radiological results in patients with scoliosis who underwent spinopelvic fusion using pedicle and iliac screws, evaluating the influence of walking ability, age, number of iliac screws used, use of posterior interbody implants, and use of a rod with sublaminar compression hooks in the case of spinopelvic nonunion. Our objective was to analyze a series of scoliosis patients who had undergone spinopelvic fusion, seeking to identify the factors associated with lumbosacral instrumentation failures in order to improve the outcomes of this surgical technique.

MATERIAL AND METHODS

We conducted a retrospective study of all patients diagnosed with scoliosis, who had not undergone any prior surgical treatment, and who were submitted to an isolated posterior approach spinopelvic fusion from a proximal thoracic level (T2 or T3), in a single surgery, using pedicle and iliac screws. A total of 44 patients were submitted to the surgical technique described - 17 males and 27 females - with an average of 23.9 years of age at time of surgery (R: 10-66). The etiology of the scoliosis was Cerebral Palsy (n=12), Idiopathic (n= 7), Congenital (n= 6), Myelomeningocele (n= 4), Degenerative (n= 3), Neurofibromatosis (n=2), Spinal atrophy (n=2), Marfan syndrome (n=2), and the remaining six with different etiologies (Mitochondrial myopathy, Crouzon syndrome, Down's syndrome, Myopathy, Poliomyelitis, and Arthrogryposis). (Table 1) There were 15 patients who could not walk, five who needed external assistance to walk, and 24 who could walk without help.

The indication to perform proximal thoracic fusion on patients with lumbar and thoracic-lumbar curves was based on the existence of a thoracic curve with a Cobb angle of more than 45º and/or a significantly altered lateral thoracic plane. In the thoracic or thoracic--lumbar curves of the ambulatory patients, spinopelvic fusion was performed when there were advanced degenerative changes at the distal lumbar levels and it was not possible to leave at least two distal levels of lumbar mobility to avoid premature disc degeneration, when pelvic tilt was greater than 15º, and in neurological scoliosis in non-ambulatory patients.

Surgical technique: The vertebral column was exposed at the planned levels by a posterior longitudinal incision, as far as the outer limits of the transverse apophysis, the sacral wings, including the posterior arch of S2, and the iliac crests as far as the posterior superior iliac spines. The external side of the wing of ilium was left exposed four or five centimeters on the outside for orientation during the insertion of the iliac screws, and also to expose the ilium distally enough to allow comfortable palpation of the sciatic notch and placement of the iliac screws proximally to the notch without damaging it. Once the exposure was complete, the instrumental introduction began with placement of the bicortical S1 pedicle screws using the freehand technique. These S1 screws, which like other pedicle screws used in the lumbar spine, are always polyaxial to reduce spondylolisthesis, facilitate the posterior placement of the 5.5 mm diameter bar into the pedicle and iliac screws. Once the S1 screws are in place, the ideal entry point for the iliac screw, proximally to the posterior superior iliac spine, can be easily visualized to facilitate connection of the iliac and lumbosacral screws to the bar. An iliac screw shorter and smaller in diameter than the maximum available was used to facilitate its exchange for another thicker and longer one, if later required. The iliac screws should preferably be variable angle, as this facilitates connection to the rod. If more than one iliac screw is going to be attached on each side, the first should be more distal, and directed toward the anterior superior iliac spine, just above the sciatic notch. Once the first iliac screw is in place, the second and/or successive one(s) are placed at an entry point separate from the first, to prevent the end of the screw, which is thicker, coming into contact with the head of the previous screw and thus weakening its bone anchor. Once the iliac screws were implanted, the pedicle screws were placed bilaterally at all the planned vertebral levels, using the freehand technique. Generally, in adults, screws of 6.5 millimeters in diameter and 50 to 55 millimeters in length are used in the lumbosacral spine, of 5.5 millimeters in diameter and 45 millimeters in length in the entire thoracic spine and middle and lower dorsal spine, and of 35 to 40 millimeters in the proximal thoracic spine. Neurophysiologic monitoring of the screws was performed according to the following method: EMG stimulation, with a series of impulses to the thoracic screws, stimulating the trajectory, and with EMG in the lumbar and iliac regions. Subsequent to neurophysiologic control of the screws, radioscopic control of the screws was conducted, beginning with the distal and proximal anterior-posterior plane, and if any screw was found, in the imaging, to be improperly placed, or if there was any doubt about its proper placement having changed, the neurophysiologic monitoring and imaging control were repeated after altering its position.

At this time, Smith-Petersen osteotomies and foraminal decompressions were performed if they had been planned. The rods were then placed, after cutting them to the appropriate length and shaping them according to the necessary requirements. At the lumbosacral

Table 1. The etiology of scoliosis.

P	ES	S	AS	M	1.2.3	PT	VA	IM	COBB	IF	CRC	MO	RB	LST	LS	LC
1	Idiopathic	M	34	84	1	<15°	T12-l4/l2	No	58°/11°/11°	L3-l4 and l4-l5 and one cage per level	Hook/l3-l5		No	No	No	No
2	Congenital	M	12	63	1	<15°	T8-l3/t11 left	4,8-5,2/1,2-4,3	88°/41°	No	No	8	L2-l3	No	No	No
3	Mitochondrial myopathy	M	14	73	1	<15°	T4-t12/t8	No	64°/13°	No	No	12	S1--iliac	No	No	No
4	Myelomeningocele	V	13	43	3	54°/16°	T10-l4/l2	28-0/6-0	93°/18°	No	No	16	No	No	No	Right iliac screw
5	Congenital	V	17	64	1	<15°	T12-l5	4,5-5,7/2,1-3,2	40°/12°	L5-s1 one cage	Hook l3-l5		No	No	No	No
6	Congenital	M	16	54	1	<15°	T3-l1	8,9-6,7/5,1-4,2	79°/48°	No	No		No	No	No	No
7	Neurofibromatosis	M	27	90	1	<15°	T4-l3/t11	No	82°/33°/39°	No	No		No	No	No	No
8	Hurler	V	21	63	1	<15°	T11-l2/l1	No	42°/9°/12°	L3-s1 one cage in both proximals and two in the distal	No		No	No	No	No
9	Marfan	M	36	52	1	<15°	T11-l4/l1	No	67°/23°/27°	L4-s1, one boomer-ang per level	No	35	L3-l4	No	No	No
10	Cerebral palsy	V	14	51	3	80°/7°/26°	T5-l4t11	7,3-5,2/2,4-3,3	93°/18°/17°	No	No		No	Severe bilateral lysis	Severe bilateral	Right iliac screw
11	Cerebral palsy	V	15	49	3	15°/06°/06°	T4-l1/t9	4,1-6,7/3,2-7,5	78°/21°/29°	No	No		No	No	No	No
12	Cerebral palsy	V	12	50	3	27°/09°/20°	T11-l4/l2	18-12/7,6-1	52°/6°/11°	No	No	9	Distal s1 on the right	Severe right iliac	Severe right iliac	No
13	Cerebral palsy	M	14	66	2	<15°	T11-l5/l2	<2-7,5/<2-6,1	59°/8°/8°	L5-s1 one cage	No		No	Severe left iliac	Severe left iliac	No
14	Myelomeningocele	V	14	56	2	34°/13°	T10-l3/l1	18-15/3,1-7,6	88°/19°/24°	No	No		No	No	No	Right iliac screw
15	Cerebral palsy	V	16	83	3	19°/11°/12°	T7-l3/t11	<2-4,5/3,1-8,4	62°/16°/21°	No	No		No	No	No	No
16	Myelomeningocele	V	13	54	3	38°/13°	T8-l5/t12	35-3,6/6,3-2.9	96°/33°/39°	No	No		No	No	No	No
17	Polymalformative syndrome	V	17	44	3	25°/10°/12°	T6-l5/t11	17,4-8,6/0,8-6,0	78°/21°/25°	No	No		No	No	No	No
18	Cerebral palsy	M	11	54	3	32°/12°/14°	T10-l5/l1	3,6-8,7/5,1-2,8	124°/49°/54°	No	No		No	No	No	No
19	Cerebral palsy	V	17	97	2	24°/18°/22°	T10-l5/t11	9,2-18,2/7-11.4	59°/21°/22°	No	No	8	S1-l5 right	L4-l5	L4-l5	No
20	Spinal atrophy	M	16	76	3	14°/05°/05°	T4-l3/t10	6,6-1,9/0,3-2.2	76°/24°/29°	No	No		No	N0	N0	No
21	Myelomeningocele	V	16	30	3	39°/5°/5°	T11-l4/l1	3,3-16,6/3,4-2,3	90°/14°/19°	No	No		No	No	No	No
22	Congenital	M	10	81	1	23°/18°/19°	T9-l5/l1	2,3-3.7/0,2-4,2	56°/35°/43°	L5-s1 one cage	No		No	No	No	N0
23	Degenerative	M	43	95	1	<15°	T12-l4/l1	3,1-4,9/0,2-2,3	43°/9°/9°	Yes from l2 to s1 (one cage per level)	No		No	No	No	No
24	Arthrogryposis	M	14	216	3	21°/10°/10°	T8-l5/l1	3.5-0/0.7-3.9 (Imbalance ap. l, preop and postop)	87°/41°/49°	No	No hooks		No	No	No	No
25	Degenerative	M	66	211	1	<15°	T11-l4/l2	1,7-7,9/2,1-3,3	56°/12°/24°	L4-s1: 5 cages	No	6	L3-l4	No lysis	No	No
26	Degenerative	M	42	30	1	<15°	T9-l3/l1	No	61°/16°/16°	No	No	8	L5-s1	No	No	No
27	Crouzon	M	15	27	1	<15°	T8-l4/t12	7,1-16,0/0-4,8	67°/16°/20°	No	L3-l5		No	No	No	No
28	Idiopathic	M	38	26	1	<15°	T10-l3/l1	No	53°/9°/12°	No	Two rods - l2-s1 and l3-s1		No	No	No	No
29	Cerebral palsy	M	17	32	2	19°/09°/09°	T7-l5/t12	8,2-7,6/2,0-2,1	60°/26°/29°	L3-s1 cages (5)	No		No	No	No	No
30	Idiopathic	V	17	32	1	<15°	T9-l4/l1	No	67°/6°/9°	L3-s1 cages (5)	No		No	No	No	No
31	Cerebral palsy	M	15	36	3	50°/15°/19°	T5-l4/t12	14,8-12,2/4,5-5,1	135°/48°/52°	No	No		No	No	No	No
32	Cerebral palsy	M	13	25	3	18°/03°/03°	T10-l4/l1	12,4-4,8/3,2-0	74°/12°/16°	No	No		No	No	No	No
33	Neurofibromatosis	V	20	28	1	<15°	T10-l4/l1	No	59°/12°/14°	L3-l4 : 2 cages	One rod 2-l4	5	L5-s1	No	No	No
34	Down's syndrome	M	15	28	1	<15°	T11-l4/l2	No	57°/10°/10°	L3-l4 (boomerang)	No	5	L4-l5	No		S1
35	Idiopathic	M	41	41	1	<15°	T9-l4/l1	No	63°/18°/18°	L4-l5 and l5-s1(one cage per level)	No		No	No	No	No
36	Congenital	M	43	38	1	<15°	T11-l4/l2	1,8-4,3/0,5-0,7	72°/21°/28°	1 cage:l3-l4	No	7	L5-s1	No	No	No
37	Idiopathic	V	41	38	1	<15°	T9-l4/l1	No	121°/32°/39°	No	No	6	L5-s1	No	No	No
38	Poliomyelitis	M	45	76	1	<15°	T5-l3/l1	3,5-1,1/0,2-4,5	64°/29°/33°	No	No		No	No	No	No
39	Cerebral palsy	M	41	35	2	<15°	T12-l5/l3	8,3-11,7/3,5-5,2	66°/27°/34°	L4-l5: 2 cages	Rod l4-s1		No	No	No	No
40	Myopathy	M	15	27	3	<15°	T7-l3/t11	4,9-2,8/1,8-2,7	55°/14°/14°	No	No		No	No	No	No
41	Idiopathic	M	36	32	1	<15°	T11-l4/l1	3,8-0/1,1-07	119°/22°/26°	No	No	11	L4-l5	No	No	No
42	Spinal atrophy	V	13	25	3	24°/06°/07°	T10-l4/l1	3,6-4,6/2,8-2,7	84°/13°/15°	No	Rod connected from the right of l1 to the distal of s1		No	No	No	No
43	Cerebral palsy	M	36	29	1	<15°	T11-l3/l2	13,6-21/2,1-4,4	110°/36°/39°	No	No	17	L4-l5	No	No	No
44	Idiopathic	M	50	30	1	<15°	T5-t12/t8	2,1-10/0,3-09	69°/13°/15°	No	No	5	L4-l5	No	No	No

P: Patient; ES: Etiology of scoliosis; S: Sex; AS: Age at time of surgery; 1.2.3: Walking, Walking with assistance, Not walking; PT: Pelvic tilt – Preop/Postop/Final; VA: Vertebrae limits/apex; IM: Imbalance, ap (>2cm)-l(>4cm) (preop/final); COBB: Cobb, ap preop/postop/final; IF: Interbody fusions (levels/no. cages); CRC: Central rod and compression hooks (no./levels); MO: Months from operation - breakage; RB: Rod breakage: level; LST: Lysis of screws: indicate screw type; LS: Lysis of screws; LC: Loosening of connections: level.

level, the rod was shaped with the help of lordosis hooks because it is usually impossible to achieve such a sharp angle with a French rod bender. The rods were placed in a distal to proximal direction using iliac screw connectors and progressively lowering the rod with the nuts of the spondylolisthesis reduction screws. We used scoliosis hooks for each rod as needed, to achieve the optimal correction. Similarly, a coplanar system was used in the convexity to correct the scoliosis. To complete the surgery, a local spongy graft extracted after bleeding the exposed spinal column was always used, obtained in decompressions and Smith-Petersen osteotomies and from the iliac crests proximally to the iliac screws.

When arthrectomies for neural decompression were performed, interbody cages or a third rod with compression hooks were used on the lumbosacral spine, at the surgeon's discretion.

Before proceeding with the surgical closure, long cassette anterior posterior radiographies were taken to assess final vertebral imbalance and to correct any imbalance before completion of the surgery.

None of the patients used postoperative orthosis.

Radiological review included anteroposterior and lateral teleradiography in a standing position or seated when the patients were not able to stand. Radiographs were requested preoperatively, immediately following surgery, at three months, at six months after surgery, and then every six months during the first two years and thereafter, on an annual basis, except in cases where patients had symptoms that warranted a new radiological study. In those cases where implant failure was confirmed (rod breakage, detachment or lysis of the screws) the previous radiograph was used as the final radiograph.

The following parameters were analyzed in the teleradiographs of the spine: whether the patient was immature according to the Risser score, the degree of the largest scoliotic curve indicating the vertebrae of the outer limits of the curve, the apex of the deformity, the Cobb angle, and spinal rotation according to Perdriolle. In the lateral plane, the Cobb angles of the thoracic spine from T5 to T12, and the lumbar lordosis from T12 to S1 were studied. Likewise, the pelvic tilt of the line formed horizontally by the highest points of the iliac crest, the imbalance values on the anteroposterior plane (distance from the center of the spinous of C7 to the center of S1), and the lateral vertebral imbalance from the posterosuperior angle of S1 to the center of the body of C7 were studied. The number of iliac screws used on each side was recorded. The "final" radiological parameters were those obtained at the end of follow-up, and in cases of rod breakage, lysis of the screws, or detachment of the implants, these parameters were obtained from the last radiograph taken prior to the rod breakage and/or detachment. Implant failure (pseudoarthrosis) was defined as evidence of rod breakage and/or detachment of connections and/or lysis of screws in the radiological study. In the presence of lysis, the levels produced were rated according to Yazici et al.19: grade 1, no radiolucency; grade 2, 1 mm; grade 3, 1-2 mm; grade 4, > 2 mm.

The relationships between screw lysis and/or detachment and/or rod breakage and age at the time of surgery, the etiology of the scoliosis, walking ability, level and severity of the scoliosis, previous use of interbody implants and/or central rods with sublaminar hooks, and the use of one or more iliac screws on each side were studied.

Two of the authors conducted radiological analysis and, when there were differences, the parameter was revised jointly to arrive at a consensus.

The SPSS 12.0 for Windows program (SPSS Inc., Chicago, IL) was used for statistical analysis. All the data was presented for statistical analysis. All the data was presented as mean ± SD or frequency. Discrete variables were analyzed using the χ^2 test, whereas continuous variables were analyzed using one way variance analysis. All tests were performed bilaterally and a value of $p<0.05$ was considered statistically significant.

RESULTS

The cases without implant failures had an average follow-up period of 57 months (R: 25-124). (Table 1)

Intraoperative and immediate postoperative results

Average surgery time was 323 minutes (R: 230-475). Average surgical bleeding was 935 cc (R: 421-2400). Two cases presented changes in the intraoperative medullary monitoring due to misplacement of thoracic pedicle screws that were resolved by repositioning of the screws, and one patient presented a loss of strength in the right quadriceps from radicular compression that required postoperative surgical decompression, with minimal loss of strength that persisted throughout the follow-up. There were three intraoperative dural lesions. Four patients had postoperative infections and required surgical cleaning without the removal of the instrumentation, and one of these patients presented chronic suppuration requiring subsequent surgical cleaning and currently continues oral antibiotic therapy. There were no cases of death.

Radiological results

In the preoperative radiographs, anterior-posterior views showed the apex of the scoliosis located in the lumbar spine in 28 (63.6%) cases and in the thoracic spine in 16 (36.4%) cases. In 26 (59%) patients the greater curve was to the left, with an average preoperative Cobb angle value of 74.2° (R: 40-135) which was reduced to 24.6° (R: 8-54) in the final review, with an average correction of 67%. The anterior posterior imbalance of the spinous of S1 to the spinous of C7 had preoperative values greater than two centimeters in 21 cases, with an average value of 7.9 centimeters (R: 0-35) and, in the final radiographic study, an average value of 3.6 centimeters (R: 0-15). Eleven had pelvic tilt greater than 15° with an average value of 14.3 centimeters (R: 0-80), and in the final study only one case had a tilt greater than 15°.

The preoperative lateral thoracic plane from T5 to T12 had angle values between 20 and +40° in 14 patients, values greater than +40° in 14 patients, and values less than +20° in 16 patients. In the final review, 31 cases had between +20 and +40°, six more than 40°, and six less than +20°, the latter two groups with near normal values.

Regarding the lateral angle value of the lumbar spine from T12 to S1, in 32 of the 44 patients these angles were between -20 and -60°, with five measuring higher and five lower. In the final radiographic review, all cases fell into the between 20 and 60° group, with the exception of one with -17°.

Seventeen patients had a preoperative lateral imbalance greater than four centimeters, with an average value of 6.1 centimeters (R: 4.2-11). In the final radiographical study, only three patients presented lateral imbalance greater than four centimeters.

Study of the lumbosacral instrumentation failures

Eighteen patients (41%) had implant failures, with an average time of 9.4 months following surgery (R: 5-20). All were located at the lumbosacral level, with the majority being rod breakage (Figure 1) in 14 cases (77%) and of these, six were bilateral in the initial radiographical study. There were two (11%) detachments of the connection of the rod with the iliac screw, two (11%) cases of lysis of the iliac screws (Figure 2), and one case (5.5%) with both detachment and lysis of the screws.

Patients younger than 17 years of age at the time of surgery had a lower incidence of implant failures, an association that was statistically significant. (Figure 1)

Seventy percent of the ambulatory patients suffered implant failures, as compared with 28% of the non-ambulatory patients, an association that was statistically significant. There was no statistical significance when comparing implant failures in ambulatory patients older and younger than 17 years (Figures 1 and 2).

No significant association was found between implant failures and the type of principal thoracic or lumbar curve, the severity of the curve, or the degree of correction. In 24 cases, one iliac screw was used on each side and in 20 cases, more than one screw was used bilaterally. Of the 24 patients with single bilateral iliac screws, ten (42%) had implant failures with the following characteristics: five (50%) broken rods, two (20%) detachments, two (20%) cases lysis of the screws, and one (10%) case of lysis of the screws together with detachment.

Of the 20 cases with more than two bilateral iliac screws, 14 had two iliac screws bilaterally, three had three screws in each iliac crest,

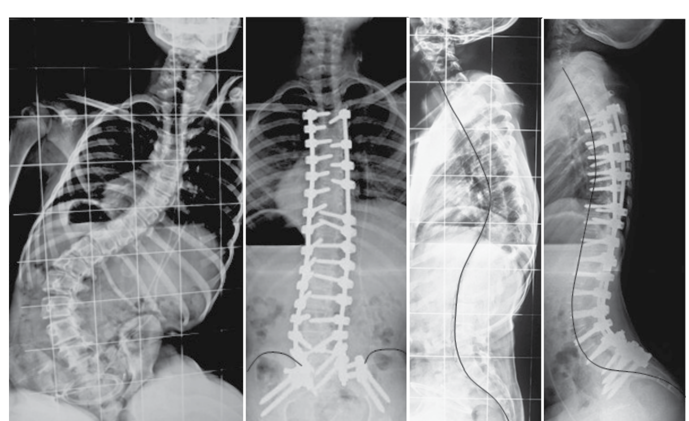

Figure 1. Girl, 13 years of age, premenarchal, diagnosed with cerebral palsy with spastic tetraparesis. Spinopelvic fusion of T3 to the ilium was performed using two bilateral iliac screws. The correction achieved was maintained without failures during control and for 25 months.

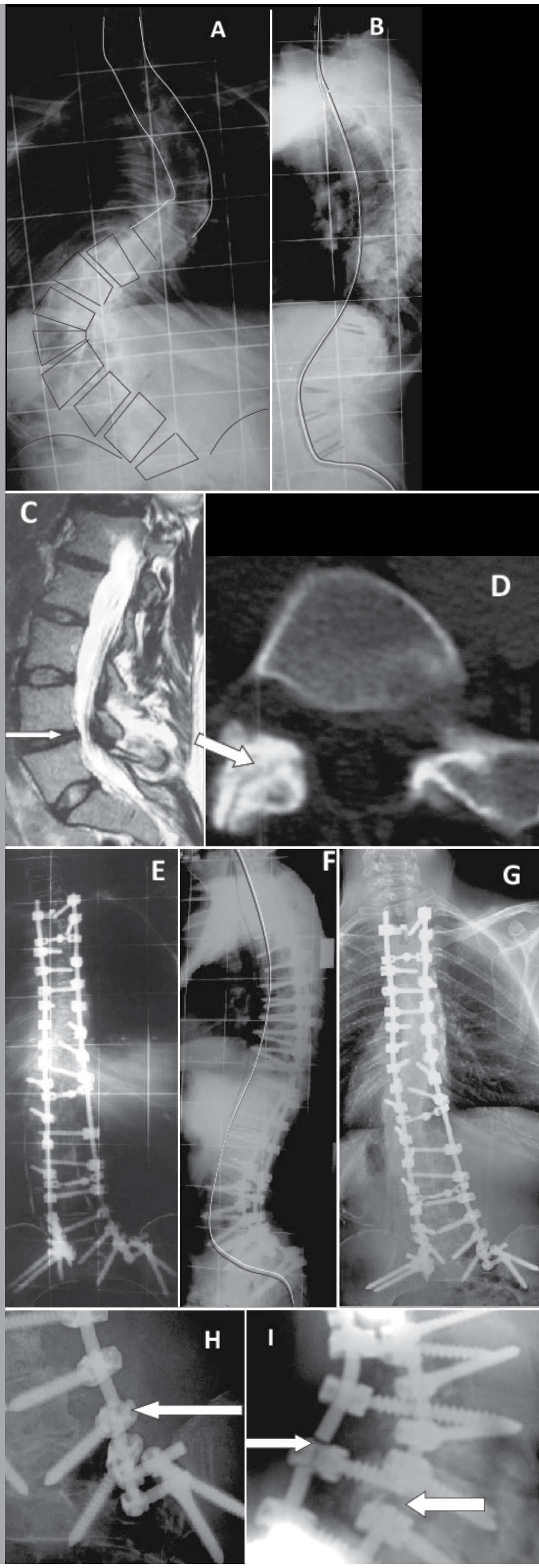

Figure 2. Patient, 39 years of age, diagnosed with idiopathic scoliosis, with bilateral lumbosciatica and chronic back pain for the previous five years. She walked normally. She presented left thoracolumbar scoliosis of 104º Cobb, with thoracic lordosis of -15º and kyphosis in the thoracic-lumbar transition (Figures 2A and 2B). There was L4-L5 discopathy with central canal and foraminal stenosis (Figure 2C) and severe bilateral L5- S1 facet joint arthrosis (Figure 2D). She underwent T2-iliac fusion surgery using pedicle screws and two iliac screws bilaterally. Postoperative control was correct, with the exception of a slight imbalance in the right trunk (Figures 2E and 2F). Twelve months after intervention, the patient noticed pain in the lumbosacral region and a crunching sound when making a forced movement. Radiography confirmed breakage of the two rods (Figures 2G, 2H, and 2I).

two had two screws on one side and three on the other, and one had three iliac screws on one side and four on the contralateral side. Of these 20 cases, nine (45%) experienced rod breakage, but there was no detachment or lysis of the screws in any case. Thus, there was statistical significance in the association of rod breakage with the use of more than two iliac screws (Figure 2). Of the 14 cases in which two screws were used bilaterally, five (35.7%) had rod breakage, and of the remaining cases, four of the six (67%) with more than four iliac screws had rod breakage. Comparing both groups with the number of implant failures, no statistical significance was found.

Of the 44 patients, in 15 (34%) of the patients who were able to walk alone underwent laminectomy for lumbar decompression distal to L2 with arthrodesis using interbody cages with autologous grafts, all with walking capability. In nine of these, interbody arthrodesis was performed at two or more levels of the lumbosacral spine and in seven of the 15 more than one cage was used per level. In four of the cases with interbody arthrodesis was associated with a rod with compression hooks. Implant failures occurred in six (40%) of the fifteen cases, however, in all cases the nonunion occurred at levels other than that with the arthrodesis. The five cases where L3 was fused to S1 experienced no implant failures.

In seven (16%) of the 44 patients, also with walking capability and who underwent decompression laminectomy, a rod with sublaminar hooks was used: in three from L3 to L5, in one from L2 to S1, in one from L2 to L4, in one from L4 to S1, and finally, in one from L1 to S1. In this group of patients one case of rod breakage occurred, with the break occurring outside the area included between the sublaminar hooks.

DISCUSSION

Based on anatomical and biomechanical studies that demonstrate the existence of an extensive anatomical area of the posteroanterior iliac spine that permits solid anchoring of iliac screws [17,19,20] and of the biomechanical improvements in the use of more than one iliac screw,[19,20] it has been proposed that the use of more than one iliac screw bilaterally improves stability and the ability to correct spinal deformities.[19,21,22]

In a previous study that presents incidence of implant failures similar to ours,[14] the incidence of failures of implants using one or two bilateral iliac screws for long fusions in patients with scoliosis of neurological etiology was evaluated, determining that the use of two bilateral iliac screws significantly reduced the number of instrumentation failures. These results do not match those of our study, in which similar percentages of complications were presented using one, two, or more iliac screws. These differences may be attributed to the fact that the etiology of patients in that series was neurological, most of them unable to walk, which would explain the lower incidence of implant failure.

We found that when we used a single screw implant, failures occurred at the distal end of the instrumentation, with detachment of the rod and lysis of the iliac screw, which did not occur when two or more iliac screws were used. On the other hand, when we used more than two iliac screws on each side, the results did not improve. On the contrary, there were a greater number of implant failures, perhaps due to the greater rigidity of the distal assembly, producing a higher number of proximal rod breakages. Based on these results, we recommend the use of bilateral iliac screws in all cases, strengthening the spinopelvic fusion with a higher number of rods or interbody fusions.

We did not find any previous study demonstrating the influence of walking ability on a greater number of implant failures. This study shows that in ambulatory patients who underwent spinopelvic fusion, the incidence of implant failure at the lumbosacral level was greater than 70%. In younger, non-ambulatory patients, the incidence of rod breakage was just under than 50%, although a comparison with the older patient group was not statistically significant.

The percentages of implant failures at the lumbosacral level in a study of ambulatory adult patients are clearly lower than ours, which may be partially attributed to the use of BMP in more than half of the patients.[22] Our results show that both interbody fusions with cages and use of a rod with sublaminar hooks decrease the incidence of failures. These satisfactory results are attributable to the fact that both interbody cages and rods with compression hooks reduce the significant flexion stresses produced on the rods in the lumbosacral spine. These stresses are due to the significant height of the most distal lumbar discs and the large lever arm located in the lumbosacral spine that supports heavy loads in movements of flexion-extension.

There was no rod breakage when a third bar with sublaminar hooks was included, or when interbody arthrodesis from L3 to S1 was performed, but the use of interbody fusions at many levels from the posterior involved longer surgery times, greater technical requirements, higher morbidity than with the use of one rod with hooks, or the need for a wide anterior approach to fuse all these levels. Therefore, our recommendation is the use of one rod with sublaminar hooks from the proximal lumbar or distal thoracic levels to the most distal lamina. We found that the lamina of S1 is often not very solid, preventing secure anchorage of the rod at this level. In these situations, the use of a rod with the distal hook anchored to the lamina of L5, and performing interbody arthrodesis in L5-S1, may be justified, or to avoid interbody arthrodesis from posterior, the inclusion of a fourth and even a fifth rod placed in parallel to the two conventional rods anchored proximally in the dorsal spine and at the most distal end of the rod, beyond the iliac screws, with domino connectors.

CONCLUSIONS

In this series, instrumentation failures occurred in 41% of cases, all at the lumbosacral level. Patients older than 17 years of age and capable of walking by themselves presented significantly more instrumentation failures. The incidence was lower in those who had undergone interbody L3-S1 fusion, or who had a third rod with sublaminar cerclage.

All authors declare no potential conflict of interest concerning this article.

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