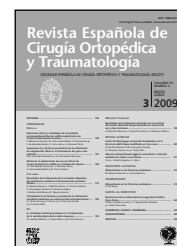




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ORIGINAL PAPERS

Adolescent idiopathic scoliosis: Results of treatment with hybrid posterior instrumentation

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KEYWORDS

Adolescent idiopathic scoliosis;
Hybrid posterior instrumentation;
SRS-22 questionnaire

Abstract

Purpose: Report on the clinical and radiological results obtained by surgical treatment of adolescent idiopathic scoliosis by means of hybrid posterior instrumentation. The repercussions of surgery on the patients' quality of life are also described.

Materials and methods: Retrospective study of 26 patients operated between 2001 and 2006, with a mean follow-up of 37.8 months. In terms of the Lenke classification, 42.3% of patients had type 1 curves, 46.2% type 3 curves, 7.7% type 5 curves, and one case of type VI curves. All patients were subjected to a hybrid posterior instrumentation with distal pedicular screws and proximal hooks. Transfusion needs and complications were duly recorded. A clinical assessment was performed by means of the SRS-22 questionnaire. A radiological assessment was conducted preoperatively, postoperatively and at the end of follow-up.

Results: There were three superficial infections, one hemothorax and one hook dislocation. The administration of the SRS-22 questionnaire produced the following mean scores: 4.41 for pain, 4.39 for activity, 3.91 for self-image, 3.98 for mental health and 3.81 for satisfaction. Mean post-surgical radiological correction for thoracic and lumbar curves was 58% and 60% respectively, with a mean loss of 7 and 5.5 degrees at the end of follow-up. There were no cases of pseudarthrosis.

Discussion and conclusions: Hybrid posterior instrumentation and fusion is an efficient and safe technique, with a low rate of pseudoarthrosis and failure. Results were good as regards pain and activity, but fair in terms of self-image and personal satisfaction. We found no statistically significant association between the patients' age, the degree of curve correction and the score on the SRS-22 questionnaire.

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PALABRAS CLAVE

Escoliosis idiopática del adolescente;
Instrumentación posterior híbrida;
Questionario SRS-22

Resultados del tratamiento de la escoliosis idiopática del adolescente mediante instrumentación posterior híbrida

Resumen

Objetivos: Describir los resultados clínicos y radiológicos así como la repercusión en la calidad de vida del enfermo tras el tratamiento quirúrgico de la escoliosis idiopática del adolescente mediante instrumentación posterior híbrida.

Material y método: Estudio retrospectivo de 26 sujetos intervenidos desde 2001 hasta 2006, con un seguimiento medio de 37,8 meses. Se obtuvieron, mediante la clasificación de Lenke de las curvas, los siguientes resultados: el 42,3% fue de tipo I, el 46,2% fue de tipo III, el 7,7% fue de tipo V y 3,8% fue de tipo VI. Se intervino a todos los sujetos mediante instrumentación posterior híbrida con tornillos pediculares distales y ganchos proximales. Se registraron las necesidades transfusionales y las complicaciones. Se realizó una evaluación clínica mediante el cuestionario SRS-22 (Scoliosis Research Society 'Sociedad de Investigación de la Escoliosis'). Asimismo, se realizó una evaluación radiológica prequirúrgica, posquirúrgica inmediata y al final del seguimiento.

Resultados: Se registraron 3 infecciones superficiales, un hemotórax y una luxación de gancho. Mediante el cuestionario SRS-22 se obtuvieron las siguientes puntuaciones medias: 4,41 en dolor; 4,39 en actividad; 3,91 en autoimagen; 3,98 en salud mental, y 3,81 en satisfacción. La corrección radiológica media posquirúrgica en las curvas torácicas fue del 58% y en las curvas lumbares fue del 60% con una pérdida media de 5,51 a 71 al final del seguimiento. No hubo casos de pseudoartrosis.

Discusión y conclusiones: La instrumentación y fusión posterior híbrida es una técnica eficaz y segura, con bajo índice de pseudoartrosis y fracasos. Los resultados fueron buenos en cuanto al dolor y a la actividad, pero fueron discretos en cuanto a la autoimagen y a la satisfacción personal. No se encontró asociación estadísticamente significativa entre la edad de los sujetos, el grado de corrección de la curva y la puntuación del cuestionario SRS-22.

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Introduction

During the last few decades there has been great advance in the treatment of adolescent idiopathic scoliosis. Substantial improvement of the correction of the deformity and progressive technological development in the field of instrumentation has been attained¹. The Harrington distraction instrumentation was a landmark in the treatment of adolescent idiopathic scoliosis², though it had disadvantages, such as incomplete correction, minimum derotation and unavoidably long fusions, all of which could generate a flat-back syndrome^{3,4}. The next step in the development of treatment was the Luque segmental instrumentation, which keeps the natural curve of the back and improves the sagittal profile by means of forces that are applied on different points⁵. Afterward, Cottrell and Dubousset tackled the difficulty obtaining curve derotation with their CD (Cottrell and Dubousset) instrumentation. Later on, pedicular screws started being used in the lumbar curves as distal anchoring, enabling the correction and stabilization of different kinds of deformity. Various studies advocate the clinical results obtained with hybrid constructs (proximal hooks and lumbar pedicular screws) as compared with instrumented hook systems^{5,6}. Some authors have applied similar techniques with thoracic pedicular screws, achieving better corrections and fewer fused areas in the

thoracic curves; however, this variant entails more risks and its benefits are therefore uncertain^{1,7,8}.

This historical development led to the present state of affairs, in which there are two chief related issues: one is the high cost of instrumentation, and the other is the lack of reliable evaluations of results that could be used in the detection of clinical differences corresponding to the improved results obtained through radiography⁸. The present day trend centers on the evaluation of results^{9,10} taking into account the patient's quality of life. The psychosocial aspect of the patient has become a key factor in the approval, evolution and prognosis of this condition^{11,14}.

The aim of this work is to examine the clinical and radiological results obtained by the surgical treatment of adolescent idiopathic scoliosis by means of hybrid posterior arthrodesis with distal pedicular screws and hooks, paying special attention to the patient's quality of life.

Materials and methods

We carried out a retrospective study of 26 patients diagnosed with adolescent idiopathic scoliosis and treated between March 2001 and January 2006; twenty patients were women. Only 4 patients (15.4%) declared having positive family

histories of scoliosis. Table 1 shows the main features of our series.

The inclusion criterion was the established indication of surgery in fully-grown patients (under Risser's stage 5) who presented curves with an over 40° Cobb angle.

All the patients underwent a presurgical anesthetic examination protocol, including a spirometry in which the totality of the values indicated surgical risk (table 1).

The patients who had been treated in 2002 (21 out of 26) were included in an autotransfusion and erythropoietin administration (Epo) program. The purpose was to obtain a minimum of 2-4 bags of red blood-cells before the surgical intervention.

Radiological assessment consisted in anteroposterior and lateral projections, on standing, that were obtained preoperatively, postoperatively and at end of follow-up¹⁵⁻¹⁹. X-rays of lateral inclination, the so-called "bending test", were also conducted with the aim of evaluating curve flexibility.

On the coronal plane the curves were measured using the Cobb method that determined the apical vertebrae and the superior and inferior end vertebrae of each curve. The rotation of the apical vertebra was analyzed in terms of the Nash and Moe classification, according to the position of the vertebral pedicles in the anteroposterior projection¹⁸. Axial misalignment was measured as the distance between the central line of the sacrum and a parallel line that crosses the spinous process of the seventh cervical vertebra (C7) (C7 plumb line). The obliquity of the last fused vertebra corresponded to the angle formed by the sacrum platform and the inferior plate of the vertebra in question.

Curves were classified in terms of the 6 types in the Lenke system¹⁶. Thoracic, lumbar or thoracolumbar curves with a lateral Cobb angle of over 25° were labeled "structural". We diagnosed 11 type I cases or major thoracic curves (42.3%), 12 type II cases or double major (46.2%), 2 type V cases or thoracolumbar (7.7%), and one type VI case or major thoracic structural lumbar thoracolumbar. There were no cases of type II or type IV curves. As regards the lumbar curve modifier

of this classification, 6 curves corresponded to type A, 5 curves to type B and 15 curves to type C.

On the sagittal plane, thoracic kyphosis was measured in degrees (the angle between the superior plate of the fifth thoracic vertebra and the inferior plate of the twelfth thoracic vertebra [T12]) and so was lumbar lordosis (the angle between the T12 inferior plate and the superior plate of the first vertebra of the sacrum [S1]). 5 hyperkyphoses (19.2%), 19 normokyphoses (10° - 14° kyphosis) (73.1%) and 2 hypokyphoses (7.7%) were diagnosed.

The number of areas to be fused was decided preoperatively and according to the type of curve, and King's classical method was followed¹⁵. In the lumbar zone, fusion of the segments of the fourth and fifth lumbar vertebrae (L5) was avoided, as well as that of the L5 and S1. This procedure was chosen whenever it was possible and with the aim of preserving mobility.

All the patients were treated by means of hybrid posterior arthrodesis with distal pedicular screws and proximal hooks (figs. 1 and 2). The instrumentation system used was the Moss Miami® (DePuy) system in 13 cases and the Monarch® (DePuy) system in 13 other cases. First, the pedicular screws were inserted in the lumbar or low thoracic zone, after localizing the adequate anatomical references^{1,20-22}; confirmation was obtained by means of an intraoperative fluoroscopy. Next, the bearing surfaces were drilled to receive the hooks on the concave side. This procedure began on the concave side of the major curve (usually the thoracic curve) in the stable vertebra above the superior end vertebra, and 2 pedicular hooks oriented toward the proximal vertebra were applied 2 vertebrae downwards. A third hook was inserted in the direction of the distal vertebra in the apex or in the vertebra beneath it. Subsequently, the concave rod, which was premodeled according to the physiological thoracic kyphosis and lumbar lordosis curves, was used to perform distraction on the different pathological segments and, according to each case, carry out derotation and in situ torsion maneuvers with the aim of achieving the best possible correction of the deformity. The next step consisted in the implantation

Table 1 Description of the series

Data

n = 26

Gender	20 women (77%)	6 men (23%)
Scoliosis family history	4 patients (15.4%)	
Risser scale	Grade 3:5 (19.2%)	Grade 4:21 (80.8%)
Age at surgery	15.38 ± 0.8 years (range: 14-17)	
Weight in kg	61.68 ± 15.04 (range: 40.5-94.1)	
Spirometry		
FVC (%)	86.65 ± 8.2	
Absolute FVC	3.6650 ± 0.8l	
FEV1 (%)	81.46 ± 7.9	
Absolute FEV1	2.9 ± 0.55l	
Follow-up time (months)	37.81 (range: 12-73)	

FVC: forced vital capacity; FEV1: forced expiratory volume at second 1.

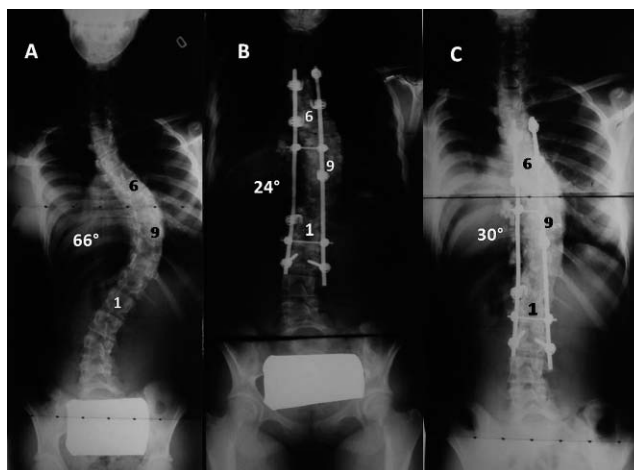


Figure 1 Coronal correction in a patient with a Lenke type I curve. Both the angles corresponding to the curves according to Cobb and the limiting vertebrae are shown (sixth thoracic vertebra and first lumbar vertebra), and the apex (ninth thoracic vertebra). A) Preoperative x-ray. B) Postoperative x-ray. C) At 3 years. An immediate 63% correction was obtained that descended to 54% after the loss of a 6° correction and its subsequent stabilization. The bending test yielded a correction of 48° (27% lateral correction). There were no cases of nonunion.

of hooks on the convex side. Usually the system was closed with a hook (laminar or transverse) oriented toward the distal vertebra in the stable vertebra above the superior end vertebra and another hook in the direction of the distal vertebra in the apical vertebra, and subsequently compression maneuvers of the curve were carried out after applying the rod (also physiologically premodeled).

The mean number of fused areas was 11.92 ± 1.3 (range: 10-14) and the mean number of hooks and screws used was 9.77 (6.15 ± 1.008 hooks and 3.62 ± 0.62 screws). The highest fused area was the third dorsal vertebra and the lowest was the L5. In all the cases, the autologous graft used proceeded from the fused vertebrae submitted to cruentation, mixed with iliac crest allograft bone (10 patients), bone bank allograft (7 patients) or synthetic bone substitute (10 patients); in one case both bank allograft and the synthetic substitute were used.

Mean surgical time was 227 min. (range: 180-300). Absence of nervous or radicular damage was confirmed in all the patients by means of motor and sensitive tests at immediate post-op. Antibiotic treatment according to protocol was administered (1 g/8 h cefuroxime or 1 g/8 h cefazoline during 2 days).

Hemoglobin and hematocrit drops were recorded, as well as the cases that needed transfusions, the time that each patient used the analgesia pump, the appearance of complications and hospital stay time.

During the 6 months following surgical treatment, patients used a thoracolumbar corset and developed an increasing, moderate activity. Mean follow-up time was 37.81 months (range: 12-73) and it was carried out by the outpatients service.

The SRS-22 (*Scoliosis Research Society*) questionnaire was administered to all the patients. This questionnaire, which is widely used and has a validated Spanish adaptation, evaluates the repercussions of surgery on the patients' quality of life^{9,14,23-26}.

The recollection of data and the statistical analyses were carried out with the SPSS 11.5.1 program by an outside researcher. Student's T test for independent samples was used to assess the relationship between curve type (according to Lenke), gender, the appearance of complications and the results of the SRS-22 questionnaire (only the 11 type I curves and the 12 type III curves that make up 88% of the sample were analyzed). The Spearman correlation coefficient was used in the analysis of the possible relation between age, curve magnitude, final correction of the major curve in degrees, final correction percentage of the major curve and the scores on the SRS-22 questionnaires.

Results

After surgery the patients received morphine via the analgesia pump during 5.08 ± 2.45 days (range: 2-10). Mean hemoglobin drop was 5 points (from 13.8 to 8.5 grams/dl) and the hematocrit drop rate was 15% (from 40.09 to 25.63%). Red blood cell concentrates were transfused in 76.9% of the patients, 4 of these being homologous concentrates (3 were conducted prior to the autotransfusion protocol) and the remaining 17, autogenous concentrates (85% of the transfusions, 65.4% of the total number of cases under study). Only one young female required autogenous and homologous blood. The mean number of red blood cell concentrates per patient was 2.5 ± 1.84 (range: 0-6) (750 ± 552 cm³). Iron was administered intravenously in 2 cases and orally in one case. Mean hospital stay was 12.65 ± 2.11 days.

No neurologic complication was recorded. One subject developed a nosocomial pneumonia that was cured with no additional complications. A young female patient presented with a left hemothorax diagnosed 14 days after surgery, almost at discharge, after a dyspnea that evolved

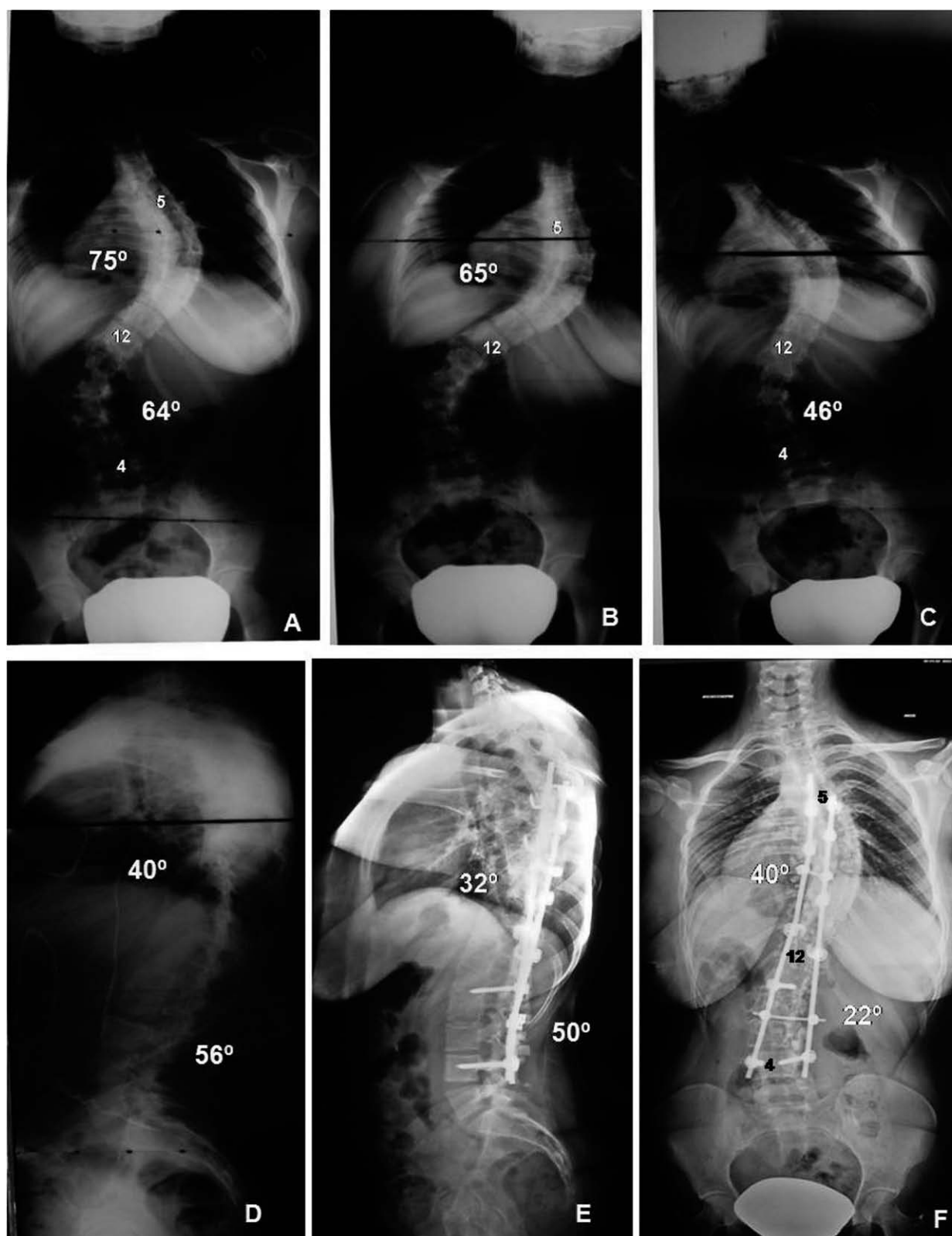


Figure 2 Radiographic evolution of the case with double major scoliosis (type III, according to Lenke) in a 14-year-old female. The corresponding Cobb angles and the end vertebrae are shown. A) Anteroposterior pre-op x-ray. B) and C) Anteroposterior lateral inclination x-ray. A 10° correction (13.3%) in the thoracic curve is shown and another of 18° in the lumbar curve. D) Lateral x-ray showing lumbar hyperlordosis and normokyphosis. E) Lateral x-ray 60 months after treatment, with an 8° decrease in the thoracic kyphosis and of up to 50° in the lumbar lordosis. F) Anteroposterior x-ray 60 months after treatment. Final 46.7% correction of thoracic curve and 68.7% correction of lumbar curve, at 60 months. Good axial alignment and signs of solid fusion are shown

satisfactorily after treatment with pleural drainage and video thoracoscopy. This was the only patient that required homologous as well as autogenous red blood cell concentrates. Three patients presented with superficial infections that were cured with topical treatment. One young female patient presented with a dislocation of one of the hooks that close the proximal end of the convexity rod. This complication was diagnosed 6 months after surgical treatment and did not involve any reduction loss or damage of stability. We delayed taking a decision until a full consolidation of arthrodesis had been obtained and we then removed the hook and cut off the piece of rod that protruded into the subcutaneous tissue. There were no implant breakages. We found no cases of nonunion, according to the criteria of localized pain associated to radiologic continuous solution signs or radiolucent zone in the fusion area²⁷.

The results obtained from the SRS-22 questionnaire are described on Table 4. The figures for pain and activity (4.41 and 4.39 out of a maximum of 5, respectively) were good, but the ones for mental health (3.98), self-image (3.91) and satisfaction (3.81) were somewhat inferior.

When the patients were asked if they would undergo surgery once again in the case of finding themselves in the same situation (question 22), one patient answered that he would certainly not, 5 patients were unsure, 16 patients declared that they probably would (61%) and 4 patients answered that they certainly would (15%). None of the patients declared taking pain-relievers for back pain, and only one was hindered in his everyday activities by difficulties in the spinal column.

Table 2 shows the radiologic correction values of the deformity on the coronal plane. The two v curves (thoracolumbar) were included within the thoracic curves with the global analysis in mind. The only type VI scoliosis (major thoracic thoracolumbar/lumbar structural) was included in the lumbar curve group. Data on preoperative kyphosis was added on the table with an orientational purpose. Mean post-op correction was 58% for thoracic curves and 60% for lumbar curves. Loss of correction was reflected in the slight losses of translation of the apical and end vertebrae, as well as in a final axial balance that was somewhat inferior to the one obtained initially after surgery. The obliquity of the last fused vertebra presented

Table 2 Radiographic coronal analysis

n = 26	Thoracic curves				Lumbar curves			
	Minimum	Maximum	Medium	Standard deviation	Minimum	Maximum	Medium	Standard deviation
Cobb (°)	40	75	48.85	10.368	34	66	45.08	11.361
Cobb Post-op	5	46	20.38	10.462	6	45	18.15	10.723
%Post-op correction	23.81	87.80	58.9496	18.63285	31.82	86.67	60.6883	16.47524
Final Cobb %	10	50	27.42	9.462	8	46	23.85	10.777
Final correction %	14.29	75.00	44.0502	14.97660	30.30	81.82	47.9388	15.17724
Correction loss (°)	0	13	7.04	3.352	1	13	5.54	3.755
Loss %	0	31.71	14.8994	7.96860	1.52	28.89	12.5128	7.54782
bending test (°)	16	64	35.12	10.930	25	51	31.77	9.951
bending test %	4.35	60.98	28.3929	14.91833	11.11	44.44	29.7569	9.73280
Apex translation (mm)	10	75	32.32	14.072	8	40	26.00	10.708
Post-op apex translation	0	48	13.15	11.298	2	32	12.67	12.138
Final apex translation	0	48	14.35	10.091	2	32	12.75	11.663
SEV translation (mm)	0	36	14.12	8.692	0	30	12.38	8.656
Post-op SEV translation	0	32	8.35	7.076	0	31	6.77	8.238
Final SEV translation	0	32	10.08	7.589	0	31	6.85	8.184
IEV translation (mm)	0	32	13.35	9.024	4	30	14.46	8.058
Post-op IEV translation	0	26	7.73	6.558	0	20	9.00	6.795
Final IEV translation	2	28	9.85	7.303	0	21	9.62	7.321
Axial misalign-ment (mm)	2	30	16.71	7.564				
Post-op axial misalignment	2	28	10.67	6.468				
Final axial misalignment	2	28	13.19	6.954				
LFV obliquity (°)	6	35	16.15	6.246				
Post-op LFV obliquity	0	13	6.46	3.190				
Final LFV obliquity	0	13	6.46	3.420				
Pre-op Kyphosis	8	55	32.42	11.680				
Fused areas	10	14	11.92	1.354				

Post-op: postoperative; Pre-op: preoperative; IEV: inferior end vertebra; SEV: superior end vertebra; LFV: last fused vertebra.

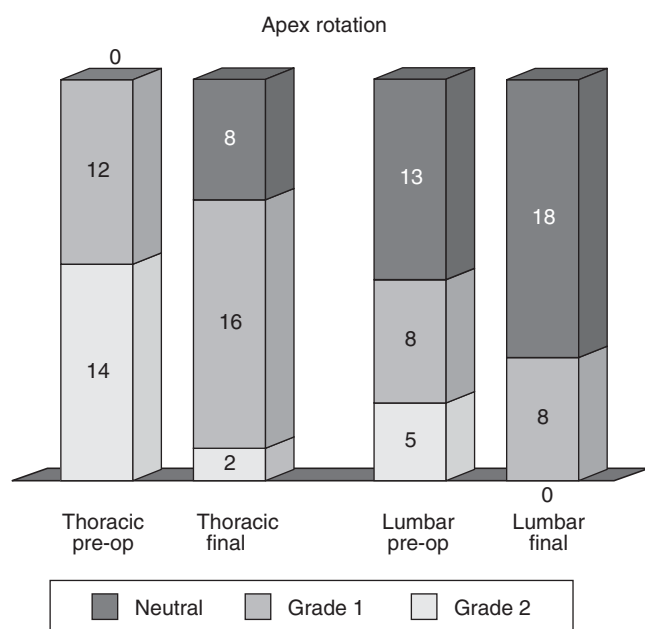


Figure 3 Thoracic and lumbar curve evolution of the apical vertebra, from pre-op to final study, expressed in number of cases within each of the Nash and Moe grades (pre-op).

no changes between immediate post-op and final evaluation.

Apical vertebra rotation never exceeded grade 2 of the Nash and Moe method, and it was reduced in practically all the cases, as is represented in figure 3.

Table 3 shows correction and evolution on the sagittal plane: global pre-op kyphosis was $32.42^\circ \pm 11.68^\circ$ and hardly presented any changes before final evaluation ($31.81^\circ \pm 7.31^\circ$). If we analyze these values according to type of kyphosis, we will see that the initial values approximated normokyphosis or remained in it in the various groups. Global pre-op lumbar lordosis was $52.31^\circ \pm 13.9^\circ$ and ended at a mean value of 47.54° at the end of evolution. In each subgroup, we found that values descended in the patients with hyperlordosis (tables 3 and 4).

Tables 5 and 6 show the results of the statistical analysis of correlation between independent variables. Due to the number of cases in the sample, we cannot find statistically significant data to state that the type of curve has an effect on the total score or on each domain of the questionnaire, though we do find a tendency in the domain for mental health ($p = 0.051$). Similarly, there are no significant differences due to the gender of the patients, nor any relation with the appearance of complications (Table 5). Nor have we found a statistically meaningful relation between patients' age, curve degree, and the correction degree of the deformity (both in absolute and relative values), except for the pain domain (Table 6). There is a significant negative relation ($p < 0.05$) between the scores for pain and final correction (both in absolute and relative values) of the major curve, i.e. the patients with a greater correction complained of greater pain.

Table 3 Radiologic sagittal study of thoracic and lumbar lordosis

n	Hypokyphosis ($<10^\circ$)				Normokyphosis ($10-40^\circ$)				Hyperkyphosis ($>40^\circ$)			
	2 (7.7%)		19 (73.1%)		5 (19.2%)							
	Minimum	Maximum	Mean	S.d. deviation	Minimum	Maximum	Mean	S.d. deviation	Minimum	Maximum	Mean	S.d. deviation
Pre-op thoracic kyphosis	8	10	9.00	1.414	14	40	30.47	6.354	43	55	49.20	5.119
Post-op thoracic kyphosis	15	21	18.00	4.243	19	40	31.11	4.829	35	48	41.20	4.658
Final thoracic kyphosis	15	23	19.00	5.657	19	40	30.63	4.798	36	48	41.40	4.336
Pre-op lumbar lordosis	32	38	35.00	4.243	35	79	54.68	13.342	30	66	50.20	14.839
Post-op lumbar lordosis	35	37	36.00	1.414	33	60	48.89	8.498	30	60	46.40	11.610
Final lumbar lordosis	35	37	36.00	1.414	33	60	49.05	8.462	30	60	46.40	11.610

Post-op: postoperative; Pre-op: preoperative.

Table 4 Mean SRS-22 questionnaire scores

Domains	Minimum	Maximum	Mean	Standard deviation
Activity	2.40	5.00	4.3923	0.51994
Pain	3.40	5.00	4.4077	0.40588
Self-image	3.00	5.00	3.9077	0.44982
Mental health	1.60	5.00	3.9769	0.61274
Subtotal	2.70	5.00	4.1750	0.40031
Satisfaction	1.00	5.00	3.8077	0.84943
Total	2.36	5.00	4.1327	0.44905

*The subtotal score is the mean value of the sum of the 4 preceding scores.

Discussion

The differences between the pre-op and post-op hemoglobin and hematocrit values do not reflect the magnitude of each patient's hemorrhage faithfully due to the fact that they are usually hemodiluted. Data about the transfusional needs of the patients may be more reliable and comparable. Various works refer to blood losses of 1,100 to 4,200 cc³ during surgical procedure^{5,27,34}. In our series we did not use a precise method to calculate blood loss; however, we estimate that the mean transfused volume of red blood cell concentrates was 750 cc³. From the beginning of the blood saving program in 2002, practically all the transfusion needs of the patients treated for adolescent idiopathic scoliosis were covered with autogenous concentrates. This kind of protocol seems to be advisable, since it saves blood and prevents the risks caused by homologous blood transfusions.

The medical literature refers to a markedly low incidence of nervous complications, between 0.6 and 2%^{8,27}, and they have described series that afforded no complications using both thoracic pedicular screws^{1,7,8,33} and hybrid instrumentation^{7,8,30,32,35}. Neurological injuries caused by hooks^{36,37} and screws^{38,39} have been recorded; according to Kuklo⁸, there is no clinical proof that screws produce more neurological injuries than hooks, though they do show a wide learning curve before a safe application is achieved.

Some publications refer to a value of up to 14% for lung complications, but they are based on series using combined approaches that had a higher grade of incidence for this kind of complication²⁷. It is necessary to be very careful when working in the thoracic region due to the fact that the closeness of the pleura increases the possibility of injury though without producing a tear or pneumothorax. However, this slight damage can bring about a delayed hemothorax, as happened in the case of the young woman described above.

There was superficial infection in 3 of the cases described here. This percentage is too high in comparison to the rates presented above (between 1.8 and 5%) for posterior scoliotic curve arthrodesis^{6,19}, but it may be accountable to possible defects in the closing of the surgical wound, and prevented by placing the different muscular planes on the

Table 5 Thoracic test for equal mean values of independent samples

SRS-22 domains	Complications				Gender				Curve type			
	NO (21)	YES (5)	T value	Sg	Male (6)	Female (20)	T value	Sg	Lenke I (11)	Lenke III (12)	T value	Sg
Activity	4.32 ± 0.55	4.68 ± 0.27	-1.40	0.173	4.37 ± 0.32	4.40 ± 0.57	-0.135	0.894	4.27 ± 0.65	4.42 ± 0.41	-0.642	0.528
Pain	4.45 ± 0.37	4.24 ± 0.55	1.029	0.314	4.40 ± 0.13	4.41 ± 0.46	-0.052	0.959	4.27 ± 0.45	4.45 ± 0.35	-1.08	0.303
Self-image	3.92 ± 0.46	3.84 ± 0.43	0.368	0.716	3.7667 ± 0.54	3.95 ± 0.42	-0.871	0.392	3.82 ± 0.45	3.88 ± 0.39	-0.369	0.716
Mental health	3.99 ± 0.68	3.92 ± 0.23	0.227	0.823	4.20 ± 0.33	3.91 ± 0.67	1.02	0.319	3.67 ± 0.72	4.17 ± 0.39	-2.07	0.051
Subtotal	4.18 ± 0.43	4.17 ± 0.24	0.030	0.976	4.20 ± 0.30	4.17 ± 0.43	0.171	0.866	4.01 ± 0.46	4.24 ± 0.26	-1.46	0.157
Satisfaction	3.74 ± 0.90	4.10 ± 0.55	-0.851	0.403	3.92 ± 0.49	3.77 ± 0.94	0.352	0.728	3.73 ± 1.01	3.75 ± 0.75	-0.062	0.952
Total	4.12 ± 0.49	4.17 ± 0.25	-0.203	0.841	4.16 ± 0.28	4.12 ± 0.49	0.146	0.885	3.96 ± 0.56	4.19 ± 0.26	-1.26	0.220

*Relation between scores of the different domains of the SRS-22 questionnaire and the appearance of complications, patients' gender and curve type (types I or III according to Lenke). The number of individuals in each group is shown in brackets. Scores are annotated using the arithmetic mean ± standard deviation. There were no statistically significant values in any of the analyses. Sg: bilateral statistical significance; SRS: *Scoliosis Research Society*; T value: thoracic value.

Table 6 Spearman's correlation between the SRS-22 questionnaire score and age at surgery. The chart also shows final correlation in degrees and the final relative correction of the major curve

		Activity	Pain	Self-image	Mental health	Subtotal	Satisfaction	Total
Age at surgery	Spearman's coefficient	-0.197	-0.28	-0.222	0.031	-0.279	-0.276	-0.326
	Sg	0.334	0.162	0.275	0.879	-0.168	0.172	0.105
Curve magnitude	Spearman's coefficient	0.094	0.019	0.199	0.075	0.093	0.267	0.130
	Sg	0.649	0.925	0.329	0.716	0.653	0.187	0.503
Major curve final correction (°)	Spearman's coefficient	-0.327	-0.39	0.004	0.224	-0.238	0.178	-0.061
	Sg	0.108	0.046	0.986	0.241	0.241	0.385	0.769
Major curve final	Spearman's coefficient	-0.37	-0.46	-0.264	0.160	-0.367	-0.20	-0.176
	Sg.	0.063	0.023	0.193	0.436	0.065	0.923	0.389

*There are no statistically significant values showing a relationship between the scores yielded by the SRS-22 questionnaire and age at surgery, magnitude of initial curve, final correction in degrees and the final correction percentage of the major curve. Values having statistical significance are annotated in bold type ($p < 0.05$). Sg: bilateral statistical significance.

instrumentation area as hermetically as possible. Nevertheless this complication does not generally persist when treatment is adequate and, furthermore, its worst consequences are a longer healing period, or hypertrophic or asymmetric scarring. There were no cases of deep infections, which presents a 0 to 7% incidence in the medical literature^{27,34,40}.

According to the quality of life SRS-22 questionnaire, the patients in this study obtained similar scores to those in the published literature for pain, activity and self-image^{9,23,41-44}, but somewhat inferior scores in relation to mental health (3.98) and satisfaction (3.81).

The mean scores for self-image, mental health and satisfaction were approximately half a point lower than for pain and activity, whereas in the published series there was greater homogeneity between the different domains of the questionnaire^{9,23,41-44}. This discordance can be explained by considering the small size of the sample, the patients' esthetic expectations or their ignorance or insufficient knowledge regarding the surgical treatment and its consequences. The relation between self-image and satisfaction has been referred to in different studies^{23,42}, as well as the influence of the patients' expectations¹¹⁻¹³.

Various authors agree that the type of curve does not affect the score of the questionnaire^{11,41}, and this concurs with the results presented here. Other authors have shown that the results are worse in the case of older patients⁹; the results we present here and other published works, however, do not support this idea^{12,41}.

The SRS-22 questionnaire is an optimal instrument for analyzing and communicating results^{9,11,23,43}; it enables the comparison of different studies and the Spanish version has proved to be valid^{24,26}. The concept of quality of life of the patient has become an assessment tool for the population at large and for different conditions⁹. This becomes more significant in the case of a nosologic entity such as scoliosis in which the psychosocial dimension has a heavy impact on the acceptance of the condition and on the results of treatment¹¹⁻¹⁴. The authors of this article advocate the idea that future randomized studies comparing pre-op and post-op scores are necessary, since this kind of study will show

the real effect of the treatment on our young patients^{9,13,42}.

Posterior hybrid arthrodesis and instrumentation yields good results in the correction of scoliosis^{6,27-31}, these being 51 to 78% for thoracic curve correction and 66 to 68% for lumbar curve correction. The results we present here come near to these published values though the mean lumbar curve correction we obtained is somewhat inferior (Table 2). This can be accounted to the fact that its pre-op flexibility (28% for thoracic curves and 29% for lumbar curves) is lower than that described in other series^{5,27,32}. The pre-op magnitude of the curves described here (48.8° for thoracic curves and 45.1° for lumbar curves) is lower than that of other series (oscillating between 54° and 62°)^{5,8,32,33}. The key procedures to obtain curve flexibility and an adequate correction are the release of soft tissue in the posterior planes (by means of subperiosteal resection) and a precise osteotomy of the facet joints.

Hybrid instrumentation consists in creating a stable base of low lumbar and thoracic pedicular screws and completing the assembly with hooks in the thoracic column. The use of pedicular screws in the lumbar curves enables the correction and stabilization of different types of deformity. Various studies favor the clinical advantages of hybrid assemblies (proximal hooks and lumbar pedicular screws) over the results obtained with the instrumented hook systems^{5,6}. Pedicular screws have a gripping capacity on the three columns and exercise a stronger anchor than sublaminar wiring⁷. They allow for a larger number of fixation points and therefore a better load distribution and less probability of implant failure or fractures. They also afford a more rigid system. Its use has become general on account of its greater degree of coronal and sagittal correction and its longer-lasting correction. Moreover, the majority of authors have not related pedicular screws with neurological risk^{5-7,27-31,33}. However, some authors, such as Storer³⁰, believe that the use of pedicular screws entails an excessively high cost that is not justified in moderate curves owing to the neurological and visceral risk involved in a method that ultimately affords similar corrections and clinical results to the ones obtained with hook instrumentation. This author also recommends pedicular screws for the cases of a major size

and rigidity, due to their superior biomechanical properties.

Pedicular thoracic screws have proved to offer a better correction and the avoidance of fused areas in thoracic curves, though at the expense of a higher risk. However a great number of studies claim that this kind of instrumentation can be performed safely^{1,5,7,28,30,31,33,35}. Studies comparing hybrid instrumentation with fixation only with screws have been published in the last few years. Kim⁷ showed that screws afford a more significant correction and duration, less blood loss and better lung function. Similar effects were obtained with the two kinds of instrumentation: correction of the last fused vertebra, surgical duration and results of the quality of life questionnaire. He concluded that both techniques are neurologically safe and acceptable for the global balance of the spinal column. Lowenstein³³, however, carried out a comparative study in which he found no significant sagittal and coronal differences between the two groups, even if the screws assemblies afford a greater correction and decrease of kyphosis. This author believes that the potential advantages of the screws' capacity of fixation must be levered against possible application complications: vascular, neurological and pleural damage, and greater radiation.

After carrying out a retrospective study of a series of 26 patients treated using a hybrid assembly and 22 patients treated only with screw fixation, Karatoprak³⁵ concluded that there are no statistically significant differences between the two groups as regards correction percentage, coronal balance, thoracic kyphosis, post-op lumbar lordosis, surgical time, blood loss and number of fused areas. He did find, though, a lower loss of correction, a better derotation angle and a better translation of the apical vertebra in the group treated only with pedicular screws. This author used pedicular screws in the lumbar zone in the hybrid assemblies, and sublaminar wiring in the apical zone of the concave side and hooks for the rest of the thoracolumbar hinge. Also, Karatoprak considered the correct localization of the anchoring points to be more important than the use, or not, of pedicular screws to obtain a better correction, but he admitted that screws afford a more rigid fixation.

It has been doubted whether it is really necessary to strive to obtain greater corrections at the expense of using costly and more intensive instrumentation, when these do not benefit the patient. To this effect, Vora³² studied the correction capacity of the two systems (screws as compared to hybrid instrumentation) in type I curves, on the Lenke scale, but he included pre-op flexibility in the analysis. He found no differences as regards the capacity of correction, and he also found a decrease of sagittal balance in the group treated with screws while in the hybrid assembly group the kyphosis was kept. The author wonders whether it is possible that coronal correction is obtained at the expense of sagittal correction (making the back flat) and if it is really necessary to increase lordosis with the aim of obtaining a few more degrees of correction. He concludes that, due to economic reasons and because a better coronal and axial balance is obtained, the hybrid assembly is more adequate for curves of the Lenke type I.

In a retrospective multicentric study where all the types of external fixation were compared, Kuklo⁸ refuted the idea

that fixation with screws is more costly, observing a lower number of reinterventions for this kind of assembly than for the hybrid type.

Loss of correction oscillates between 1° and 10° with evolution^{27,29,34} and occurs mainly during the first year after fixation¹⁹. Nonunions are highly infrequent (between 0 and 3%), and so are reoperations and material failure^{5,8,17,27}.

The effect of radiological changes on the score of the SRS-22 questionnaire has also been analyzed by different authors. D'Andrea finds no relation between clinical and radiological results¹². A relation has been found between major curves and worse results in the questionnaire, both globally¹¹ and specifically in the self-image domain⁴¹. After carrying out a study on 81 patients that had undergone treatment and a minimum follow-up period of 2 years, Watanabe concluded that a better correction of scoliotic curves is related to a better self-image and less pain⁴¹. According to Climent, a greater correction in the radiological angle of the deformity produces better results in the SRS-22 questionnaire. We have not been able to confirm in our series, probably due to its size. In this sample the patients with a better correction, both absolute and relative, obtained a worse result in the pain domain; this conclusion has not been recorded in the medical literature we consulted^{9,11-13,41}.

Generally speaking we can say that the greatest limitations of this study have been the small size of the series and the fact that it was a retrospective study.

In conclusion, posterior hybrid instrumentation is an effective and safe technique for the correction of scoliotic curves, yielding a low rate of failures and nonunions. Our results for pain and activity were good, but those for self-image and personal satisfaction were fair. However, only one patient declared that he would not undergo surgical treatment again if he were to find himself in the same situation. No significant differences have been found between the score of the SRS-22 questionnaire and curve type, curve magnitude, absolute and relative correction, gender, age or the appearance of complications.

Conflict of interests

The authors have declared that they have no conflict of interests.

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