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ORIGINAL ARTICLE

Can multiple-level posterior release improve curve correction in adolescent idiopathic scoliosis?

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KEYWORDS
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Abstract
Purpose: To compare the results of posterior correction using hybrid instrumentation and classical posterior release with those obtained with an extended posterior release.
Material and methods: We carried out a retrospective cohort study of 46 patients diagnosed with adolescent idiopathic scoliosis (AIS). A posterior correction was carried out using hybrid instrumentation. In the first group, a standard posterior release (SPR) was performed, whereas in the second an extended release (EPR) was carried out, resecting all posterior ligaments and performing an extended bilateral facetectomy. The results of the measurements were compared using pre-op, post-op and 2-year-follow-up anteroposterior and lateral teleradiographs. Clinical results were evaluated using the SRS22 questionnaire.
Results: There were no differences as regards gender, age, curve type, instrumented levels, OR time or pre-op Cobb's angle (SPR: 60 ± 10; EPR: 59 ± 8) of the principal curve. In the extended release group the correction obtained was significantly greater at post-op ($p < 0.001$) and at 2 years ($p < 0.05$). Correction of the proximal and lumbar curve was similar in both groups, with no significant differences. Minor complications were similar in both groups, with no serious complications.
Conclusion: Multiple-level posterior release improves correction of the principal curve on the coronal plane in patients with AIS, without an increase in the complications rate. The procedure also extends the arthrodesed area and facilitates introduction of the wires.

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PALABRAS CLAVE
Columna vertebral;
Escoliosis idiopática del adolescente;
Liberación posterior;
Instrumentación híbrida

¿Mejora la liberación posterior ampliada a múltiples niveles la corrección de la curva en la escoliosis idiopática del adolescente?

Resumen

Objetivo: Comparar los resultados de la corrección por vía posterior con una construcción híbrida mediante el empleo de una liberación posterior clásica y la liberación posterior ampliada (LPA).

Material y métodos: Efectuamos un estudio de cohortes retrospectivo con 46 pacientes diagnosticados de escoliosis idiomática del adolescente (EIA). Se realizó una corrección por vía posterior mediante el empleo de una instrumentación híbrida. En el primer grupo se realizó una liberación posterior estándar (LPE) y en el segundo se realizó una LPA, y se resecaron todos los ligamentos posteriores y se realizó una facetectomía amplia bilateral. Se compararon los resultados de las mediciones en telerradiografías anteroposteriores y laterales preoperatorias, postoperatorias y a los 2 años. Se valoraron los resultados clínicos mediante el cuestionario SRS22.

Resultados: No hubo diferencias en cuanto al sexo, edad, tipo de curva, niveles instrumentados, tiempo quirúrgico o Cobb preoperatorio (LPE: 60 ± 10; LPA: 59 ± 8) de la curva principal. En el grupo de LPA la corrección obtenida fue significativamente mayor en el postoperatorio ($p < 0,001$) y a los 2 años ($p < 0,05$). La corrección de la curva proximal y lumbar resultó similar en ambos grupos y no se encontraron diferencias significativas. Las complicaciones menores fueron similares en ambos grupos y no existieron complicaciones graves.

Conclusión: La LPA a múltiples niveles mejora la corrección de la curva principal en el plano coronal en los pacientes con EIA, sin aumento de la incidencia de complicaciones, además de aumentar la superficie de artrodesis y facilitar la introducción del alambrado.

Introduction

In recent years transpedicular screw instrumentations for the correction of scoliosis have become more popular, owing to their greater corrective capacity[1] and better vertebral fixation in comparison with instrumentations which employ hooks. Even so, some authors defend the use of hybrid instrumentations (proximal hooks, sublaminar wires and distal transpedicle screws) as an effective tool in the treatment of deformity, even in curves exceeding 100.[2]

In the past decade we have employed hybrid instrumentations with sublaminar wiring to transfer the apex of the curve towards a premoulded rod in the sagittal plane.[3] We have gradually extended the posterior release, especially in more rigid curves,[4,5] and we have performed complete resection of the spinous processes, and of the supraspinous, interspinous and yellow ligaments, as well as performing a bilateral extended facetectomy. We have not found any studies in the medical literature in which standard posterior release (SPR) is compared with extensive posterior release (EPR) for the correction of scoliosis. Some authors mention extensive posterior release as a way of increasing the flexibility of curves[5-8] without analyzing the effect it might have in terms of correcting the deformity.

The aim of our review is to learn and compare the results obtained in the posterior surgical correction of adolescent idiopathic scoliosis (AIS) using a hybrid instrumentation in patients with and without an EPR.

Patients and methods

We conducted a retrospective cohort study in order to determine the influence of the technique in patients with AIS, in whom posterior correction and an arthrodesis were performed by means of hybrid instrumentation (Isola®, DePuy Spine, Raynham, Massachusetts, USA) using proximal hooks, sublaminar wiring and distal transpedicle screws, and 6.35mm steel bars. The same surgeon (IS) operated all the patients.

The study groups were designated depending on the extent of posterior release. The first group consisted of 25 consecutive patients who underwent SPR from 1997 to 2002. The second group included another 21 patients who underwent consecutive operations and were treated from 2004 to 2006 by means of EPR. The patients who had operations in the interim between these two periods were not included because EPR had not been standardized. At first EPR of posterior elements was used to confer flexibility to the apex of more rigid curves and to achieve better corrections.

The patients in both groups were alike in terms of their age and fusion levels and the distribution of their curve type was very similar. None of the main parameters, except average follow-up time, which was higher in the SPR group, showed significant differences between the two groups (table 1).

Surgical technique

In all the study patients an instrumented arthrodesis was performed by means of a single posterior intervention and

Table 1 Demographic data and types of curve

	SPR	EPR
Age when surgery performed (years)	15 ± 2	15 ± 5
Sex, n (%)		
Males	3 (12)	2 (9.5)
Females	22 (88)	19 (90.5)
Lenke Classification, n (%)		
Type 1	17 (68)	10 (47.6)
Type 2	2 (8)	5 (23.8)
Type 3	3 (12)	3 (14.3)
Type 4	1 (4)	0 (0)
Type 5	1 (4)	3 (14.3)
Type 6	1 (4)	0 (0)
Lumbar modifier		
A	10	12
B	7	3
C	8	6
Sagittal modifier		
N	21	15
+	2	1
—	2	5
Mean follow-up time (months)	99 ± 32	31 ± 11

EPR: extensive posterior release; SPR: standard posterior release; N: neutral.

a local autogenous bone graft was employed. In the first group (SPR) the technique involved posterior intervention along the midline, subcutaneous dissection and subperiosteal exposure of laminae, and spinous and transversal processes. For the decortication the spinous processes were resected at their base, as well as the lower facets of the upper vertebrae and the exposed cartilage of the upper facets of the lower vertebrae. In order to insert the sublaminar wires, the supraspinous and interspinous ligaments were bisected and the yellow ligament was opened along the mid-line.

In the group in which an EPR was performed a full resection of the supraspinous and interspinous ligaments was also performed at each level, as well as a full resection of the yellow ligament, which began at the mid-line and extended laterally as far as the articular facets. An extensive facetectomy, which included the entire lower facet of the upper vertebra and much of the upper facet of the lower vertebra as far as the opening of the foramen, was also performed. This EPR was executed at each level of the main curve.

To determine fusion levels X-rays of patients in a standing position and bending tests were evaluated. Proximal anchoring was performed by means of a claw with hooks, transverse facets, and distal anchoring by means of transpedicle screws. The wires were inserted using the classical technique and the curve was progressively transferred towards a premoulded rod in the sagittal plane on the concave side of the main curve.

All the patients were evaluated before their operation, during the immediate post-intervention period, one month after the intervention and at least 2 years later. Image analysis was conducted using antero-posterior and lateral teleradiographic images taken in a standing position. The Cobb angle of the proximal thoracic curve, the main thoracic curve and the thoracolumbar or lumbar curve were determined. Lenke's classification was employed to classify the AIS. Thoracic kyphosis was measured between the upper end-plate of T5 and the lower end-plate of T12 and lumbar lordosis was measured between the upper end-plate of L1 and that of S1. To determine the flexibility of the curve before the operation its correction was measured in bending tests.

Any complications were recorded and the clinical results were evaluated by means of the SRS 22 questionnaire. The statistical analysis was conducted using SPSS software (version 11.5, SAS Institute Inc, Cary, North Carolina, USA). The distribution of variables was expressed by the mean and standard deviation. The variables were compared by means of the Student's t test, Fisher's exact test and the χ^2 test with a significance level of 5% ($p < 0.05$.)

Results

There were no significant differences with respect to the number of fused vertebrae between the two groups. The surgical time was comparable in both groups. Less blood was delivered by transfusion during the perioperative period in the EPR group, 4.3 ± 2 red blood cell concentrates being administered to the first group and 2.7 ± 2 to the EPR group, which was statistically significant (table 2). There were no fatalities, infections, or spinal or radicular lesions in either of the groups.

We did not find significant differences in the pre-operative Cobb angle of the main curve in the two groups. The first group exhibited greater flexibility of the main curve (40.8%) compared to the EPR group (29.2%) ($p = 0.01$). A correction of 57% was obtained in the first group (SPR) and a 68.6% correction in the second group (EPR) ($p < 0.001$). The post-operative correction at 2 years was significantly greater in the second group ($p = 0.015$) (table 3). The Cobb angle of the proximal thoracic curve and of the secondary lumbar curve was comparable in both groups before and after surgery. The coronal imbalance was significantly greater in the second group and there were no significant differences immediately after the operation and 2 years later.

The thoracic kyphosis of T5–T12 in the sagittal plane was similar for both groups in the pre-operative period (21.9 ± 11.1° in the SPR group and 18.4 ± 11° in the EPR group) ($p = 0.35$). There were no significant differences in the immediate post-operative period and there was a kyphosis of 22.19 ± 10.1° in the first group and 18 ± 6.7° in the second group ($p = 0.09$). A (positive) grade of correction was obtained in the first group and a correction of —0.4° in the second group ($p = 0.91$). Two years after the operation the kyphosis was 23.6 ± 8.8° in the first group and 17.6 ± 6.1° in the second group ($p = 0.01$). The final correction was 1.6° in the SPR group and —0.8° in the EPR group ($p = 0.43$).

The pre-surgery L1–S1 lordosis was similar in both groups and significant differences were not found with respect to correction in the post-operative period or 2 years later.

Table 2 Fusion levels, surgical time and blood transfusion

	SPR	EPR	p value
Number of fused vertebrae	11.4 ± 1.8	10.8 ± 2.7	0.28
Surgical time (hours)	4 ± 1	4 ± 1	0.11

EPR: extensive posterior release; SPR: standard posterior release.

Table 3 Comparative coronal results

	SPR (X±SD)	EPR (X±SD)	p value
Main Cobb angle			
Pre-operative	60.3 ± 10.1°	59.3 ± 8°	0.71
Flexibility	35° (40.8%)	42° (29.2%)	0.015*
Post-operative correction (%correction)	26.2 ± 8.4° (57%)	18.1 ± 6.2° (68.6%)	0.001*
Post-operative correction (2 years) (%correction)	29.4 ± 10° (51.6%)	22.3 ± 8.5° (61.8%)	0.015*
Proximal Cobb			
Pre-operative	27.4 ± 11.3°	30.9 ± 12.4°	0.47
Immediate post-operative (%correction)	17 ± 8.6° (35.7%)	17.8 ± 6.2° (44.5%)	0.17
Post-operative (2 years) (%correction)	16.2 ± 7.1° (36.4%)	17.8 ± 6° (44.8%)	0.24
Lumbar curve Cobb			
Pre-operative	35.2 ± 15°	34.0 ± 9°	0.79
Immediate post-operative (%correction)	15.6 ± 8.9° (58.2%)	14.1 ± 8.3° (59.1%)	0.90
Post-operative (2 years) (%correction)	17.7 ± 7.4° (47.4%)	16 ± 11° (55.4%)	0.42
Balance			
Pre-operative	12 ± 9 mm	20 ± 13 mm	0.015*
Immediate post-operative	7 ± 7 mm	9 ± 8 mm	0.23
Post-operative (2 years)	4 ± 5 mm	5 ± 7 mm	0.47

EPR: extensive posterior release; SPR: standard posterior release.
*Statistically significant.

Table 4 Results of the SRS-22 Questionnaire

	Pain	Self-image	Function	Mental health	Satisfaction	Total
SPR	4.2	3.7	4.3	4.0	4.6	4.1
EPR	3.7	3.5	4.1	3.7	3.9	3.8
p value	0.2	0.5	0.5	0.4	0.01*	0.1

EPR: extensive posterior release; SPR: standard posterior release.
*Statistically significant.

The result of the SRS 22 questionnaire 2 years after surgery (table 4) was comparable in both groups, except for patient satisfaction, and the result was better in the SPR group.

Discussion

There is a tendency to correct vertebral deformity, even the most severe curves, by means of a single posterior technique[9-11] or with hybrid instrumentations,[2,12] avoiding the morbidity associated with anterior approach.[13] Despite the results published on the effectiveness for correction purposes of the pedicle screw-only technique,[10,14,15] we generally employ a hybrid system based on transferral.[3] This system is as effective and safe as other systems[16] and it attempts to avoid the tendency of the "all-screw" system to reduce thoracic kyphosis.[17-19] There is little evidence that "all-screw" instrumentations are better for correcting and maintaining correction, given that there are studies which obtain similar correction results for both instrumentations, with comparable correction losses and fusion levels.

Furthermore, these results have not correlated with an increase in patient satisfaction or an improvement in quality of life.[20-23]

We became more and more radical in our posterior release interventions because with EPR we observed an increase in the flexibility of the most rigid areas of the deformity and in the capacity for correction. Shufflebarger et al[4] were the first to employ EPR to correct lumbar curves in adolescent patients with scoliosis, when they resected all the posterior elements. With this technique lumbar correction improved from 64 to 76%, even reaching 80% when the all-screws technique was used.[5] But, in turn, it

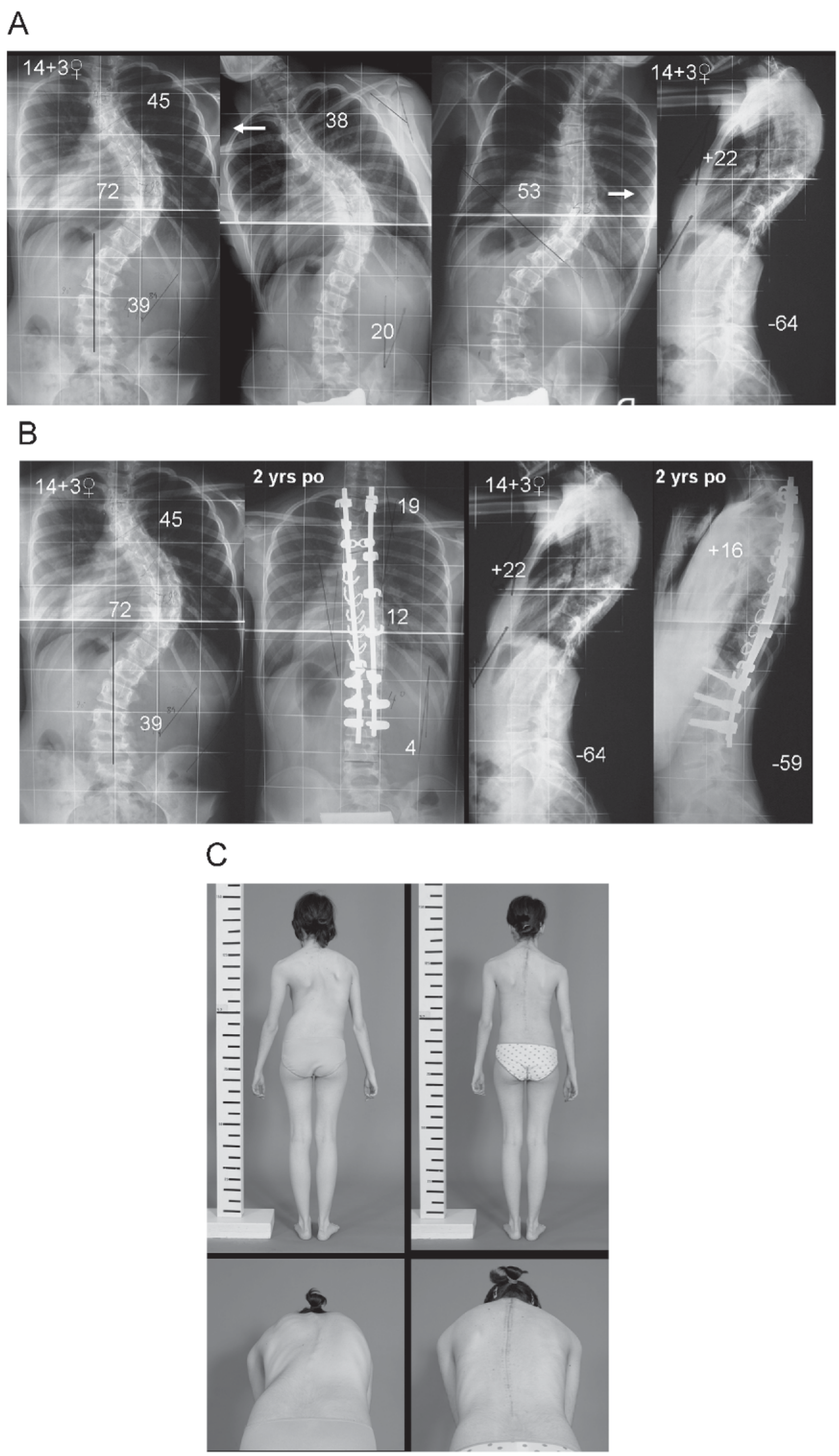

Figure A) Frontal Pre-operative Bending test Image and Lateral Image of a Case with a Lenke 2AN Curve with only 26% Flexibility. B) Post-operative Images of the same Case after Extensive Posterior Release and Arthrodesis of T2–L3. The Post-surgery X-rays demonstrate a correction of 83% C) Clinical Pre-operative and Post-operative Images.

showed an increase in lordosis of 12° as a result of the shortening of the posterior elements. Lehman et al[24] sustained that extensive facetectomy not only improved the visualization of the anatomical points for the implantation of the thoracic screws, but also provided bone graft material and a larger surface for arthrodesis. For their part, Hamzaoglu et al[6] obtained good corrections in severe scoliosis treated with halo-femoral traction when a bilateral facetectomy and resection of the supraspinous and interspinous ligaments, and the yellow ligament, were added. Herrera Soto et al[7] stressed the need to perform more intensive facetectomies to improve corrections and promote arthrodesis using instrumentations with transpinous wiring, while Mehlman et al[8] obtained corrections of 71% in severe curves with extensive facetectomies when they used halo-femoral traction. Although these authors mention EPR in relation to the treatment of rigid curves, they do not describe it as such and fail to analyse how it behaves comparatively in the correction of scoliosis.

In our technique we performed a full resection of the 3 ligaments, the supraspinous, interspinous and yellow ligaments. We also performed a bilateral extended facetectomy with resection of the lower articular facet of the upper vertebra and a large part of the upper facet of the lower vertebra, which involved opening the foramen. This release was performed at each level of the structured (thoracic or lumbar) curve. When this release was employed in conjunction with a hybrid instrumentation, we obtained 68.6% corrections of the main curve with a correction loss of 6.8% after 2 years and this is a much greater correction (over 10%) than that obtained with SPR. These results are even more significant if we take into account the fact that the patients in whom an EPR was performed had more rigid curves (29%) in comparison with the SPR patients (40.8%). This difference seems logical, given that it is in more rigid curves that a more extensive release is required in order to make the curve more flexible and optimize the correction. Multiple-level EPR has helped us to improve the flexibility of the curve and has permitted maximum transferral of the curve towards the rod (fig.). In turn, we have obtained a good correction of the proximal thoracic curve without changes during follow-up (44.5%) and of the secondary lumbar curve (59.1%) with a good final coronal balance.

Corrections published for Isola® instrumentation range from 63–69%.[16,23-26] Lehman et al[10] reported a 72.1% correction of the main thoracic curve by using transpedicle screws, with a correction loss of 4%, a 49.8% correction of the proximal thoracic curve with a correction loss of 0.2% and a coronal imbalance of 6.7 mm.

None of the patients treated in our study suffered neurological injuries when the sublaminar wires were inserted, although this complication has been described.[27,28] It may be the case that a greater exposure of the posterior elements as a result of the full resection of the yellow ligament facilitates the manoeuvring required to insert the wires. Moreover, it creates drainage channels which may avoid compressive dural haematomas.

EPR did not require more surgical time compared to the standard procedure, although this may be related to the greater experience of the main surgeon. Neither were there more cases of surgical haemorrhage, although this finding is merely anecdotal, as in this period anti-fibrinolytic medications were used during operations.

One of our objectives was to ascertain whether EPR produces a decrease in thoracic kyphosis. Shufflebarger et al[4] observed that, when lumbar curves were treated, lordosis increased as a result of the subsequent shortening effect secondary to extensive release. In fact, a Ponte osteotomy, which is in every respect similar to the intervention we performed, is indicated in the correction of Scheuermann's kyphosis.[29] Our results showed that kyphosis changes very slightly in the immediate post-operative period and slightly (0.8°) after 2 years of follow-up. Even with these results, none of our patients exhibited a negative sagittal modification after surgery. The post-operative kyphosis values were concentrated close to normal kyphosis ranges with a decrease in the highest values and an increase in the lowest values. This effect may be due to the instrumentation technique which was employed, as the rod is moulded when the physiological sagittal curve, to which the deformity is transferred by means of the sublaminar wires, is reproduced. Various studies have shown a decrease in post-operative kyphosis following instrumentation, as well as a flattening of the thoracic curve, with intraspinous segmental wires[7,21] and with "all-screw" transpedicular instrumentations,[1,10,17-19,21] whilst in the sagittal context it has been maintained with hybrid constructs.[1,21]

The benefit obtained in the correction of the sagittal and coronal planes of AIS patients when we performed an EPR was not reflected in the results of the SRS 22 questionnaire. This had been observed with other instrumentations (sublaminar wires, hooks, hybrid instrumentations, CD Horizon® and transpedicle screws[10,20]). Subsequent studies have not confirmed a correlation between radiological and clinical variables.[30] Therefore, we are unsure whether the pursuit of additional correction is really important for patients and whether it is necessary to achieve their satisfaction.[31]

The performance of a multiple-level EPR as part of the correction of AIS is a safe and effective surgical procedure for correction of the curve by transferral and to achieve its balance. It improves coronal correction of the curve compared to SPR and a good coronal balance and physiological thoracic kyphosis is obtained. Employed in conjunction with a hybrid instrumentation using sublaminar wires, it has shown itself to be comparable to other instrumentations. It also provides an additional amount of autologous graft tissue, permits the drainage of dural haematomas and facilitates the insertion of sublaminar wires.

Conflict of interests

The authors declare that they have no conflicts of interest.

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