Does Wide Posterior Multiple Level Release Improve the Correction of Adolescent Idiopathic Scoliosis Curves?

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Study Design: Retrospective matched cohort study.

Objective: To compare results of posterior correction and fusion with a hybrid construct using a standard posterior release (SPR) versus adding a wide posterior release (WPR), in adolescent idiopathic scoliosis (AIS) treated at a single institution, with a minimum 2-year follow-up.

Summary of Background Data: Although the importance of posterior release has been enhanced for the correction of AIS, there have been no reports comparing correction results when posterior wide release (excision of all posterior ligaments and bilateral extended facetectomy at multiple levels) is used.

Methods: A retrospective study of 46 patients with AIS was performed. Posterior-only hybrid instrumentation with sublaminar wires was included. SPR group consisted of 25 patients and WPR group consisted of 21 patients.

Results: There was no difference in sex, age, type of curve, number of instrumented levels, length of surgery, and preoperative main curve Cobb (SPR: 60 ± 10 degrees WPR: 59 ± 8 degrees). In the WPR group, the amount of main curve correction obtained was significantly greater (SPR: 57% vs. WPR: 68.6%) $P < 0.001$, and maintained at final follow-up (SPR: 51.6% vs. WPR: 61.8%) $P < 0.05$. Preoperative and postoperative proximal thoracic and lumbar secondary curves were similar in both the groups. T5-T12 preoperative kyphosis were (SPR: 22.2 ± 11 degrees vs. WPR: 19 ± 11 degrees) the degrees corrected in postoperation (SPR: +1.2 ± 6 degrees vs. WPR: −0.9 ± 9 degrees) and at final follow-up (SPR: +1.6 ± 8 degrees vs. WPR: −0.8 ± 11 degrees), and were not statistically different $P > 0.05$. Minor complications were similar in both groups and no major complications were found.

Conclusions: Posterior wide release at multiple levels improves coronal main curve correction in patients with AIS, without an increase in the incidence of complications. Furthermore, it improves fusion surface and makes insertion of sublaminar wires easier.

Key Words: adolescent idiopathic scoliosis, wide posterior release, hybrid instrumentation

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Over the past few years, the pedicle screw instrumentation used in the correction of adolescent idiopathic scoliosis (AIS) has gained in popularity due to its perceived superior power of correction[1] and vertebral grip when compared with the hook construct.[2–4] Even so, some still consider the hybrid construct (proximal hooks, distal screws, and apical sublaminar wires) as an effective tool for the correction of scoliosis,[5,6] even for curves greater than 100 degrees.[4]

At our institution, we have used the hybrid construct as our preferred method of correction for the majority of the curves, usually by translating the apex of the thoracic scoliosis to a precontoured sagittal rod by means of sublaminar wires.[7–9] We have been progressively more aggressive in the surgical treatment of stiff curves, adding wider posterior releases to the standard posterior approach.[10,11] These extended releases include a complete excision of: the spinous process, the supra and interspinous ligaments and the *ligamentum flavum*, in combination with a bilateral extended facetectomy. To the best of our knowledge, no one has reported the comparative results in the correction of scoliosis, when the posterior wide release is performed. Some authors have described the need for posterior bone and soft tissue releases[11–14] and extended facet joint exposures[15,16] to properly place the instrumentation. But they do not analyze the exact effect that this release causes in the correction of the deformity. Our aim was to compare the initial postoperative and sustained (2-year follow-up) correction of AIS curves, using a posterior hybrid construct with and without a wide posterior surgical release.

MATERIALS AND METHODS

All the patients in the study suffered from AIS, and were surgically treated by the same surgeon (E.I.) using a

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posterior-only approach. All were instrumented using Isola [DePuy Spine (J&J), Raynham, MA, EEUU] hybrid instrumentation (proximal hooks, apical sublaminar wires, and distal pedicle screws) with 6.35 mm stainless steel rods. Two groups of patients were separated depending on the extension of the posterior release (as described later). The first group consisted of 25 consecutive patients treated with a standard posterior release (SPR), between the years 2000 and 2002. The second group comprised 21 consecutive patients, surgically treated using a wide posterior release (WPR) and operated between the years 2004 and 2006. The WPR was added at each level of the main curve, in the belief that this maneuver could create a more flexible setting of the rigid zones of the deformity, thus obtaining a better correction. The AIS patients who were operated upon between these 2 periods of time were discounted because the WPR was not performed in a standardized manner. The patients were similar according to: age at surgery, number of fused levels, operative correction maneuvers, Lenke curve type,[17] and preoperative Cobb angle of major curves. This allowed the most exact comparison.

All patients were evaluated preoperatively, early postoperatively (within 1 mo postoperatively), and at a minimum of 2 years postoperatively. Radiographic analysis was performed on 36-inch long-cassette coronal and lateral radiographs of the spine with the patient standing to determine Cobb angle measurements: coronal proximal thoracic (PT), main thoracic, and thoracolumbar/lumbar. Thoracic kyphosis was measured from the upper endplate of T5 to the lower endplate of T12, and lumbar lordosis was measured from the upper endplate of L1 to the upper endplate of S1. Curve flexibility was determined preoperatively using supine side-bending films. Complications were recorded, and clinical outcomes were evaluated using the Spanish Scoliosis Research Society (SRS)-22 Questionnaire.[18,19]

Statistical analysis was carried out using the SPSS software (version 11.5, SAS Institute Inc, Cary, NC). Distribution of variables is given as mean and standard deviation. Comparisons between variables were made using 2-tailed independent t test, the Fisher exact test, and χ^2 statistics as appropriate, with a significance level of 5% ($P < 0.05$).

Operative Procedure

All patients in both groups underwent posterior arthrodesis by posterior-only approach, using bone site grafts. In the first group of patients, in which an SPR was carried out, posterior exposure consisted of a midline incision, dissection of subcutaneous tissue, and subperiosteal dissection of the spinous processes, laminae and transverse processes.[20] For decortication, spinous processes were removed at their base, as were the inferior facets of the superior vertebra and the cartilage of the exposed superior facet of the inferior vertebra. To insert the sublaminar wires, the supra and interspinous ligaments were removed, and the *ligamentum flavum* was incised in the midline. In the second group of patients, in which the WPR was performed, several surgical gestures were added to this standard posterior exposure. These included a complete removal of the supra and interspinous ligaments at each level, together with a complete excision of the *ligamentum flavum* by means of a Kerrison rongeur. The release of this rongeur was extended throughout the ligament, beginning in the midline and proceeding laterally toward both facets. The final step was the extended bilateral facetectomy, where the inferior facet of the superior vertebra was removed, as was much of the superior facet of the inferior vertebra. This WPR was performed along the main curve at each level.

Evaluating upright and bending radiographs determined fusion levels as described in the literature.[21,22] To secure the upper foundation, we used a intrasegmental claw,[7,8] as distal anchors pedicle screws were used. Sublaminar wires were inserted with the classic technique,[23,24] and used in translational apical correction to a precontoured sagittal rod placed in the concave side of the main curve.

Demographic data are shown in Table 1. Surgical classification of AIS was carried using the Lenke system.[17] None of the parameters, except mean follow-up, showed statistical difference between both groups ($P > 0.05$).

RESULTS

Coronal Plane Radiographic Results

The preoperative Cobb angle of the major curve was 60.3 ± 10.1 degrees in the SPR group and 59.3 ± 8 degrees in the WPR group ($P = 0.71$) (Table 2). The first group presented more flexibility of the major curve: 40.8% compared with 29.2% for the wide release group ($P = 0.01$). Immediate postoperative Cobb angle of the major curve in the SPR was 26.2 ± 8.4 degrees and

TABLE 1. Demographics and Curve Type

	SPR Group	WPR Group
Age at surgery	14.9 ± 2.3	15.2 ± 5.4
Sex	3 male (12%)	2 male (9.5%)
	22 female (88%)	19 female (90.5%)
Lenke curve type frequency		
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
Average follow-up	99.3 ± 32 mo	31.3 ± 11 mo

SPR indicates standard posterior release; WPR, wide posterior release.

TABLE 2. Comparison of Coronal Plane Change

	SPR Group	WPR Group	*P*
Major curve Cobb angle			
Preoperative	60.3 ± 10.1 degrees	59.3 ± 8 degrees	0.71
Flexibility	35 degrees (40.8%)	42 degrees (29.2%)	0.015*
Immediate postoperation (% correction)	26.2 ± 8.4 degrees (57%)	18.1 ± 6.2 degrees (68.6%)	0.001*
2-y postoperation (% correction)	29.4 ± 10 degrees (51.6%)	22.3 ± 8.5 degrees (61.8%)	0.015*
PT curve Cobb angle			
Preoperative	27.4 ± 11.3 degrees	30.9 ± 12.4 degrees	0.47
Immediate postoperation (% correction)	17 ± 8.6 degrees (35.7%)	17.8 ± 6.2 degrees (44.5%)	0.17
2-y postoperation (% correction)	16.2 ± 7.1 degrees (36.4%)	17.8 ± 6 degrees (44.8%)	0.24
Secondary lumbar curve Cobb angle			
Preoperation	35.2 ± 15 degrees	34.0 ± 9 degrees	0.79
Immediate postoperation (% correction)	15.6 ± 8.9 degrees (58.2%)	14.1 ± 8.3 degrees (59.1%)	0.90
2-y postoperation (% correction)	17.7 ± 7.4 degrees (47.4%)	16 ± 11 degrees (55.4%)	0.42
Global balance			
Preoperation	12 ± 9 mm	20 ± 13 mm	0.015*
Immediate postoperation	7 ± 7 mm	9 ± 8 mm	0.23
2-y postoperation	4 ± 5 mm	5 ± 7 mm	0.47

PT indicates proximal thoracic; SPR, standard posterior release; WPR, wide posterior release.
*Statistically significant.

18.1 ± 6.2 degrees in the WPR group, with a major curve correction of 57% in the SPR group and 68.6% in the WPR group ($P = 0.001$). Postoperative 2-year Cobb angle of the major curve was 29.4 ± 10 degrees in the SPR group and 22.3 ± 8.5 degrees in the WPR group, with a major curve correction of 51.6% in the SPR group and 61.8% in the WPR group ($P = 0.015$).

Preoperative Cobb angles of the PT curves were comparable in both groups (27.4 ± 11.3 degrees and 30.9 ± 12.4 degrees, $P = 0.47$). Immediate postoperative and postoperative 2-year Cobb angles, and curve correction of the PT curves showed no significant difference between groups $P > 0.05$. Preoperative Cobb angles of the secondary lumbar curves were comparable in both groups (35.2 ± 15 degrees and 34.0 ± 9 degrees, $P = 0.79$). The results of correction of the secondary lumbar curves showed no significant difference between groups $P > 0.05$ (Table 2).

Global coronal balance before surgery was 12 mm in the SPR group and 20 mm in the group where WPR was performed ($P = 0.015$), but balance after surgery and at 2-year follow-up showed no statistical difference $P > 0.05$ between groups (Table 2).

Sagittal Plane Radiographic Results

The thoracic T5-T12 angle was similar in both groups before surgery (+21.9 ± 11.1 degrees in the SPR group and +18.4 ± 11 degrees in the WPR group, $P = 0.35$) (Table 3). There was no difference in the immediate postoperative thoracic kyphosis: +22.9 ± 10.1 degrees in the SPR group and +18 ± 6.7 degrees in the group where wide release was performed, $P = 0.09$. A correction of +1 degree was obtained in the SPR group, and −0.4 degrees in the WPR group ($P = 0.91$). At 2-year postoperation, thoracic kyphosis in the SPR group was +23.6 ± 8.8 degrees and 17.6 ± 6.1 degrees in the WPR group, $P = 0.01$. A final correction of +1.6 degrees in the SPR group and −0.8 degrees in the WPR group ($P = 0.43$) was achieved.

The lumbar lordosis angle L1-S1 was very similar preoperatively in both the groups. The postoperative and

TABLE 3. Comparison of Sagittal Plane Change

	SPR Group	WPR Group	*P*
Thoracic kyphosis (T5-T12)			
Preoperative	21.9 ± 11.1 degrees	18.4 ± 11 degrees	0.35 NS
Immediate postoperation (degree of correction)	22.9 ± 10.1 degrees (+1 degrees)	18 ± 6.7 degrees (−0.4 degrees)	0.91 NS
2-y postoperation (degree of correction)	23.6 ± 8.8 degrees (+1.6 degrees)	17.6 ± 6.1 degrees (−0.8 degrees)	0.43 NS
Lumbar lordosis (L1-S1)			
Preoperative	−58 ± 12.5 degrees	−54 ± 10.4 degrees	0.25 NS
Immediate postoperation (degree of correction)	−57.2 ± 12 degrees (+0.8 degrees)	−54.2 ± 10.3 degrees (−0.2 degrees)	0.42 NS
2-y postoperation (degree of correction)	−56.9 ± 7.7 degrees (+1.1 degrees)	−56.2 ± 9.1 degrees (−2.2 degrees)	0.79 NS

NS indicates not statistically significant; SPR, standard posterior release; WPR, wide posterior release.

TABLE 4. SRS-22 Scores

	Pain	Self-image	Function	Mental Health	Satisfaction	Total
SPR Group	4.2	3.7	4.3	4.0	4.6	4.1
WPR Group	3.7	3.5	4.1	3.7	3.9	3.8
P	0.2	0.5	0.5	0.4	0.01*	0.1

SPR indicates standard posterior release; SRS, Scoliosis Research Society; WPR, wide posterior release.
*Statistically significant.

2-year follow-up results showed no significant change compared with preoperative results (Table 3).

SRS-22 Score, Fusion Levels, Blood Loss and Operating Time, Neurologic Complications

Postoperative 2-year SRS-22 scores are presented in Table 4 by domains. The results show that only the satisfaction domain showed some statistical difference, demonstrating better results in the standard release group. The fusion length averaged 11.4 ± 1.8 levels in the SPR group, similar to the WPR group 10.8 ± 2.7 ($P = 0.28$). Average operating time was 4.5 ± 0.9 hours in the standard released group and 4.0 ± 0.9 hours in the wide released group ($P = 0.11$). The number of blood transfusions needed perioperatively in the SPR group was significantly higher 4.3 ± 2, compared with the WPR group 2.7 ± 2 ($P = 0.01$) (Table 5). There were no deaths, spinal cord or spinal nerve injuries, or acute wound infections in either group.

DISCUSSION

Nowadays there is a tendency to correct spinal deformity, even the severe curves, by posterior-only approach.[25–27] Surgeons try to avoid the morbidity caused by anterior approaches, with minimal coronal correction difference being noted when compared with a combined anterior and posterior approach. Although some authors defend the need for anterior releases in large curves, especially when using hooks to correct the thoracic spine,[28–31] others have recently reported successful posterior-only fusion for the treatment of large curves, using either hybrid instrumentation,[32] or sublaminar wire constructs.[4] At our institution, we are trying to correct stiff curves by posterior-only approach using WPRs together with systems based on segmental apical vertebral translation by sublaminar wires.[33]

Lately, we have seen how thoracic pedicle screw (TPS) instrumentations are giving higher stiffness and strength to constructs compared with hooks,[34] achieving better corrections to the coronal and rotation deformity, with shorter fusion length and less loss of correction.[2,26,35–37] In contrast, it seems that TPS have a tendency to decrease thoracic kyphosis.[38–40] The latest reports using TPS show corrections in the main thoracic curves of 69%,[41] 72%,[26] and 73%.[37] Despite these figures, there is still weak evidence (level III) to show that all pedicle screw constructs improve and maintain scoliosis curve correction, and in addition, the surgical results may not be associated with an improved patient-related quality of life outcome or long-term outcome.[42] It is still uncertain whether the all pedicle screw constructs are significantly superior to the hybrid ones. Some authors support the superiority of TPS over hook constructs,[1,43] but without demonstrating better SRS-24 outcomes. In contrast, there are those who report similar major curve correction with similar loss of correction over time, similar fusion lengths, and similar SRS scores, with lower implant costs.[5,44,45] This similarity has been established especially when sublaminar wires are added in the hybrid construct.[45] These have been reported to be at least as safe and effective as other instrumentations.[6]

In the past few years, we have been progressively more aggressive in the posterior exposure, performing WPRs that allow us to gain flexibility in the stiffer parts of the deformity, thus augmenting the power of our correction. Shufflebarger and Clark[10] were the first ones to emphasize the WPR to enhance correction of lumbar scoliosis in adolescents, when they included the excision of all posterior structures of the interspace (facet joint, much of the inferior process of the proximal vertebra, and the *ligamentum flavum*). With this technique, correction in the lumbar spine improved from 64% to 76%, and as it was also used as posterior shortening, lordosis increased by 12 degrees. Shufflebarger and colleagues[11] later reported a better coronal correction of lumbar curves (80%) when pedicle screws were used. Lehman et al[16] argued that a wide facetectomy not only aids in the visualization of the facet to improve anatomic landmarks for the starting point of thoracic pedicle insertion, but also provides local bone graft, and improves surface area for fusion. Hamzaoglu et al[12] obtained good corrections in severe scoliosis treated by intraoperative halo femoral traction, when adding a wide facet resection and posterior release with removal of supraspinous and interspinous ligaments, and the *ligamentum flavum*. Herrera-Soto et al[13] emphasized the need for aggressive wide facetectomies at both the thoracic and lumbar regions to achieve better correction and promote fusion when using collar-button wire instrumentation. Finally, Mehlman et al[14] obtained a 71% correction in severe curves, by means of spinal release (removal of facet capsular tissue and facetectomy) in conjunction with halo-femoral traction. Although all these authors felt that extended release was a useful maneuver to deal with rigid deformity, no one has reported comparative results in the correction of scoliosis, when posterior wide release is performed.

TABLE 5. Fusion Level, Operative Time, Blood Loss

	SPR Group	WPR Group	*P*
No. fused vertebrae	11.4 ± 1.8	10.8 ± 2.7	0.28
Operative time	4.5 ± 0.9 h	4 ± 0.9 h	0.11
No. blood transfusions	4.3 ± 2	2.7 ± 2	0.01*

SPR indicates standard posterior release; WPR, wide posterior release.
*Statistically significance.

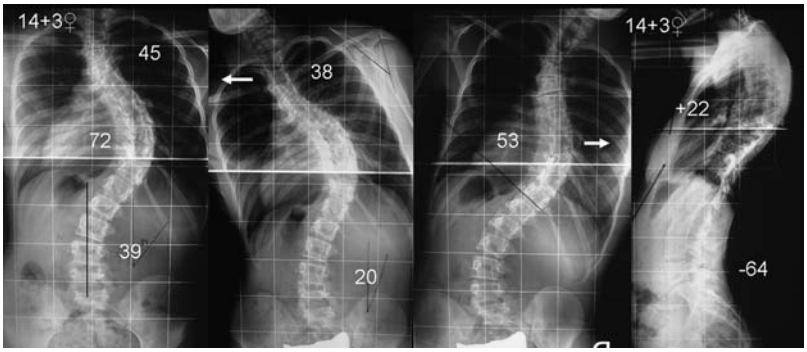

FIGURE 1. Preoperative coronal, side-bending, and sagittal views of a case with a Lenke type 2AN curve with 26% side-bending flexibility.

Our release includes a complete removal of the 3 ligaments: the supraspinous, the interspinous, and the *ligamentum flavum*; together with a bilateral extended facetectomy: complete excision of the inferior facet of the superior vertebra and of the superior facet of the inferior vertebra, which finally opens the foramen. This extended release is performed along the structural[17] curve (thoracic or lumbar) at each level. Using this WPR and a hybrid wired construct, we have been able to achieve a postoperative 68.6%, with a final 61.8%, main curve correction. This resulted in a much better correction (more than a 10%) than the one accomplished with the SPR. These results are even more significant taking into account that in the wide released group, the patients had stiffer curves (29% flexibility) compared with a 40.8% flexibility presented by the standard release group. This difference seems logical, because it is in stiff curves where extended release is needed, to create a flexible setting to optimize correction. Multilevel WPR has allowed us to surgically gain flexibility of the major curve, and this has enabled us to tighten the sublaminar wires to a limit where maximum allowable translation of the spine to the rod could be achieved (Figs. 1–3). The corrections of primary curves reported using Isola instrumentation range from 63% to 69%.[6,21,45–47] However, we assume that this maneuver (WPR) may not be the only reason for the better results obtained in the latter group. When comparing consecutive cohorts operated by the same surgeon, improvement in time of clinical judgment, surgical skills, and experience may bias the results.

Although there are reported neurologic injuries while passing the sublaminar wires,[48–55] none of the patients treated in our study suffered this complication. It is possible that the wide release of the posterior elements with the complete excision of the *ligamentum flavum* could have helped in preventing this complication, as it makes this maneuver easier to perform. Wide release also prevents the formation of dural hematomas as it provides better drainage.

The posterior wide release did not need additional operative time, although we assume that this could be related to the experience gained by the leading surgeon; and operative blood loss was not higher because of the extended release, although this fact could be anecdotal as in recent years antifibrinolytic drugs have been introduced and used intraoperatively.

One major concern was that the extended release of the posterior elements could decrease the postoperative thoracic kyphosis. Shufflebarger and Clark[10] reported an increase of the lordosis with the posterior shortening in lumbar curves, secondary to the release. Furthermore, the so-called "Ponte" osteotomy, which is indeed a similar procedure to the one we perform, is used in the treatment of Scheuermann disease to decrease thoracic kyphosis.[56]

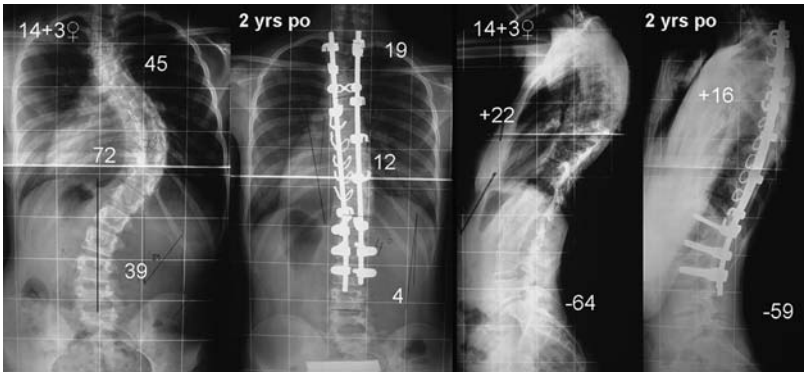

FIGURE 2. The patient underwent a posterior spinal fusion (T2-L3) with a wide posterior release and a hybrid sublaminar-wire construct. Postoperative radiographs showing 83% of correction.

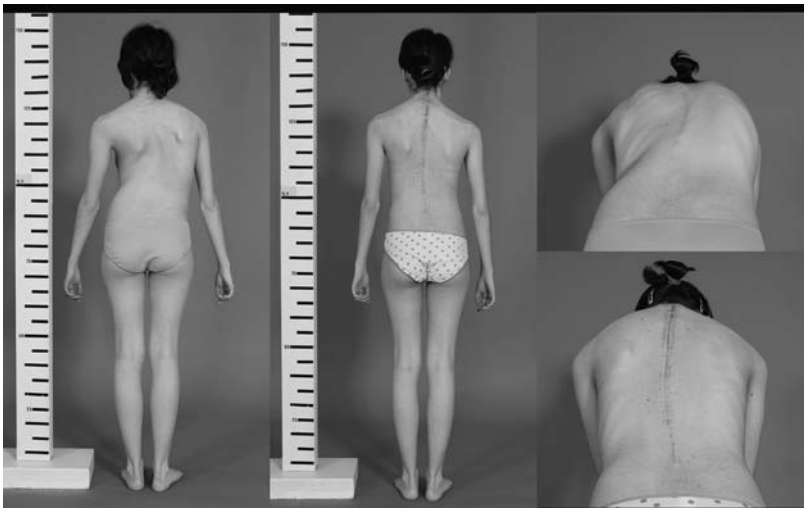

FIGURE 3. Preoperative and postoperative clinical pictures.

Our results showed that kyphosis changed slightly in the immediate postoperative period, and decreased (0.8 degrees) at 2-year follow-up. None of these patients showed Lenke's negative sagittal modifier after surgery. Postoperative kyphotic values concentrated around normality, with a decrease of the higher values and an increase of the lower ones. A protective effect against hypokyphosis can be achieved with the use of wired instrumentation, as vertebral apical translation is carried out to a precontoured rod that reproduces physiologic kyphosis. Reports have shown a decrease of postoperative kyphosis after instrumentation, thus flattening the thoracic curve, with segmental intraspinous collar button wires[5,13] and pedicle screw constructs,[1,5,26,38–40] whereas sagittal contour has been maintained with hybrid constructs.[1,5]

The benefit obtained in the correction of the coronal and sagittal deformity of adolescent scoliotic patients when adding a WPR was unfortunately not reflected as we would have liked in postoperative SRS-22 scores. Although the results in self-image, function and metal health are very similar between groups, satisfaction was greater for the SPR group. We cannot prove that better corrections lead to better clinical outcomes. This same fact has also been reported for other instrumentations (sublaminar wires, hooks, hybrid instrumentations or CD, and pedicle screws).[26,42] As later studies have not confirmed an association between radiographic variables and patient outcome variables,[57] it is still unclear whether this additional amount of correction is important. We still have to continue working to determine whether it is really necessary to achieve that extra bit of coronal correction[58] to fulfill patient satisfaction.

In conclusion, we can say that the addition of a wide, extensive, multilevel release of the posterior elements when correcting AIS deformity is a safe and useful surgical gesture for correction in the translation and stabilization of spinal alignment. It improves main curve coronal correction compared with the SPR, obtaining a good coronal balance, and a physiologic thoracic kyphosis. Used in conjunction with hybrid-sublaminar wire instrumentation, it compares quite favorably with other segmental rod combinations. This WPR has also added benefits as it provides more local bone graft, allows the drainage of dural hematomas if necessary, and makes sublaminar wire insertion easier to perform.

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