Original Article

Over 70° thoracic idiopathic scoliosis: Results with screws or hybrid constructs

ABSTRACT

Background: Adolescent idiopathic scoliosis is the most common type of scoliosis. High degrees curve can be treated with the anterior, posterior, or combined anterior–posterior approach. Contrarily to the anterior approach, the posterior one is widely used nowadays for its good correction outcomes and relatively low-complication rate.

Materials and Methods: We evaluated retrospectively 27 patients, treated with posterior approach. Patients were divided into two groups, namely pedicle screws group (PSG) and hybrid group (pedicle screws + sublaminar bands). Radiographic measurements, including thoracic and lumbar Cobb measurements of primary and secondary curves, coronal balance and sagittal balance, kyphosis and lordosis, curve exibility, first and last vertebra included in the arthrodesis, and implant density were evaluated. Clinical patients' satisfaction was also evaluated with Scoliosis Research Society (SRS) 24 questionnaire.

Results: Considering both groups, on preoperative X-rays, the average primary scoliotic curve angle was 83.56 ± 10.96 (range 70 –112), whereas the global flexibility was 64 ± 7.63 (range 46 –72). The curves were classified following the Lenke classification: 17 Type 1, 2 Type 2, and 8 Type 3. The primary curve resulted to be well corrected in both groups. In T0, the groups were homogeneous, but in T1 and follow-up, PSG stated a better mean value. No other significative differences can be found between groups for all other items ($P > 0.05$). Clinical results of SRS 24 were excellent in both groups.

Conclusions: The posterior approach proved to be an excellent technique for obtaining good clinical and radiographic results if the surgeon adopts the third-generation high-density implants.

Level of Evidence: III.

Keywords: Hooks, hybrid instrumentations, posterior approach, scoliosis, screws, sublaminar bands

INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is the most common type of idiopathic scoliosis.[1] About 2%–3% of participants aged between 10 and 18 years are affected.[2] Curves over 50° with a high likelihood of progression rate can be treated with an anterior, posterior, or combined anterior–posterior approach.[3] Since the improvement of modern surgical implants, the posterior approach is more and more used in AIS[4] respect combined approach that expose to many risks of complications.[5] This monocentric retrospective study aims to evaluate the correction of severe AIS obtained with the third-generation instrumentations through the posterior approach and define which group is more performing.

Pasquale Cinnella, Alessandro Rava[1], Antonio Abed Mahagna[2], Federico Fusini[1], Alessandro Masse[1], Massimo Girardo

Spine Surgery Unit, Orthopaedic and Trauma Centre, Città della Salute e della Scienza di Torino, University of Turin, [1]Department of Orthopaedic and Traumatology, Orthopaedic and Trauma Centre, Città della Salute e della Scienza di Torino, University of Turin, Turin, [2]Department of Orthopaedic and Traumatology, IRCCS Foundation, S. Matteo Hospital Institute, University of Pavia, Pavia, Italy

Address for correspondence: Dr. Alessandro Rava, Department of Orthopaedic and Traumatology, Orthopaedic and Trauma Centre, Città della Salute e della Scienza di Torino, University of Turin, Via Zuretti 29, 10121, Turin, Italy.
E-mail: dralessandrorava@gmail.com

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MATERIALS AND METHODS

From January 2010 to December 2016, 178 scoliotic patients underwent a surgical treatment by the same spine surgical team. Twenty-seven patients were selected according to the following inclusion criteria: (1) diagnosis of idiopathic scoliosis, (2) age between 10 and 20 years, (3) severity of the primary scoliotic curve of at least 70°Cobb, (4) Lenke type 1, 2, or 3 scoliosis, (5) minimum of 2 years follow-up (FU), and (6) treated only with a posterior approach. Magnetic resonance imaging and computed tomography scan were done before surgery to evaluate the presence of diastematomyelia,[6-8] syringomyelia, or other spinal cord affections.

General data of these 27 patients are reported in Table 1.

Two independent operators, not involved in the surgical treatment, performed radiographic data collection with Syncro Fuji 2012. All radiographic measurements were made on the preoperative (T0), immediate postoperative (T1), and at FU. Thoracic and lumbar Cobb° measurements of primary and secondary curves and coronal balance were achieved on standing posteroanterior X-rays. Sagittal balance, kyphosis, and lordosis angles were determined on standing lateral X-rays. Curve flexibility was evaluated on the preoperative side-bending anteroposterior radiographs. Finally, implant density (defined as number of screws and sublaminar bands for instrumented level) and first and last vertebra included in the arthrodesis were established too. We divided patients into two groups as follows: pedicle screws' group (PSG) and hybrid group (HG). The two groups were homogeneous for mean age, duration of FU, preoperative primary and secondary curve Cobb°, thoracic kyphosis and lumbar lordosis angle, coronal and sagittal alignment, curve flexibility, and number of instrumented vertebrae.

As corrective measures, in PSG, an apical translation was performed, followed by segmental compression-distraction and direct vertebral derotation, whereas, in the HG, a simultaneous apical concave translation and apical derotation.

Table 1: General information of the 27 cases we treated

Variables	Values
Mean age	16.31 (13-19)
Gender (male:female)	9:18
AIS curve according to the Lenke classification	17 Type 1, 2 Type 2, 8 Type 3
Follow-up (years)	4.28
Main curve preoperative (°)	83.56
Before surgery side bender main thoracic (°)	64
Hypokyphosis (*n*)	3
Normal kyphosis (*n*)	9
Hyperkyphosis (*n*)	15

AIS - Adolescent idiopathic scoliosis

No patients were lost during follow-up.

All patients were submitted to the Scoliosis Research Society (SRS) 24 questionnaire[9,10] to evaluate the clinical satisfaction after recovery. SRS 24 questionnaire investigated problems related to the intervention such as pain, the recovery of motor skills, the esthetic results, and the eventual affliction of the patient's social life. Score of each domain ranges from 1 (worst) to 5 (best).

Statistical analysis was performed using the Mann–Whitney test. Results are expressed as the mean (range) and the results were considered significative for $P < 0.05$.

RESULTS

PSG included 15 patients (five males and ten females), whereas HG included 12 patients (four males and eight females). Considering both groups, on preoperative X-rays, the average primary scoliotic curve angle was 83.56° ± 10.96° (range 70°–112°), whereas the global flexibility was 64° ± 7.63° (range 46°–72°). According to the classification system proposed by Lenke *et al.*,[11] we recognize as follows: 17/27 (63%) Type 1 (main thoracic curve), 2/27 (7%) Type 2 (double thoracic curve), and 8/27 (30%) Type 3 (double major curve). On the sagittal plane, 3/27 (11.2%) patients had thoracic hypokyphosis (Cobb angle <25°), 15/27 (55.5%) patients had hyperkyphosis (Cobb angle >45°), and 9/27 (33.3%) had normal kyphosis (25°–45° Cobb angle). As corrective measures, in PSG, an apical translation was performed, followed by segmental compression-distraction and direct vertebral derotation, whereas, in the HG, a simultaneous apical concave translation and apical derotation.

Radiographic results

All results are reported in Tables 2a and 2b.

In the coronal plane, we first measured Cobb angle of primary curve. This resulted to be well corrected by all devices, in fact in PSG and HG, significative differences were found between T0, T1, and FU ($P < 0.05$) as reported in Table 2a. In T0, the two groups were homogeneous, PSG showed a mean value of 80.07° ± 5.51°, while HG 87.92° ± 14.06° ($P = 0.32$) and significative differences about correction of primary scoliotic curve between groups were found. In T1 and FU, PSG stated a mean value of 31.4° ± 7.26° and 33.40° ± 7.64°, whereas HG mean values were 37.42° ± 6.22°

Table 2a: Pedicle screw group and hybrid group radiographic results

	Primary curve (mean Cobb°)	Secondary curve (mean Cobb°)	Coronal plane imbalance (mean mm)	Sagittal plane imbalance (mean mm)	Lumbar lordosis (mean Cobb°)	Kyphosis (mean Cobb°)
PSG						
Before surgery (T0)	80.10±5.51	48.13±14.58	22.48±10.14	−12.78±12.68	52.93±11.26	41.26±12.46
After surgery (T1)	31.40±7.26	20.47±11.05	23.26±17.41	−29.21±21.18	47.40±9.15	36.53±4.83
FU	33.40±7.64	21.87±12.78	14.44±10.44	−20.07±17.08	47.60±8.75	37.27±3.32
Mann-Whitney test T0 versus T1 (*P*)	<0.00001*	<0.00001*	0.37	0.72	0.23	0.05
Mann-Whitney test T1 versus FU (*P*)	0.44	0.71	0.45	0.28	0.96	0.65
Mann-Whitney test T0 versus FU (*P*)	<0.00001*	0.0002*	0.07	0.36	0.19	0.06
HG						
Before surgery (T0)	87.92±14.06	37.42±6.22	40.25±6.53	<0.00001*	0.30	<0.00001*
After surgery (T1)	48±15.09	21.08±6.85	21.83±7.31	<0.00001*	0.90	<0.0002*
FU	17.88±12.93	11.64±5.62	11.54±4.57	0.61	0.56	0.24
Mann-Whitney test T0 versus T1 (*P*)	−5±28.66	−13.73±29.56	−13.09±27.28	0.26	0.29	0.94
Mann-Whitney test T1 versus FU (*P*)	56.16±10.37	50.75±7.61	47.08±7.72	0.29	0.28	0.07
Mann-Whitney test T0 versus FU (*P*)	44.16±11.85	39.5±7.34	41.41±8.30	0.14	0.43	0.25

*Differences are marked with. PSG - Pedicle screw group; HG - Hybrid group; FU - Follow-up

Table 2b: Analysis of results in the two groups studied

	PSG	HG	Mann-Whitney test (*P*)
n	15	12	-
Mean age (years)	16±1.56	16.58±2.63	0.23
Mean FU (months)	60.93±22.82	58.67±20.56	0.74
Primary curve before surgery (mean Cobb°)	80.10±5.51	87.92±14.06	0.32
Primary curve after surgery (mean Cobb°)	31.40±7.26	37.42±6.22	0.03*
Primary curve at FU (mean Cobb°)	33.40±7.64	40.25±6.53	0.02*
Secondary curve before surgery (mean Cobb°)	48.13±14.58	48±15.09	0.96
Secondary curve after surgery (mean Cobb°)	20.47±11.05	21.08±6.85	0.98
Secondary curve at FU (mean Cobb°)	21.87±12.78	21.83±7.31	1
Side-bending flexibility (mean Cobb°)	63.73±8.64	64.25±6.55	0.76
Coronal plane imbalance before surgery (mean mm)	22.48±10.14	17.88±12.93	0.32
Coronal plane imbalance after surgery (mean mm)	23.26±17.41	11.64±5.62	0.03*
Coronal plane imbalance at FU (mean mm)	14.44±10.44	11.54±4.57	0.58
Sagittal plane imbalance before surgery (mean mm)	−12.78±12.68	−5±28.66	0.88
Sagittal plane imbalance after surgery (mean mm)	−29.21±21.18	−13.73±29.56	0.49
Sagittal plane imbalance at FU (mean mm)	−20.07±17.08	−13.09±27.28	0.61
Lumbar lordosis before surgery (mean Cobb°)	52.93±11.26	56.16±10.37	0.41
Lumbar lordosis after surgery (mean Cobb°)	47.40±9.15	50.75±7.61	0.21
Lumbar lordosis at FU (mean Cobb°)	47.60±8.75	47.08±7.72	0.86
Instrumented vertebrae (mean)	11.10±1.69	11.25±1.83	0.65
Density of instrumentation (mean)	1.51±0.10	1.64±0.12	0.009*
Surgical time (mean minutes)	386±55.95	405±49.07	0.36

*Differences are marked with. PSG - Pedicle screw group; HG - Hybrid group; FU - Follow-up

and 40.25° ± 6.53°, respectively. These differences resulted to be statistically significative with $P < 0.05$ ($P = 0.03$ and 0.02, respectively) [Table 2b]. HG showed a better coronal imbalance control in T1, but this significative difference was not maintained at FU. As reported in Table 2b, PSG needed a minor density of instrumentation for obtaining correction results ($P = 0.009$).

No other significative differences can be found between groups for all other items ($P > 0.05$).

At FU, 26/27 patients (96.30%) achieved normokyphosis, confirming the high correction power of only screws and hybrid constructs.

The upper-instrumented vertebra was between T1 and T6. In PSG, T1 = 2, T2 = 1, T3 = 2, T4 = 4, T5 = 5, and T6 = 1. In HG, T2 = 1, T3 = 3, T4 = 7, and T5 = 1. The last instrumented vertebra was between T12 and L5. In PSG, T12 = 3, L1 = 4, L2 = 2, L4 = 5, and L5 = 1. In HG, T12 = 3, L1 = 1, L2 = 2, L3 = 3, and L4 = 3 [Table 3].

Table 3: Upper-instrumented vertebra, last instrumented vertebra - results of the study

PSG				HG			
UIV		LIV		UIV		LIV	
Level	Number of patients	Level	Number of patients	Level	Number of patients	Level	Number of patients
T1	2	T12	3	T1	0	T12	3
T2	1	L1	4	T2	1	L1	1
T3	2	L2	2	T3	3	L2	2
T4	4	L3	0	T4	7	L3	3
T5	5	L4	5	T5	1	L4	3
T6	1	L5	1	T6	0	L5	0

UIV - Upper-instrumented vertebra; LIV - Last instrumented vertebra; PSG - Pedicle screw group; HG - Hybrid group

Table 4: Scoliosis Research Society 24 questionnaire results

Patient-based outcome tools (follow-up)	PSG	HG	Mann-Whitney test (*P*)
SRS pain	4.46±0.74	4.58±0.51	0.88
SRS general self-image	4.33±0.72	4.58±0.66	0.39
SRS self-image after surgery	4.73±0.45	4.66±0.65	1
SRS function after surgery	4.67±0.49	4.75±0.45	0.72
SRS general function	4.73±0.59	4.5±0.67	0.37
SRS function-activity	4.53±0.63	4.75±0.45	0.47
SRS satisfaction with surgery	5±0	5±0	0.98

SRS - Scoliosis Research Society; PSG - Pedicle screw group; HG - Hybrid group

Clinical results

Clinical results of SRS 24 questionnaire are reported in Table 4. No differences were reported for each domain between the two groups.

In PSG, one patient presented a deep infection after 3 years: he underwent a removal of the instruments and a surgical debridement. In HG, there was a temporary loss of somatic and motor potentials in one case during surgical correction, with recovery of normal values after some minutes.

DISCUSSION

Surgical treatment is recommended for patients with Cobb angle wider than 45°.[12]

Since the introduction of high-density third-generation implants, surgical approach has undergone an evolution. In severe and rigid curves, Bullman *et al*.[5] considered that an anterior release was necessary in addition to the posterior fusion to obtain an effective three-dimensional curve correction. However, other authors believe that the posterior approach alone is enough to correct even the most severe curves, thus sparing the complications related to the anterior approach to the patient.[13-15] Posterior instrumentation consists of the use of pedicle screws, hooks, sublaminar bands, or hybrid constructions. Nowadays, they are widely used for the effectiveness of correction and relatively low-complication rate. Burton *et al*.,[16] who focused on the potential of hybrid instrumentation investigated the role of the posterior approach in severe thoracic curves. On an average, it was possible to move to particularly severe curves of about 75° to curves of 25°, all with very few complications. The results were encouraging on the radiographic, functional, and esthetic level. The first to introduce the pedicle screws in idiopathic curves was Suk *et al*.[17] Crostelli *et al*.[18] have recently highlighted the results that can be obtained with all pedicle screws in thoracic chest curves of 95° achieving encouraging results and comparable to those obtained with the combined approach like stated in the literature.[19] Di Silvestre *et al*.[20] performed a comparative study between pedicle screws and hybrid instrumentation, highlighting a higher correction rate in the all pedicle screw group. In the present study, we evaluated the patient globally and analyzing the real possibilities of the posterior approach (thanks to high-density instrumentations) to obtain good radiographic, functional, and cosmetic results in severe scoliosis. In the sagittal plane, comparable and satisfactory results can be obtained both with pedicle screws and with hybrid instrumentation. Patients with a starting hypokyphosis or hyperkyphosis recovered a normal profile at follow-up. Normokyphosis was maintained in physiological ranges. Furthermore, the maintenance of the normal lumbar lordotic profile can be achieved too and sagittal misalignment showed a trend in line with data from other studies in the literature.[18,20,21] As for the coronal displacement, both methods were acceptable to obtain a global balance of the spine highlighting; however, in the postoperative, a better ability of hybrid instruments to reduce the misalignment.

We found significative differences in favor of PSG that seems to guarantee better corrections of primary scoliotic curve with lesser density of instrumentation respect to HG. However, we feel that hybrid implant is also valid;[22,23] patients treated with hybrid instruments presented a generally more severe scoliotic curve and in relative terms, obtained a result almost analogous to those of the other group. It is, therefore, not possible to establish a net superiority of one method on the other as stated in the

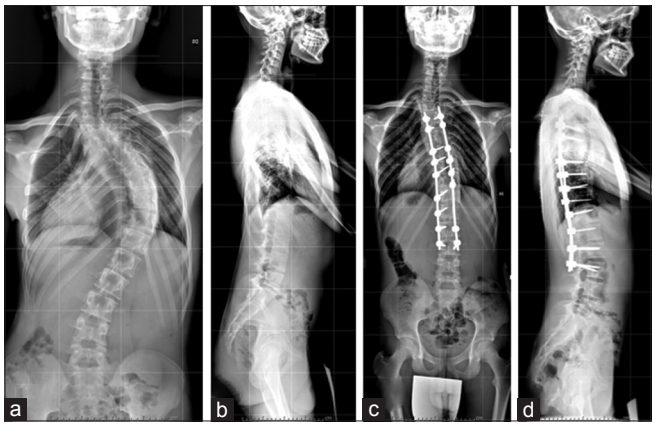

Figure 1: Male 15 years old, Lenke 1, all pedicle screw implant. (a and b) X-rays in the frontal and lateral view of scoliosis in presurgery time; (c and d) X-rays in frontal and lateral view of scoliosis at 2-year follow-up

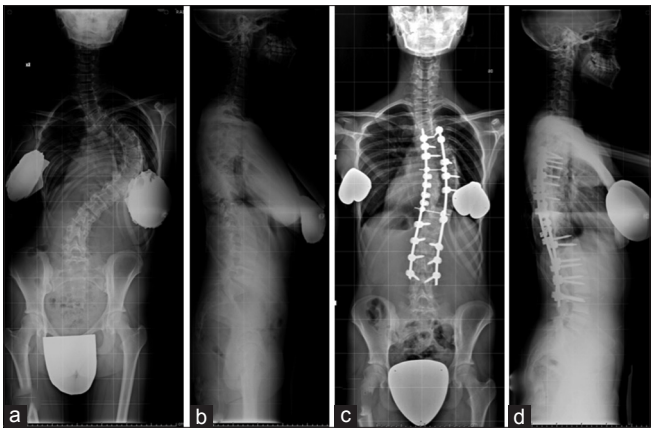

Figure 2: Female 15 years old, Lenke 1, hybrid implant. (a and b) X-rays in the frontal and lateral view of scoliosis in presurgery time; (c and d) X-rays in frontal and lateral view of scoliosis at 2-year follow-up

literature,[18-20] since the variability of the response to the intervention comes into play and above all much depends on the skill of the surgeon who may not be able to master at the same level both techniques. In our study emerges that with the use of posterior approach is possible to obtain good and stable correction of the deformities with a limited number of instrumented vertebrae, preserving so the patient's mobility without causing severe functional limitations.

Complications were extremely rare in both arms of the study with the same rate of other studies that show how the posterior approach is safer for the patient.[24-30] Clinical results were also satisfactory [Figures 1 and 2]. The scores obtained with the administration of the SRS 24 questionnaire (which has been used for years in studies published in the literature)[31,32] were comparable in the two study-arms. Pain has never been a problem except in the immediate postoperative period; the patient felt comfortable wearing clothes, more attractive, managed to maintain a socially active life, and could even perform light-to-moderate physical activity. All patients would have repeated the same treatment. Moreover, PSG and HG were homogeneous for age, severity of scoliosis, reducibility of the curve, and sagittal profile, making the results comparable.

Some limitations to this study must be acknowledged; some are intrinsic to the study design due to its retrospective nature or the lack of randomization. In addition, the low number of patients and the lack of *a priori* sample size calculation exposes results to some risk of bias. Moreover, the lack of a wide literature on this topic did not allow an extensive comparison with our study, in terms of clinical and radiological findings.

CONCLUSION

The posterior approach proved to be an excellent technique for obtaining good clinical and radiographic results if surgeon adopts third-generation high-density implants. Our data confirm that both pedicle screws and hybrid screws-sublaminar bands implants can guarantee good corrections and stability at FU.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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