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Comparative Analysis of Combined (First Anterior, Then Posterior) *Versus* Only Posterior Approach for Treating Severe Scoliosis

A Mean Follow Up of 8.5 Years

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Study Design. A retrospective, one center, institutional review board approved study.

Objective. Two methods of operative treatments were compared in order to evaluate whether a two-stage approach is justified for correction of bigger idiopathic scoliosis curves. Two stage surgery, combined anterior approach in first operation and posterior instrumentation and correction in the second operation. One stage surgery included only posterior instrumentation and correction.

Summary of Background Data. Studies comparing two-stage approach and only posterior approach are rather scarce, with shorter follow up and lack of clinical data.

Methods. Three hundred forty eight patients with idiopathic scoliosis were operated using Cotrel–Dubousset (CD) hybrid instrumentation with pedicle screw and hooks. Only patients with curvatures more than or equal to 61° were analyzed and divided in two groups: two stage surgery (N=30) and one stage surgery (N=46). The radiographic parameters as well as duration of operation, hospitalization time, and number of segments included in fusion and clinical outcome were analyzed.

Results. No statistically significant difference was observed in correction between two-stage group (average correction 69%) and only posterior approach group (average correction 66%). However, there were statistically significant differences regarding hospitalization time, duration of the surgery, and the number of instrumented segments.

Conclusion. Two-stage surgery has only a limited advantage in terms of postoperative correction angle compared with the posterior approach. Posterior instrumentation and correction is satisfactory, especially taking into account that the patient is subjected to only one surgery.

Key words: anterior approach, CD hybrid instrumentation, correction angle, posterior approach, scoliosis.

Level of Evidence: 3

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The device(s)/drug(s) is/are FDA-approved or approved by corresponding national agency for this indication.

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Spine

Scoliosis is a three-dimensional deformation of the spine. The goal of an operative treatment is to do an effective correction of the coronal, sagittal, and rotational deformities with minimal fusion levels, while maintaining appropriate coronal and sagittal balance. A three-dimensional correction in scoliosis surgery was introduced in the 1980s by Cotrel–Dobousset¹ and Zielke.² In the past, the treatment of severe idiopathic scoliosis was performed by an anterior release with an open thoracotomy, followed by posterior instrumented fusion.³ This was done either in one or in two stages. There are different studies analyzing scoliosis surgery with posterior instrumentation mainly comparing hybrid and only screw constructs.^{4–9} Literature studies comparing two-stage approach and only posterior approach are rather scarce. Luhmann *et al*¹⁰ found two-stage approach slightly better than only a posterior approach with hooks and hybrid instrumentation. However, a subgroup operated with all segment screw instrumentation had results comparable with the two-stage group. Unnikrishnan *et al*⁸ reported no significant difference between the two approaches. For specific indications, Lenke¹¹ and Niemeyer *et al*¹² reported that thoracoscopic anterior release and posterior instrumentation and fusion

can represent a safe and effecting technique for the treatment of spinal deformity. However, Arlet *et al*,¹³ and Suk *et al*¹⁴ showed that satisfactory correction of curvatures 70° to 90° of Cobb angle can also be achieved without any anterior release, especially when using a posterior segmental pedicle screw fixation. Furthermore, the all level pedicle screw fixation is nowadays universally recognized as the most corrective method in adolescent idiopathic scoliosis surgery.

The objective of the retrospective study was to compare long-term clinical and radiological outcomes in comparable groups of patients when using different surgical approaches (two-stage and only posterior) for idiopathic scoliosis operation using Cotrel–Dubousset (CD) hybrid instrumentations (Medtronic, Minneapolis, MN). In addition, we aimed to compare the performance of different generations of CD hybrid instrumentations that were used on our patient groups in the period of 15 years.

MATERIALS AND METHODS

From January 1995 to December 2010, 380 patients were operated due to idiopathic scoliosis. Among them 348 were operated with CD instrumentation. Detailed retrospective data were collected to evaluate the results of surgical intervention in whole group of patients. Only patients operated with CD instrumentation whose curvatures were equal or greater than 61° of Cobb angle were selected. We identified 76 patients with curvature greater than and equal to 61°. According to the operating technique, patients were divided into two groups. In the first group a two-stage approach with anterior approach with discectomy and after that posterior approach with instrumentation and correction was used in 30 patients. An interval of 1 week to 10 days was set between the two stages. No traction was used between the two stages. Second group comprised 46 patients operated using only posterior approach.

Comparisons between groups were made regarding the following variables: sex, age at surgery, follow-up duration, number of segments, duration of surgery, hospitalization time, and different radiological parameters. The anteroposterior (AP) and lateral standing radiographs were used to check for deformity; numbers of instrumented segments, curve flexibility (bending test), coronal and sagittal balance, and rotation deformity. The coronal balance was measured as the distance between the C7 plumb line and the perpendicular line drawn from the center of S1. The sagittal balance was measured as shortest distance between the C7 plumb line and the posterior superior corner of the S1 body. For both coronal and sagittal measurements, balance was considered abnormal if the distance was greater than 2 cm. Measurement of vertebral rotation was done using the Nash-Moe method. In December 2014, all patients were invited in an outpatient clinic to fill out a short-form health survey (SF-36) and to make a control x-ray of the whole spine. Competent medical staffs not involved in spinal surgery have collected measured data. Taking into account the experience of examiners, the error in measurements of

TABLE 1. The Curve Distribution in Groups According to Lenke¹⁶ Classification

Lenke Type	Posterior Group	Combined Group
1	14	12
2	7	7
3	18	8
4	0	1
5	4	1
6	3	1

Cobb angle was estimated to 2°. According to Lenke classification,¹⁵ the curve types were as represented in Table 1. The radiological parameters were measured on the preoperative, immediate postoperative, and at the latest follow-up (Figure 1A–F). All operations were performed by the same team of four surgeons. Only the main surgeon, with approval from other colleagues of the team, made operative planning. The decision whether to use only posterior approach or combined approach was not based on any specific criteria. It was in the domain of the main surgeon. Clinical outcome was analyzed using validated SF-36 questionnaires. In the 15-year period, different instrumentation was used: CD 1st generation, CD Horizon, and CD Legacy. All patients were operated by hook/screw multisegmental instrumentation for correction in coronal and sagittal plane in order to regain and preserve body balance.^{16–18}

Data were analyzed using IBM SPSS Statistics 23 (IBM Corporation, Armonk, New York, USA). Following statistical methods were used: Pearson Chi-square test, Pearson correlation coefficient, *t* test for independent samples and one way analysis of variance. When statistically significant differences were found we used Tukey post hoc test in the case of equal group's variances and Games-Howell test when there were differences in variances.

Differences were considered significant at 5% ($P < 0.05$).

RESULTS

In the group of 46 patients with posterior approach, the average curvature was 70.4°, correction on bending x-ray 44.2% (30.9°), postoperative correction 65.9% (46.2°), and loss of correction at the last control 21.5% (4.84°) (Table 2). Loss of correction was present in 69.6% of cases.

In the group of 30 patients with ant/post approach (combined group), the average curvature was 74.5°, correction on bending x-rays 45.8% (34°), postoperative correction 69% (50.9°), and loss of correction at the last control 25.8% (5.1°) (Table 2). Loss of correction was present in 93.3% of cases.

The mean hospitalization time was statistically higher in the two-stage approach group ($P < 0.001$) (Figure 2).

In the two-stage approach group operational correction greater than 4.7° (50.87° vs. 46.17°) was accomplished in comparison to posterior approach group ($P = 0.009$) (Figure 3). Between posterior and two-stage approach group there were no significant differences in the initial angle

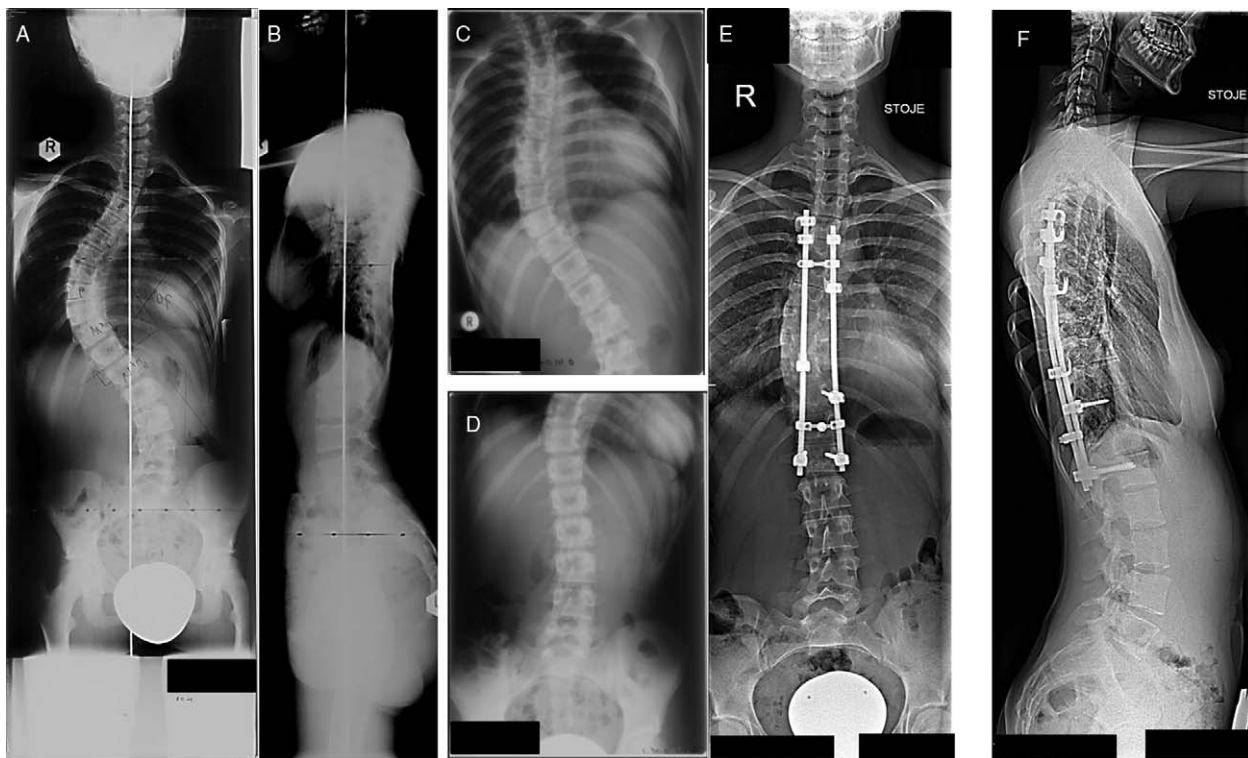


Figure 1. 13-year-old girl with AIS. **A, B,** Preoperative Lenke type 1AN. **C,** Right side bending radiograph. **D,** Left side bending radiograph. **E, F,** Six years postoperative AP and lateral radiographs. AIS indicates adolescent idiopathic scoliosis; AP, anteroposterior.

($P = 0.094$), bending results ($P = 0.163$), and loss of correction at the last control ($P = 0.080$) (Table 1).

The preoperative bending angle was compared with the final postoperative outcome. We found a strong statistical correlation between possible correction of scoliosis on bending x-rays and after surgery correction ($P < 0.001$).

The number of segments included in fusion was slightly greater in posterior approach group (11.0) than in two-stage approach group (10.3), ($P = 0.043$), (Figure 4).

The mean difference in patient age of 1.8 years had no influence on the comparability of the groups since the flexibility of spine remains comparable (bending among groups $P > 0.135$).

There was no statistically significant difference between the groups for rotation, thoracic kyphosis, lumbar lordosis, and for coronal and sagittal balance (Table 3). More than half of the patients in both groups (posterior approach group 65% patients and two stage approach group 53%

TABLE 2. Comparison Between Posterior and Two-Stage Approach

	Posterior Approach			Two-Stage Approach			P
	Count	Mean	Standard Deviation	Count	Mean	Standard Deviation	
Gender							
Male	9			5			
Female	37			25			0.987
Age at surgery (yr)	46	14.48	2.55	30	13.37	4.72	0.188
Follow-up (yr)		8.62	5.13		8.24	3.57	0.720
Duration of surgery (min)		263	262		347	69	<0.001
Hospitalization time (days)		18.6	7.1		32.6	10,6	<0.001
Initial angle (°)		70.4	9.6		74.5	11.0	0.094
Correction initial vs. bending angle (°)		30.9	8.8		34.0	10.3	0,163
Correction postop vs. initial angle (°)		46.2	7.7		50.9	7.0	0.009
Correction last control vs. postop angle (°)		3.4	3.7		4.8	3.0	0.080
Number of segments		11.0	1.7		10.3	1.2	0.043

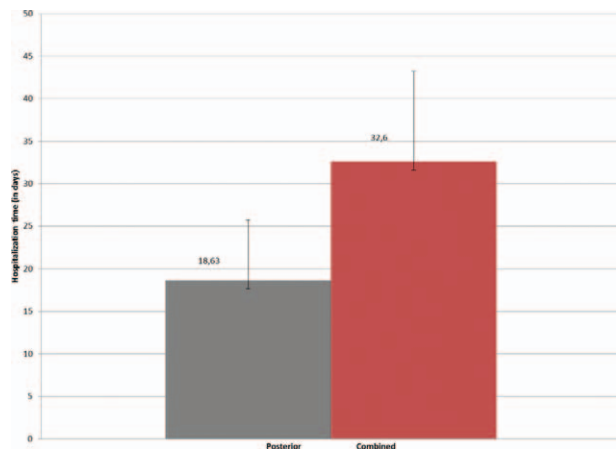


Figure 2. Hospitalization time in groups of patients with posterior and combined approach.

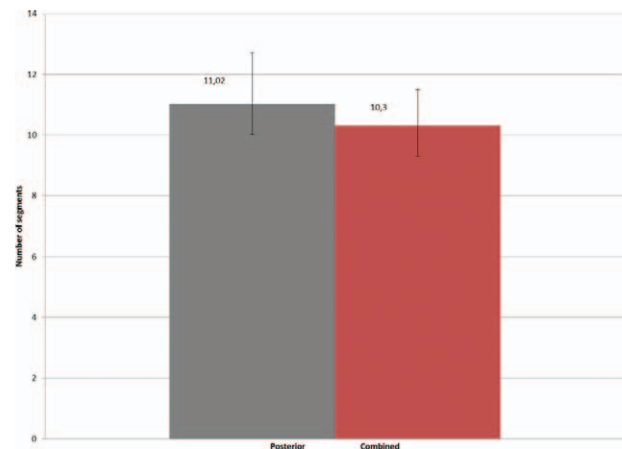


Figure 4. Number of segments in groups of patients with posterior and combined approach.

patients) were not balanced in sagittal plane. Regarding the coronal plane, 26% of the patients in posterior approach group and 27% in two-stage approach group were not balanced.

We reoperated one patient undergone two-stage operation because of skin necrosis in the skin incision area. There was not a single neurological complication present and none infection in both groups.

The SF-36 scores were available in 33 of 46 patients in posterior group and 22 of 30 patients in combined approach group at the last follow up. The scores were similar and there were no statistically significant differences between different health dimensions among comparing groups. The greatest differential found in mean scores was for energy and vitality (Figure 5).

The mean follow up was 8.26 years for posterior approach and 8.24 years for combined approach. The difference was not statistically significant ($P=0.720$).

The differences in mean correction among three groups of generation of CD instrumentation were tested on a subgroup of patient with curvature greater than and equal to

61° (Table 4). There are no statistically significant differences in initial angles ($P=0.478$), bending results ($P=0.478$), operational correction ($P=0.401$), and loss of correction at last control ($P=0.343$) between patients operated using different types of instrumentation. However, by starting to use the CD Legacy system, we slowly began to abandon the two-stage approach. As it is shown in Table 4, CD Legacy system was used for two-stage approach only on one patient out of 12.

CD legacy patients had curvatures that included larger number of segments than both CD class (mean difference [MD] = 1.389, $P=0.015$) and CD horizon (MD = 1.417, $P=0.017$) patients.

DISCUSSION

The results of two operative approaches for severe idiopathic scoliosis were analyzed retrospectively in a relatively large group of patients compared with previous studies.^{10,12-14} Significant improvement of correction of curvatures greater than 61° reaching up to 65% to 69% was achieved by both treatments. By comparing data in each subgroup, we found significant but minimal difference in correction (4.7°), which alone does not justify the two-stage operation. Furthermore, we succeeded to regain body balance in both groups. In favor of single posterior approach speaks also the data on hospitalization time and duration of surgery which were significantly longer in two stage surgery group ($P < 0.001$). However, an average of 18 days of hospitalization time after single posterior approach is a lot and could be ascribed to specific national health care system at the time of surgeries that favored longer hospital stay. Last but not least, there was also no significant difference in clinical results between the two operative groups on the long run (average follow up more than 8 yr). However, preferred Scoliosis Research Society questionnaire was not used, because of lack of validation for our country. Given the risk of two operations, including risk of diminishing pulmonary function, few days of thoracic

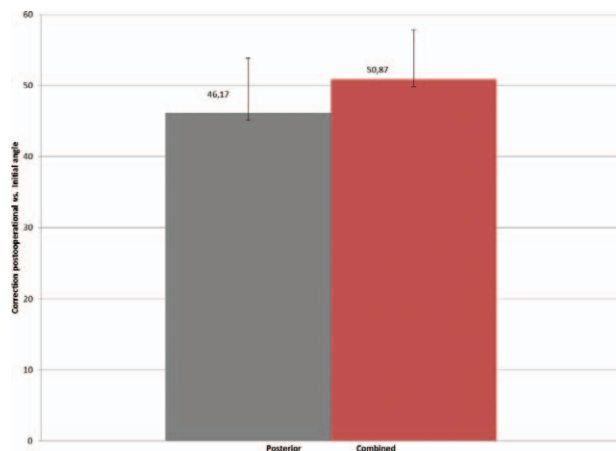


Figure 3. Correction postoperative versus initial angle in groups of patients with posterior and combined approach.

TABLE 3. Comparison Between Posterior and Two-Stage Approach

			Posterior Approach		Two-Stage Approach		P
			Mean	Standard Deviation	Mean	Standard Deviation	
Preoperative	Rotation		3	0.63	3	0.45	0.362
	Kyphosis (°)		17.18	10.32	20.73	10.27	0.569
	Lordosis (°)		37.10	11.43	39.00	10.10	0.478
	Balance (mm)	Coronal	19.54	11.14	19.00	12.24	0.748
	Balance (mm)	Sagittal	29.63	22.10	19.64	14.93	0.116
Postoperative	Rotation		2.5	0.52	2.2	0.60	0.672
	Kyphosis (°)		29.73	11.05	29.10	5.12	0.898
	Lordosis (°)		41.91	8.25	42.45	6.39	0.949
	Balance (mm)	Coronal	7.64	3.67	7.36	4.20	0.847
	Balance (mm)	Sagittal	16.82	12.41	11.54	6.71	0.519
Final follow-up	Rotation		2.45	0.52	2.18	0.60	0.672
	Kyphosis (°)		33.64	11.55	35.00	6.20	0.519
	Lordosis (°)		45.18	8.51	48.91	5.84	0.332
	Balance (mm)	Coronal	8.54	10.11	8.36	5.73	0.562
	Balance (mm)	Sagittal	16.00	11.26	11.64	6.10	0.562

drainage representing major discomfort for the patient, worse esthetic effect—two scars instead of one (in case of thoracoscopic discectomy—multiple small scars), conclusion could be drawn that single posterior approach would be better option for patients with severe idiopathic scoliosis than two-stage combined approach.

According to the literature,¹⁸ the most important prognostic sign of outcome of correction is the bending test. This was shown also in our study, where possible correction on bending x-ray films was highly correlated to final correction after operation ($P < 0.001$).

Most of surgeons perform posterior approach in scoliosis surgery because it achieves good results with minimal risk of intraoperative complications.^{19,20} In the last decade, there is

a trend for using all pedicle screw instrumentation, with hybrid instrumentation being still in use. There was also gradual orientation from hybrid construct toward all pedicle screw construct over time in our series. Results of both instrumentation techniques have been extensively studied and compared.^{4,6,7,21–23} There is some disagreement in the literature; better primary and secondary curve correction were demonstrated using pedicle screws compared with only hooks or hybrid instrumentation,^{6,24} on the other hand Storer *et al*,⁷ showed that either all pedicle or hybrid construct effectively corrects adolescent idiopathic scoliosis. Suk *et al*¹⁴ found that anterior release for correction of severe scoliosis is not necessary when using all segments pedicle screw posterior instrumentation. Luhman study¹⁰ concluded that a two-stage approach of large thoracic curves allows greater coronal correction of thoracic curves between 70° and 100°, when compared with posterior instrumentation alone using thoracic hook constructs but not with the use of thoracic pedicle screw constructs. Results of our retrospective study suggest that operative corrections along with long-term radiological results are not dependent on the instrumentation technique used.

Certainly, the results of present study need to be interpreted with regard to its limitations. Study is retrospective in its basis; there was no randomization between the two operative approaches. Although the series is consecutive, there is no significant difference between the two groups in terms of age, curve magnitude, flexibility, and follow-up. Although, there was statistical significant difference ($P = 0.043$) between groups in the number of segments included in fusion, the absolute difference was less than one segment. With the development of new instrumentation techniques in the period of study the approach used slowly switched from double to posterior only, which could potentially affect the results.

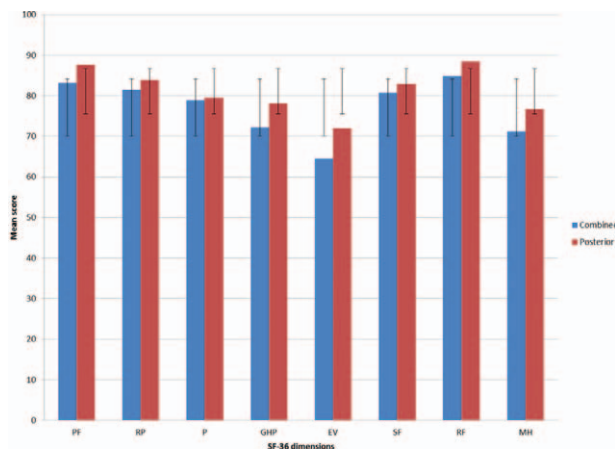


Figure 5. SF-36 results according to different health dimensions in both groups of patients. Abbreviations: PF—physical functioning, RP—role limitation-physical, P—bodily pain, GHP—general health, EV—Energy and vitality, SF—social functioning, RF—role limitation-emotional, MH—mental health. SF-36 indicates short-form health survey.

TABLE 4. Comparison Among CD Instrumentation of Different Generations—Subgroup Initial Angle of Deformities $\geq 61^\circ$ (N = 76)

	Instrumentation									
	CD 1st generation			CD Horizon			CD Legacy			P
	Count	Mean	Standard Deviation	Count	Mean	Standard Deviation	Count	Mean	Standard Deviation	
Gender										
Male	9			4			1			
Female	27			24			11			0.338
Initial angle		71.93	10.49		72.21	10.43		71.75	10.58	0.990
Correction initial vs. -banding angle		31.79	9.74		33.57	9.89		29.67	7.72	0.478
Postop correction vs. initial angle		46.75	8.80		49.14	6.17		49.25	7.72	0.401
Correction last control vs. postop angle		3.75	3.65		4.61	3.63		2.92	2.35	0.343
Number of segments		10.53	1.48		10.50	1.23		11.92	1.83	0.012*
Approach										
Posterior	28			7			11			
Two-stage	8			21			1			

CD indicates Cotrel–Dubousset.

CONCLUSION

Results of our study indicate that both, single posterior and two stage-combined approach are equally effective for operative treatment of severe idiopathic scoliosis in terms of regaining good balance, achieving maximal possible correction with minimal complications, and good long-term clinical result. However, considering minimal differences in the correction of curvatures, longer surgery duration, and hospital stay, single posterior approach could be advocated for surgical management of severe idiopathic scoliosis.

Key Points

- ❑ Literature studies comparing two-stage approach and only posterior approach in scoliosis surgery are rather scarce.
- ❑ Long-term clinical and radiological outcomes in comparable groups of patients, which are presented in our study, are needed for measurement of the long term effectiveness of each method.
- ❑ Posterior approach only for bigger ($\geq 61^\circ$) idiopathic scoliosis curves is satisfactory in terms of regaining good correction, body balance and fine long-term clinical result.

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