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DEFORMITY

Adult Scoliosis Deformity Surgery

Comparison of Outcomes Between One Versus Two Attending Surgeons

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Study Design. Retrospective review of prospectively collected data.

Objective. Assess outcomes of adult spinal deformity (ASD) surgery performed by one *versus* two attending surgeons.

Summary of Background Data. ASD centers have developed two attending teams to improve efficiency; their effects on complications and outcomes have not been reported.

Methods. Patients with ASD with five or more levels fused and more than 2-year follow-up were included. Estimated blood loss (EBL), length of stay (LOS), operating room (OR) time, complications, quality of life (Health Related Quality of Life), and x-rays were analyzed. Outcomes were compared between one-surgeon (1S) and two-surgeon (2S) centers. A deformity-matched cohort was analyzed.

Results. A total of 188 patients in 1S and 77 in 2S group were included. 2S group patients were older and had worse deformity based on the Scoliosis Research Society-Schwab classification ($P < 0.05$). There were no significant differences in levels fused ($P = 0.57$), LOS (8.7 *vs* 8.9 days), OR time (445.9 *vs* 453.2 min), or EBL (2008 *vs* 1898 cm^3; $P > 0.05$). 2S patients had more three-column osteotomies (3CO; $P < 0.001$) and used less bone morphogenetic protein 2 (BMP-2; 79.9% *vs* 15.6%; $P < 0.001$). The 2S group had fewer intraoperative complications (1.3% *vs* 11.1%; $P = 0.006$). Postoperative (6 wk to 2 yr) complications were more frequent in the 2S group (4.8% vs 15.6%; $P < 0.002$). After matching for deformity, there were no differences in (9.1 *vs* 10.1 days), OR time (467.8 *vs* 508.4 min), or EBL (3045 *vs* 2247 cm^3; $P = 0.217$). 2S group used less BMP-2 (20.6% *vs* 84.8%; $P < 0.001$), had fewer intraoperative complications ($P = 0.015$) but postoperative complications due to instrumentation failure/pseudarthrosis were more frequent ($P < 0.01$).

Conclusion. No significant differences were found in LOS, OR time, or EBL between the 1S and 2S groups, even when matching for severity of deformity. 2S group had less BMP-2 use, fewer intraoperative complications but more postoperative complications.

Key words: adult deformity surgery, scoliosis complications, spine deformity surgery, two-surgeon teams.
Level of Evidence: 2
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Inadequate sagittal and coronal alignment can negatively affect quality of life in adult patients with spinal deformity.[1] With advances in surgical techniques and instrumentation, improved outcomes after long spinal fusions are increasingly possible. Complications, however, remain common and surgeons aim to decrease them and improve patient outcomes.[2] The incidence of complex adult spinal deformity (ASD) surgery has increased significantly[3] and with it complications, readmissions, and need for revision procedures, that have been reported to be between 13% and 45%.[4,5] Because of the technical complexity, operative length, and high complication risks of ASD surgery,[6] some centers have developed systems using two attending surgeons to improve efficiency in the operating room (OR). Benefits of two cosurgeons in other complex procedures such as nephrectomies, bilateral simultaneous anterior cruciate ligament reconstruction, and esophagectomy have been reported.[7–10] A single institution recently

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demonstrated that two cosurgeons performing a pedicle subtraction osteotomy (PSO) decreased estimated blood loss (EBL) and OR time compared to a single-surgeon procedure.[11] Similar results were shown for pediatric scoliosis patients undergoing posterior final fusion by two attending surgeons compared with single-surgeon cohorts.[12,13] Here, in addition to a decrease in EBL and shorter OR time, fewer perioperative complications and shorter hospital stays were noted. It is reasonable to believe that in complex spine surgeries EBL and OR time are linked to higher rates of perioperative complications.[8,11,14]

With the recent availability of large multicenter prospective databases, ASD surgery outcomes can be closely evaluated and cost-effectiveness of scoliosis surgical correction studied.[15–17] McCarthy *et al*[17] reported that surgical ASD treatment is cost-effective after a 10-year period. But secondary to the individualized nature of the indications and treatment algorithms, appropriate operative *versus* nonoperative comparisons are extremely difficult to achieve. As suggested by other authors, the cost of ASD surgical management is extremely high and it is likely that the findings of McCarthy *et al* reflect a best-case scenario.[18] Having two cosurgeons performing an ASD surgery will likely increase the cost of operative treatment. The benefits and effectiveness of two-surgeon teams need to be evaluated before evaluating the cost-effectiveness of this approach that attempts to improve ASD outcomes.

The purpose of our study is to assess operative, clinical, and radiographic outcomes of ASD surgery based on performance by one *versus* two attending surgeons from a multicenter database.

MATERIALS AND METHODS

This is a prospective, multicenter, consecutive series of patients with ASD treated by members of the International Spine Study Group. The group consists of 11 sites from across the United States. Inclusion criteria for the database are age older than 18 years and presence of at least one of the following measures of spinal deformity: coronal Cobb angle of 20° or more, sagittal vertical axis (SVA) of 5 cm or more, pelvic tilt of 25° or more, and thoracic kyphosis of 60° or more. In addition to the database inclusion criteria, patients were included in the present study if they met the following criteria: (1) five or more levels of posterior instrumented fusion was performed, (2) availability of information about performance of the procedure by one or two attending surgeons, and (3) at least 2-year follow-up. Patients were enrolled through a protocol approved by the institutional review boards of the participating sites. Deformities resulting from neuromuscular disease, trauma, spinal infection, ankylosing spondylitis, or tumors are not included in the database.

All demographic, clinical, operative, and follow-up data were extracted from the database. Variables evaluated included patient age, sex, and history of prior spine surgery. Operative data included levels of spinal instrumented arthrodesis, whether a PSO was performed, EBL, OR time, and use of recombinant human bone morphogenetic protein 2 (BMP-2; Infuse Bone Graft, Medtronic, Minneapolis, MN).

Postoperative variables included length of stay (LOS) and review of standardized complication assessment forms completed for each patient at each follow-up (typically at 6 wk, 6 mo, 1 yr, and 2 yr). Complications were grouped based on time of occurrence and severity. "Intraoperative" complications occurred during the case, "perioperative" were those between immediate post-op and 6-week follow-up, and "postoperative" between 6 weeks and 2 years. Regarding severity, complications were classified as minor or major and those requiring reoperation.

Radiographic parameters include SVA, pelvic tilt, and the mismatch between pelvic incidence and lumbar lordosis (PI-LL). Patients were assessed using the Scoliosis Research Society (SRS)-Schwab ASD classification and Health Related Quality of Life (HRQOL) questionnaires (Oswestry Disability Index, SRS-22r and Short Form 12). Information regarding the number of surgeons performing each procedure was obtained from each institution. Outcome variables were compared between single-surgeon and two-surgeon centers. Ten sites were included in the study, three of them had two-surgeon teams and seven centers performed single-surgeon procedures. In two third of the two-surgeon centers the instrumentation, osteotomy and the correction were performed by two cosurgeons, whereas in one two-surgeon center only the osteotomy and the correction were performed by two cosurgeons. One center was excluded from the study because there were insufficient data regarding number of attending surgeons.

Statistical analysis was performed with SPSS20.0 software.[19] Comparison of patient outcomes between matched and unmatched single-surgeon and two-surgeon groups was carried out using an unpaired Student *t* test or Mann-Whitney *U* test for continuous variables, and a chi-square for categorical parameters. The normality of data was investigated using the Shapiro-Wilk test.

RESULTS

Comparison of the Full Cohort

A total of 265 patients met inclusion criteria. One hundred eighty-eight patients had surgery performed by a single surgeon (1S), whereas 77 had ASD surgery performed by two cosurgeons (2S). Patients in the 2S group were significantly older than those in the 1S group (61.5 *vs* 54.2 yr, respectively; $P < 0.01$). Other demographic variables such as sex (1S/2S: 86.7% *vs* 77.9% women), body mass index (S1/S2: 27.2 *vs* 27.4 kg/m^2), or history of previous spine surgery (1S/2S revision: 43.3% *vs* 49.4%) were not different between groups.

Preoperative radiographic parameters demonstrated that patients operated by two cosurgeons had significantly worse baseline deformity (PI-LL 1S/2S: 12.16° *vs* 20.03°, $P = 0.006$; C7-S1 SVA 1S/2S: 51.15 *vs* 84.09 mm, $P = 0.001$; T1 pelvic angle[20] 1S/2S: 20.26° *vs* 25.18°,

TABLE 1. Comparison of Preoperative, 2-Year Postoperative and Change on Sagittal Parameters Between the Single-Surgeon and Two-Surgeon Group

Parameter		1 Surgeon			2 Surgeons			P
Pre-op	PT	22.60°	±	11.31°	25.00°	±	10.59°	0.113
	PI-LL	12.16°	±	21.72°	20.03°	±	19.77°	**0.006**
	T10-L2	−12.82°	±	16.51°	−9.21°	±	18.64°	0.12
	T4-T12	−32.45°	±	18.25°	−28.48°	±	18.18°	0.109
	SVA	51.15 mm	±	76.85 mm	84.09 mm	±	69.58 mm	**0.001**
	TPA	20.26°	±	13.76°	25.18°	±	12.82°	**0.008**
Post-op 2 yr	PT	21.61°	±	10.40°	20.51°	±	9.61°	0.425
	PI-LL	4.18°	±	15.72°	3.59°	±	13.99°	0.773
	T10-L2	−6.59°	±	12.39°	−5.01°	±	14.34°	0.371
	T4-T12	−40.19°	±	15.97°	−39.09°	±	17.27°	0.619
	SVA	30.44 mm	±	58.15 mm	36.49 mm	±	55.43 mm	0.438
	TPA	17.71°	±	11.78°	17.23°	±	10.05°	0.753
Change	PT	−0.99°	±	7.79°	−4.37°	±	7.79°	**0.002**
	PI-LL	−8.02°	±	17.59°	−16.44°	±	16.73°	**<0.001**
	T10-L2	6.02°	±	15.08°	4.19°	±	18.07°	0.399
	T4-T12	−7.87°	±	16.73°	−10.61°	±	13.92°	0.206
	SVA	−21.63 mm	±	62.56 mm	−45.71 mm	±	67.75 mm	**0.006**
	TPA	−2.79°	±	9.98°	−7.66°	±	10.12°	**<0.001**

PI-LL indicates pelvic incidence to lumbar lordosis mismatch; PT, pelvic tilt; SVA, sagittal vertical axis; TPA, T1 pelvic angle.
Bold values signifies statistically significant ($P < 0.05$).

$P = 0.008$; Table 1). This difference was also significant when comparing the groups based on SRS-Schwab classification system.[21] Specifically, the analysis of the SRS-Schwab classification revealed that patients in the 2S group had worse PI-LL modifier (S1/S2: 30.2% *vs* 50.6% graded as ++; $P = 0.004$) and SVA modifier (S1/S2: 25.7% *vs* 41.6% graded as ++; $P = 0.004$). There was no difference in the mean number of levels fused between the groups (S1/S2: 11.2 *vs* 11.5; $P = 0.57$). At postoperative follow-up, all radiographic parameters improved in both groups but the 2S patients had a statistically significant larger correction than the 1S group (PI-LL 1S/2S: −8.02° *vs* −16.44°; $P < 0.001$; SVA 1S/2S: 21.63 *vs* −45.71 mm; $P = 0.006$) (Table 1).

We found no significant differences in perioperative variables between 1S and 2S groups: LOS (8.7 *vs* 8.9 days, $P = 0.755$), OR time (445.9 *vs* 453.2 min; $P = 0.764$), EBL (2008 *vs* 1898 cm^3; $P = 0.65$), number of levels fused (11.26 *vs* 11.58; $P = 0.575$), or use of interbody fusion (62.4% *vs* 61%, $P = 0.832$). The 2S group had more 3CO (1S/2S: 21.7% *vs* 59.6%; $P < 0.001$) and had less use of BMP-2 (1S/2S 79.9% *vs* 15.6%; $P < 0.001$). All HRQOL parameters, including SRS-22, Oswestry Disability Index, and Short Form 12, significantly improved at 6-week, 1-year, and 2-year follow-up compared with preoperative values, but there were no significant differences between groups.

The analysis of complications revealed that the 2S group had significantly fewer overall intraoperative complications (1S/2S: 0.38 *vs* 0.13 per patient; $P = 0.001$), fewer intraoperative major complications (1S/2S: 0.16 *vs* 0.03 per patient; $P < 0.001$), and fewer intraoperative complications requiring revision (1S/2S: 0.02 *vs* 0 per patient; $P = 0.045$). The percentage of patients that sustained at least one intraoperative complication was significantly fewer in the 2S group than in the 1S group in terms of overall complications (1S/2S: 25.9% *vs* 10.4%; $P = 0.005$), and major complications (1S/2S: 13.8% *vs* 2.6%; $P = 0.007$). No differences between groups in terms of perioperative (0–6 wk) complications were found. At longer follow-up, the percentage of patients that sustained at least one major complication (1S/2S: 36.5% *vs* 50.6%; $P = 0.033$), one postoperative major complication (1S/2S: 19% *vs* 49.4%; $P < 0.001$), and one requiring reoperation (1S/2S: 11.1% *vs* 31.2%; $P < 0.001$), between 6-week and 2-year follow-up were significantly more frequent in the 2S group (Table 2).

Comparison After Matching

To obtain an equivalent comparison between groups, a matched cohort for age, deformity, and complexity of surgery was created. After matching for PI-LL, SVA, and the use of 3CO, 46 patients were operated by a single surgeon (1SM) and 28 patients by two cosurgeons (2SM). There were no significant demographic differences between the two groups in terms of age (1SM/2SM: 58.2 *vs* 61.8 yr), sex (1SM/2SM: 80.4% *vs* 82.1% women), body mass index (1SM/2SM: 28.6 *vs* 29.9 kg/m^2), and history of prior spine surgery (1SM/2SM: 56.5% *vs* 59%).

As illustrated in Table 3, the main deformity parameters were appropriately matched between 1SM and 2SM cohorts: PI-LL: 22.27° *versus* 26.46° ($P = 0.401$), C7-S1 SVA 96.53 *versus* 105.25 mm ($P = 0.63$). The only difference was in terms of kyphosis with the 2SM group presenting a smaller thoracic kyphosis (1SM/2SM: −35.42° *vs*

TABLE 2. Distribution of Intra-, Peri- (0–6 wk), and Postoperative (6 wk to 2 yr) Complications Among Single-Surgeon and Two-Surgeon Groups

		No Complications per Patient			Percentage of Patients With >1 Complication		
		1 Surgeon	2 Surgeons	*P*	1 Surgeon (%)	2 Surgeons (%)	*P*
Intra	Any	0.38	0.13	**0.001**	25.90	10.40	**0.005**
	Major	0.16	0.03	**<0.001**	13.80	2.60	**0.007**
	With reoperation	0.02	0.00	**0.045**	2.10	0	–
Peri	Any	0.59	0.38	0.072	38.6	28.6	0.121
	Major	0.24	0.26	0.804	16.9	19.5	0.621
	With reoperation	0.04	0.13	0.104	3.2	10.4	**0.017**
Post	Any	0.50	0.77	**0.021**	36.5	50.6	**0.033**
	Major	0.23	0.75	**<0.001**	19.0	49.4	**<0.001**
	With reoperation	0.12	0.51	**<0.001**	11.1	31.2	**<0.001**

Bold values signifies statistically significant ($P < 0.05$).

−25.53°; $P = 0.015$) and thoracolumbar kyphosis (1SM/2SM: −18.71° *vs* −10.28°, $P = 0.046$) than the 1SM group. SRS-Schwab classification coronal and sagittal modifiers were also appropriately matched (Table 3). At 2-year follow-up radiographic parameters were improved on both groups, there was no significant difference in sagittal alignment between the both groups or in terms of improvement.

TABLE 3. Patient Characteristics in Propensity Matched Cohorts

Schwab Classification		1 Surgeon	2 Surgeons	*P*
Pre-op	Coronal curve type	N: 16	N: 18	**0.050**
		L: 18	L: 14	
		D: 12	D: 7	
	PI-LL>20	47.8%	61.5%	0.356
	SVA >9.5 cm	47.7%	56.4%	0.714
	Pelvic tilt >30	41.3%	38.5%	0.542
	Levels fused	12.59	12.85	0.766

Sagittal Parameters		1 Surgeon			2 Surgeons			*P*
Pre-op	PT	27.10°	±	13.59°	27.55°	±	8.83°	0.859
	PI-LL	22.27°	±	25.84°	26.46°	±	18.65°	0.401
	T10-L2	−18.71°	±	18.17°	−10.28°	±	20.15°	**0.046**
	T4-T12	−35.42°	±	17.28°	−25.53°	±	19.14°	**0.015**
	SVA	96.53mm	±	88.45mm	105.25mm	±	74.74mm	0.631
	TPA	27.60°	±	16.47°	29.07°	±	12.28°	0.651
Post-op 2-years	PT	24.60°	±	12.49°	21.33°	±	8.42°	0.172
	PI-LL	6.87°	±	19.36°	4.36°	±	14.17°	0.505
	T10-L2	−8.94°	±	14.79°	−3.58°	±	12.77°	0.082
	T4-T12	−42.91°	±	15.97°	−39.27°	±	14.64°	0.282
	SVA	42.22 mm	±	64.24 mm	34.61 mm	±	56.32 mm	0.569
	TPA	21.39°	±	14.19°	17.76°	±	9.80°	0.186
Change	PT	−2.50°	±	7.97°	−5.74°	±	7.60°	0.062
	PI-LL	−15.81°	±	17.06°	−22.10°	±	15.87°	0.086
	T10-L2	9.02°	±	18.81°	6.70°	±	18.34°	0.570
	T4-T12	−8.03°	±	17.58°	−13.73°	±	11.96°	0.092
	SVA	−57.64 mm	±	70.61 mm	−68.66 mm	±	73.78 mm	0.492
	TPA	−7.07°	±	11.48°	−10.70°	±	10.58°	0.142

Preoperative Schwab classification and levels fused demonstrating no difference in distribution of sagittal modifiers or coronal types. N: no major coronal deformity; L: thoracolumbar/lumbar curve; D: double curve, both over 30°. Comparison of preoperative, 2-year postoperative, and change on sagittal parameters between the single-surgeon and two-surgeon group.

PI-LL indicates pelvic incidence to lumbar lordosis mismatch; PT, pelvic tilt; SVA, sagittal vertical axis; TPA, T1 pelvic angle.

Bold values signifies statistically significant ($P < 0.05$).

TABLE 4. Distribution of Intra-, Peri-, and Postoperative Complications Among Matched Single-Surgeon (1SM) and Two-Surgeon (2SM) Groups

		No Complications per Patient			Percentage of Patients With >1 Complication		
		1 Surgeon	2 Surgeons	*P*	1 Surgeon (%)	2 Surgeons (%)	*P*
Intra	Any	0.67	0.23	**0.015**	41.30	17.90	**0.020**
	Major	0.33	0.05	**0.015**	26.10	5.10	**0.009**
	With reoperation	0.02	0	0.323	2.20	0	–
Peri	Any	0.5	0.23	0.081	32.60	20.50	0.211
	Major	0.26	0.13	0.17	21.70	12.80	0.282
	With reoperation	0.02	0.08	0.236	2.20	7.70	0.231
Post	Any	0.7	0.95	0.301	47.80	53.80	0.58
	Major	0.33	0.95	**0.01**	23.90	53.80	**0.005**
	With reoperation	0.13	0.64	**0.017**	13.00	33.30	**0.025**

Bold values signifies statistically significant ($P < 0.05$).

After analyzing perioperative variables, no difference in LOS was found; 1SM group remained in the hospital for a mean of 9.1 days, whereas 2SM group patients were admitted for a mean of 10.1 days. Operative time did not differ between groups: 467.8 *versus* 508.4 minutes ($P = 0.745$) and EBL was not significantly different with 3045 mL average in 1SM and 2247 mL in 2SM group ($P = 0.217$). Both groups had similar number of 3CO (1SM/2SM: 47.8% *vs* 51.3%; $P = 0.75$). The 2SM group used BMP-2 less frequently than the 1SM (1SM/2SM: 84.8% *vs* 20.6%; $P < 0.001$).

The findings with regard to complications for the matched cohort analysis (Table 4) were similar to those of the unmatched cohort. In the intraoperative period, the 2SM group had fewer overall complications (1SM/2SM: 0.67 *vs* 0.23 per patient; $P = 0.015$), and fewer major complications (1SM/2SM: 0.33 *vs* 0.05 per patient; $P < 0.001$). The percentage of patients that sustained at least one intraoperative complication was significantly less in the 2SM group than in the 1SM group in terms of overall complications (1SM/2SM: 41.3% *vs* 17.9%; $P = 0.02$), and major complications (1SM/2SM: 26.1% *vs* 5.1%; $P = 0.009$). In the perioperative period, no differences between groups were found in measures of complication. Between 6-week and 2-year follow-up, the 2SM group had a significantly higher percentage of patients that sustained at least one major complication (1SM/2SM: 23.9% *vs* 53.8%; $P = 0.005$), or one complication associated with the need for a reoperation (1SM/2SM: 13% *vs* 33.3%; $P = 0.025$).

The analysis of individual complications (Table 5) revealed that 23.9% of patients in the 1SM group had blood loss of more than >4 L *versus* 2.6% in the 2SM group ($P = 0.005$); no other differences in terms of individual complications were found. Of note, the postoperative data demonstrated that the majority of complications were related to implant rod breakage, pseudarthrosis and proximal junctional kyphosis.

TABLE 5. Relevant Details of Intra- and Postoperative Complications for Matched Single-Surgeon (1SM) and Two-Surgeon (2SM) Cohorts

	Percentage of Patients With Intraoperative Complications		
Type of Complication	1SM (%)	2SM (%)	*P*
Intra_MAJOR-Motor Deficit	4.3	5.1	0.866
Intra_MAJOR-Nerve Root Injury	2.2	0.0	0.354
Intra_MAJOR-Excessive Bleeding	23.9	2.6	**0.005**
Intra_MAJOR-Monitoring Anomaly	2.2	0.0	0.354
Post_ Implant Rod Breakage	15.2	28.2	0.144
Post_ Infection_Deep	2.2	5.1	0.462
Post_Motor Deficit	2.2	5.1	0.462
Post_Reop Implant_Rod Breakage	8.7	10.3	0.806
Post_Reop_PJK	4.3	7.7	0.514
Post_Reop_pseudarthrosis	0.0	7.7	0.055
Post_Reop_X-ray_Sagittal Imbalance	2.2	0.0	0.354

PJK indicates proximal junctional kyphosis; Post, 6 weeks to 2 years; Reop, complication requiring reoperation.
Bold values signifies statistically significant ($P < 0.05$).

DISCUSSION

With the complexity of ASD cases increasing, complications are more frequent and close attention to decreasing these is imperative.[22] It has been demonstrated that two-surgeon teams can improve outcomes in complex procedures.[7,8,11] In the adult spine literature, two reports have demonstrated benefits of a two-team approach in terms of shorter operative time, lower risks of infection, and decreased EBL.[11,23]

The multicenter nature of the present study involves variations in surgeon experience and practice; therefore, definitive and generalizable conclusions are difficult. The study also has some limitations, such as a mean follow-up period of only 2 years and the lack of detailed assessment of surgeon-specific fusion techniques that may contribute to late complications. Our results, however, allow us to report some important findings. In the initial full cohort analysis, patients in the two-surgeon (2S) group had more complex deformities, were older, had more prior surgeries, and significantly worse sagittal spinopelvic modifiers than patients in the single-surgeon group (1S). This is likely due to the fact that centers with two-surgeon teams are referral centers that deal with more complex pathology. This is supported by the fact that more 3CO were performed in the 2S group. An unexpected finding was the fact that BMP-2 use was more frequent in the 1S group. This is likely a practice preference finding with an unclear explanation other than surgeon preference.

The 2S group with worse deformities also had more postoperative complications (6 wk to 2 yr). It has been reported in previous research studies that patients with larger deformities and more complex correction including PSO have complication risks as high as 40%.[2,22] The intraoperative complications such as neuromonitoring changes, screw misplacements, excessive blood loss, and so on were decreased in the 2S group and we believe that this could be secondary to the increased experience and attention to detail and efficiency in the OR attributed to the presence of two cosurgeons operating simultaneously.

In order to obtain an equivalent comparison a matched cohort for age, deformity, and complexity of surgery was analyzed. The matched cohort analysis demonstrated that LOS, OR time, and EBL were not significantly different between the two cohorts. This was also an unexpected finding because it was our hypothesis that a two-surgeon team would decrease at least EBL and OR time. But importantly the 2SM group demonstrated decreased intraoperative complications. When evaluating individual complications the 2SM group had less incidence of major blood loss (>4 L), this can be related to the benefit of an additional surgeon and improved bleeding control.

Technical and cognitive limits of surgeons may be difficult to accept and it was believed that expert surgeons were those who never required help. The surgical field is evolving and modern practice emphasis is in maximizing safety and improving patient outcomes. ASD surgeries are complex procedures and as demonstrated in several surgical training reports, having the support of a second surgeon in the OR is beneficial and leads to better outcomes.[24] "True expertise is increasingly understood to include appropriate recognition and response to one's technical and cognitive limits."[24] In a recent review of intraoperative consulting for complex procedures it was found that a second surgeon can better anticipate next technical steps, can provide emotional support, "political cover," and provide learning opportunities.[24] With the result of our study we believe that all this positive additions to the case from a two-surgeon team approach are likely responsible for the decrease in intraoperative complications.

Long-term complications were, however, more frequent in the matched patients of the two-surgeon (2SM) than in the single-surgeon (1SM) cohort. Although the two-surgeon teams might deal with more complex patients on a regular basis the matching methodology eliminates this as a reason for the greater number of postoperative complications and need for reoperations in this patient cohort. Individual long-term complications included rod breakage, pseudarthrosis, and proximal junctional kyphosis. Although 2SM patients had higher pseudarthrosis rates, it did not achieve statistical significance. Interestingly, the use of BMP-2 was significantly more frequent in the 1SM group, which had fewer long-term complications (*e.g.*, rod breakage, pseudarthrosis).

Overall, the two-surgeon approach decreased the incidence of intraoperative complications, but the cost-effectiveness of this approach should be studied in depth to make future recommendations on its widespread use.

➢ Key Points

- ASD centers have developed two attending surgical teams to improve efficiency; its effect on complications and outcomes have not been reported.
- The matched cohort analysis demonstrated that LOS, OR time, and EBL were not significantly different between the two cohorts.
- The 2SM group demonstrated decreased intraoperative complications.
- The use of BMP-2 was significantly more frequent in the 1SM group, which had fewer long-term complications.

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