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Planned Staging for Posterior Surgical Correction of Multiplanar Spinal Deformities: Does It Differ from Single-Stage Procedure?

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ABSTRACTS

Background Data: Complex spine surgery is a challenging and difficult procedure. It has to be performed by senior spine surgeons to correct complex deformities. This type of corrective procedures can be challenging and commonly requires long operations, with subsequent higher rates of complications when compared to ordinary spine operations. The literature has few data comparing the outcomes of single-stage posterior operation versus staged posterior correction of complex spine surgery. Single-session surgery entails the classical correction of complex deformities via a single-stage posterior operation, while staged posterior surgery means dividing the surgical maneuver into two posterior sessions with the final correction being performed in the second session. Studying the clinical and radiological data is extremely helpful in determining the safety and effectiveness of staging long spinal operations for the correction of complex spinal deformities.

Purpose: This study aims to compare perioperative and 1-year outcomes of single-stage posterior correction versus staged posterior surgical correction of complex spine deformities.

Study Design: Prospective cohort study.

Patients and Methods: *Patient sample:* A total of 22 patients with complex spinal deformity were recruited for this study (12, one-stage operation; 10, two-stage operation). *Outcome measures:* Perioperative and one-year postoperative clinical and radiological data were collected and analyzed. Data included operative time, blood loss, immediate postoperative Cobb angle, one-year Cobb angle and percentage of correction of the deformity, one-year loss of correction, and one-year complication rate.

Results There were no significant differences between the 2 groups as regards immediate postoperative Cobb angle (33.0±15.0, one-stage operation; 30.8±14.8, two-stage operation; P=0.771); percentage of correction within one year (60.7±12.0%, one-stage operation; 60.1±16.1%, two-stage operation; P=0.974); one-year loss of correction % (7.8±3.2, one-stage operation; 6.3±3.3, two-stage operation; P=0.238); one-year complication rate (83.3%, one-stage operation; 60%, two-stage operation; P=0.348).

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However, statistically significant difference was found between the 2 groups in terms of the total blood loss (3366.7±499.7 ml, one-stage operation; 4035.0±887.0 ml two-stage operation; P=0.038) and total operative time (353.3±46.8 min, one-stage operation; 486.5±131.5 min two-stage operation; P=0.011). Neurological complications (16.7%) and malpositioned screws (25%) were reported only in one-stage operations (however, this was statistically nonsignificant when comparing total complications in both groups (χ^2=1.833 and 2.895, resp.; P=0.481 and 0.221, resp.). Neurological complications were directly related to operative time (415±35.4 min) (P=0.033), average blood loss (4100±141.4 ml) (P=0.014), and postoperative hemoglobin (Hb) (5.5±0.7 g) (P=0.002).

Conclusion: Our data suggest that staging complex spine procedures should be considered in any lengthy spinal operations (≥ 415 min) and operations with excessive blood loss (≥ 4100 ml) to protect against and prevent irreversible neurological insults. (2019ESJ186)

Keywords: Spinal deformities; Complex spine; Neurological deficits; Kyphoscoliosis.

INTRODUCTION

Complex spine surgery represents a challenging type of surgery for spine surgeons as it is a significant stress burden for both surgeons and patients.[4] Such complex procedures are often lengthy ones, with subsequent higher rates of complications compared with other ordinary spine surgeries.[12,9] Dividing the complex procedure into two separate stages has been proposed as a potential means for decreasing complications and risks associated with lengthy complex procedures.[4] A staged procedure involves another visit to the operating field, with subsequent anasthesia exposure. The resulting increase in the total operative time and blood loss may increase the overall complication rate. However, many authors have demonstrated that there is no difference between single-stage and staged complex spine procedures.[7]

The literature has few data comparing the outcomes of single-stage posterior operation to staged posterior correction of complex spine surgery. Single-session surgery involves the classical correction of complex deformities via a single-stage posterior operation, while staged posterior surgery means dividing the surgical maneuver into two posterior sessions with the final correction being applied in the second session.

Studying the clinical and radiological data is extremely helpful in determining the safety and effectiveness of staging long spinal operations for the correction of complex spinal deformities. In this study, we hypothesize that staging complex spine procedures will give similar or even better results than a single lengthy procedure.

PATIENTS AND METHODS

A total of 22 patients having complex spinal deformity were recruited for this study. The first 12 patients (Group 1) underwent a one-stage procedure, and the subsequent 10 patients (Group 2) a two-stage procedure. Pediatric and adolescent deformities (congenital scoliosis and adolescent idiopathic scoliosis) were included, while patients with neuromuscular and degenerative scoliosis were excluded from this study (Tables 1 and 2).

Outcome Measures

Perioperative and one-year postoperative clinical and radiological data were collected and analyzed. Data included operative time, blood loss, immediate postoperative Cobb angle, one-year Cobb angle, percentage of correction of the deformity, one-year loss of correction, and one-year complication rate. Surgimap software version 2.2.12 (Nemaris, Inc., US, https://www.surgimap.com) was used to calculate percentage of correction of deformities and Cobb angles.

Preoperative Epidemiological Data

The mean age of patients in the two groups was more or less similar (15.3±2.1 years in one-stage surgery; 15±3.1 years in staged surgery), with female predominance (66.7% in one-stage surgery; 70% in staged surgery). There were 4 patients with congenital deformities (scoliosis and kyphoscoliosis) and 18 patients with adolescent idiopathic scoliosis (AIS). Group 1 patients included 11 patients with AIS and one patient with congenital kyphoscoliosis. Group 2 patients included 7 patients with AIS and 3 patients with congenital scoliosis and kyphoscoliosis. The mean preoperative Cobb angle was 89.4±26.3 (55–140) in Group 1 and 78.5±13.5 (60–100) in Group 2 (Table 3).

Operative Procedure

All patients underwent surgical correction under general anaesthesia. Intraoperative neuromonitoring was used in 9 cases from Group 1 and during the second stage in 8 cases of Group 2. After subperiosteal exposure of the desired spine levels, the Ponte osteotomy was done at periapical levels which entails removal of the ligaments (supraspinous, interspinous, and ligamentum flavum) together with wide facetectomy to ensure posterior release. Pedicle screws were inserted in the desired levels by freehand technique and their positions were checked by the C-arm image intensifier. Stagnara wake-up test was done in all cases after the insertion of pedicle screws. Copious lavage with 500 ccs normal saline and 5 ampoules of Gentamicin 80 mg was performed, and then vancomycin powder was placed in the wound. At that stage, the first session of staged operation was finished, with meticulous hemostasis and closure. After recovery, patients were admitted to the postoperative ICU for 1 week to be prepared for the second session. During that period, correction of the general condition and witnessed mobilization of patients with adequate postoperative analgesia were the main goals. Plain X-ray and CT scans were done to assess any malpositioned screws. No traction was used in between the two stages.

The second session started by opening the wound with adequate exposure of the instrumented levels; copious lavage was done with 500 ccs normal saline and 5 ampoules of Gentamicin 80 mg; any malpositioned screws were removed and reinserted in the correct plane. Three-column spinal osteotomy in rigid cases was started at that stage, in which removal of apex vertebra was done via a posterior costotransversectomy approach or lateral extracavitary approach depending on the degree of rotation of the apical vertebrae. The apical vertebra, together with the adjacent discs, was completely removed after wide laminectomy and facetectomy starting from the convex side. After finishing the removal of the apex from the convex side, a temporary rod was inserted at the convex side to allow for complete removal of the rest of the apex from the concave side. After complete release, the spine is then divided into a proximal limb and a distal limb that were brought together slowly with anterior fusion via insertion of bone graft. Otherwise, the correction was done gradually by a combination of rod-to-screw technique and cantilever technique. Again, Stagnara wake-up test was done at the end of correction. After a positive Stagnara test, copious irrigation was done again by 500 ccs normal saline and 5 ampoules of Gentamicin 80 mg with wound debridement together with placement of vancomycin powder. This was followed by meticulous hemostasis, insertion of 2 vacuum drains, and closure of the wound.

Statistical Analysis

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY, IBM Corp). The Kolmogorov–Smirnov test was used to verify the normality of distribution of variables. Comparisons between groups for categorical variables were assessed using Chi-square test (Fisher or Monte Carlo). Student's *t*-test was used to compare two groups for normally distributed quantitative variables. Mann–Whitney test was used to compare the two groups for not normally distributed quantitative variables. The significance of the obtained results was judged at the 5% level.

RESULTS

Clinical parameters: Group 1 patients included 11 patients with AIS and one patient with congenital kyphoscoliosis, while Group 2 patients included 7 patients with AIS and 3 patients with congenital scoliosis and kyphoscoliosis. The mean preoperative Cobb angle in Group 1 was 89.4±26.3 (55–140), while it was 78.5±13.5 (60–100) in Group 2 (*P*=0.456).

Operative parameters: Statistically significant difference was found between the 2 groups as regards the total blood loss (3366.7±499.7 ml, one-stage operation; 4035.0±887.0 ml, two-stage operation; *P*=0.038) and total operative time (353.3±46.8 min, one-stage operation; 486.5±131.5 min, two-stage operation; *P*=0.011). However, the staged group had statistically significant shorter operative time (353.3±46.8 min one-stage operation; two-stage operation: 288±66.6 min, 1st stage, p_1=0.014*; 232.5±62.4, 2nd stage, p_2<0.001) and less blood loss per stage (3366.7±499.7 ml one-stage operation; two-stage operation: 2380.0± 468.6 ml, 1st stage, p_1<0.001; 1655.0±663.5, 2nd stage, p_2<0.001) than the single-stage group (Tables 4 and 6)

Radiological parameters: There were no significant differences between the 2 groups in regard to immediate postoperative Cobb angle (33.0±15.0, one-stage operation; 30.8±14.8, two-stage operation; *P*=0.771), percentage of correction within one year (60.7±12.0%, one-stage operation; 60.1±16.1%, two-stage operation; *P*=0.974), and one-year correction loss % (7.8±3.2, one-stage operation; 6.3±3.3, two-stage operation; *P*=0.238) (Table 5).

Complications: No statistically significant differences were found between the two groups in terms of one-year complication rate (83.3%, one-stage operation; 60%, two-stage operation; *P*=0.348). Cosmetic complications were the most common complications encountered in the study (7 cases in Group 1 patients; 6 cases in Group 2; χ^2=0.006, *P*=1.000). These complications were mainly due to shoulder imbalance in 10 cases and residual rib hump in 3 cases. Neurological complications were developed in 2 patients (16.7%) and malpositioned screws were encountered in 3 patients (25%) (6 malpositioned screws out of the total 242 screws used in Group 1). These complications were reported only in one-stage operations. One of the patients suffered from irreversible spastic paraplegia, while the second patient experienced spastic paraparesis but recovered partially within one year of follow-up. However, this was statistically nonsignificant when comparing these complications in both groups (χ^2=1.833 and 2.895; *P*= 0.481 and 0.221, resp.) (Table 7). Neurological complications were directly related to operative time (415±35.4 min) (*P*=0.033); average blood loss (4100±141.4 ml) (*P*=0.014), and postoperative hemoglobin level (Hb) (5.5±0.7 g) (*P*=0.002) (Table 8).

Table 1. Summary data of patients in Group 1.

Age	Sex	Deformity	Pre Cobb/ Kyph	Immediate post-op Cobb/Kyph	1 y Post Cobb/ Kyph	1y correction loss	blood loss (ml)	Post-op Hb	Operative time (min)	Complications.
14	M	AIS	89	26	28	9%	3000	9	330	Cosmetic
17	M	Congenital kyphoscoliosis	70/66	27/22	30/24	11%/9%	4000	6	390	Neurological, malpositioned screw
16	F	AIS	92	22	24	9%	3200	8	350	No
14	F	AIS	140	62	65	5%	4200	5	440	Neurological
14	M	AIS	118	26	29	11%	3000	8	300	Cosmetic
19	F	AIS	65	20	22	10%	3800	7	400	NO
17	F	AIS	64	11	12	9%	3700	7	390	Malpositioned screw
12	F	AIS	86	40	43	8%	3000	8	320	Cosmetic
15	F	AIS	125	51	53	3%	3500	7	360	Cosmetic, malpositioned screw
16	M	AIS	55	24	27	11%	2500	9	290	Cosmetic
17	F	AIS	91	49	50	2%	3500	8	370	Cosmetic
12	F	AIS	78	38	40	5%	3000	8	300	Cosmetic

AIS: adolescent idiopathic scoliosis; Pre Cobb/Kyph: preoperative Cobb angle/kyphosis angle in congenital kyphoscoliosis; Immediate post-op Cobb/Kyph: immediate postoperative Cobb angle/kyphosis angle in congenital kyphoscoliosis; 1y post Cobb/Kyph: 1y postoperative Cobb angle/kyphosis angle in congenital kyphoscoliosis; Post-op Hb: postoperative hemoglobin.

Table 2. Summary data of patients in Group 2.

Age	Sex	Deformity	Pre Cobb/ Kyph	Immediate post-op Cobb/Kyph	1 y Post Cobb/Kyph	1y Correction loss	Blood loss in 1st stage	Blood loss in 2nd stage	Post-op Hb 1st stage	Post-op Hb 2nd stage	Op-time 1st stage	Op-time 2nd stage	Complications
13y	F	AIS	75	19	20	5%	2500	1000	8	9	220	200	Cosmetic
15Y	F	AIS	96	65	66	2%	2800	1000	7	8	200	185	NO
14y	F	Congenital scoliosis	90	30	34	13%	2500	3000	9	8	260	290	Cosmetic
17y	M	Congenital kyphoscoliosis	71/65	23/16	24/17	4%/7%	2800	1450	7	8	250	230	Cosmetic
16y	M	AIS	78	40	44	10%	2000	1700	9	10	290	240	Cosmetic
16y	F	AIS	60	20	21	5%	2500	1500	9	9	300	120	No
19y	F	AIS	100	29	31	7%	2500	2500	10	9	360	320	Cosmetic
18y	F	AIS	70	37	39	6%	2500	1900	9	10	400	260	Cosmetic
8y	M	Congenital kyphoscoliosis	63/84	12/34	13/36	8%/6%	1200	1000	10	9	360	300	NO
14y	F	AIS	82	33	34	3%	2500	1500	9	10	240	180	NO

AIS: **adolescent idiopathic scoliosis**; Pre Cobb/Kyph: **Preoperative Cobb angle/kyphosis angle in congenital kyphoscoliosis**; Immediate post-op Cobb/Kyph: **immediate postoperative Cobb angle/kyphosis angle in congenital kyphoscoliosis**; 1y post Cobb/Kyph: **1y postoperative Cobb angle/**kyphosis angle in congenital kyphoscoliosis; Post-op Hb: **postoperative hemoglobin**; Op-time: **operative time**.

Table 3. Preoperative epidemiological data.

Parameters	Group I (N=12)	Group II (N=10)	Test	*P*
Sex				
Male	4(33.3%)	3(30.0%)	χ^2=0.028	1.000
Female	8(66.7%)	7(70.0%)		
Age (years)				
Median (Min– Max)	15.5(12–19)	15.5(8.0–19.0)	t= 0.224	0.825
Mean ± SD	15.3±2.1	15.0±3.1		
Clinical diagnosis				
AIS	11	7		
Cong scoliosis and Kyphoscoliosis	1	3		
Pre-op Cobb angle				
Median (Min–Max)	87.5(55–140)	76.5(60.0–100.0)	U= 48.0	0.456
Mean ± SD	89.4 ± 26.3	78.5±13.5		

χ^2: **Chi-square test**; U: **Mann–Whitney test;** t: **Student's *t*-test.**
P: *P*-value for comparison between the two groups.
*: statistically significant at $P \leq 0.05$.

Table 4. Operative data.

Parameters	Group I (N=12)	Group II (N=10)	Test	P
Blood loss (ml)				
Median (Min– Max)	3350(2500–4200)	4000(2200–5500)	$t=2.227^*$	0.038^*
Mean ± SD	3366.7±499.7	4035.0±887.0		
Operative time (min)				
Median (Min–Max)	355(290–440)	425.0(310.0–680.0)	$t= 3.046^*$	0.011^*
Mean ± SD	353.3±46.8	486.5±131.5		

Table 5. Postoperative radiological data.

Parameters	Group I (N=12)	Group II (N=10)	Test	P
Immediate post-op Cobb				
Median (Min–Max)	26.5(11–62)	29.5(12–65)	U= 55.0	0.771
Mean ± SD	33.0±15.0	30.8±14.8		
1-year post-op Cobb angle				
Median (Min–Max)	29.5(12–65)	32.5(13.0–66.0)	U= 54.5	0.772
Mean ± SD	35.3±15.2	32.0±15.7		
% of correction (1y)				
Median (Min–Max)	57.4(45. 81.3–)	63.6(31.3–81.3)	U= 59.0	0.974
Mean ± SD	60.7 12.0 ±	60.1±16.1		
1y Correction loss %				
Median (Min– Max)	9(2–11)	5.5(2–13)	U= 43.0	0.283
Mean ± SD	7.8±3.2	6.3±3.3		

χ^2: **Chi-square test**; U: **Mann–Whitney test;** t: **Student's *t*-test.**
P: *P*-value for comparison between the two groups.
*: statistically significant at $P \leq 0.05$.

Table 6. Comparison between the 2 groups according to operative parameters.

Parameters	Group I (N=12)	Group II (N=10)		
		1st	2nd	Total
Blood loss (ml)				
Median (Min–Max)	3350(2500–4200)	2500(1200–2800)	1500(1000–3000)	4000(2200–5500)
Mean ± SD	3366.7±499.7	2380.0±468.6	1655.0±663.5	4035.0±887.0
Sig.	$p_1<0.001^*$, $p_2<0.001^*$, $p_3=0.\ 0.038^*$			
Postoperative Hb				
Median (Min– Max)	8(5–9)	9(5–10)	9(8–10)	
Mean ± SD	7.5±1.2	8.7±1.1	9±8	
Operative time (min)				
Median (Min–Max)	355(290–440)	275(200–400)	235(120–320)	425(310–680)
Mean ± SD	353.3±46.8	288±66.6	232.5±62.4	486.5±131.5
Sig.	$p_1=0.014^*$, $p_2<0.001^*$, $p_3=0.011^*$			

p_1: *P*-value for **Student's *t*-test** for comparing **one-stage operation** and **1st** stage of the staged operations.
p_2: *P*-value for **Student's *t*-test** for comparing **one-stage operation** and **2nd stage of the staged operations.**
p_3: *P*-value for **Student's *t*-test** for comparing **one-stage operation** and **two-stage operation.**
*: statistically significant at $P \leq 0.05$.

Table 7. Reported complications in our study.

Parameters	Group I (N=12)	Group II (N=10)	Test	*P*
Complications	**10(83.3%)**	**6(60.0%)**	χ^2=1.497	0.348
Cosmetic	7(58.3%)	**6(60.0%)**	χ^2=0.006	1.000
Neurological	2(16.7%)	0(0%)	χ^2=1.833	0.481
Mispositioned screw	3(25%)	0(0%)	χ^2=2.895	0.221

χ^2: **Chi-square test;** U: **Mann–Whitney test;** t: **Student's *t*-test.**
P: *P*-value for comparison between the two groups.
*: statistically significant at $P \leq 0.05$.

Table 8. Correlation between neurological complications and operative parameters in Group 1.

Parameters	Neurological complications		t	*P*
	No (N=10)	Yes (N=2)		
Operative time (min)				
Median (Min–Max)	340(290–400)	415(390–440)	2.472*	0.033*
Mean ± SD	341 ± 39	415 ± 35.4		
Average blood loss (ml)				
Median (Min–Max)	3100(2500–3800)	4100(4000–4200)	2.977*	0.014*
Mean ± SD	3220 ± 399.4	4100 ± 141.4		
Postoperative Hb				
Median (Min–Max)	8.0(7.0–9.0)	5.5(5.0–6.0)	4.216*	0.002*
Mean ± SD	7.9±0.7	5.5 ± 0.7		

t: Student's *t*-test.
P: *P*-value for comparison between the different categories.
*: statistically significant at $P \leq 0.05$.

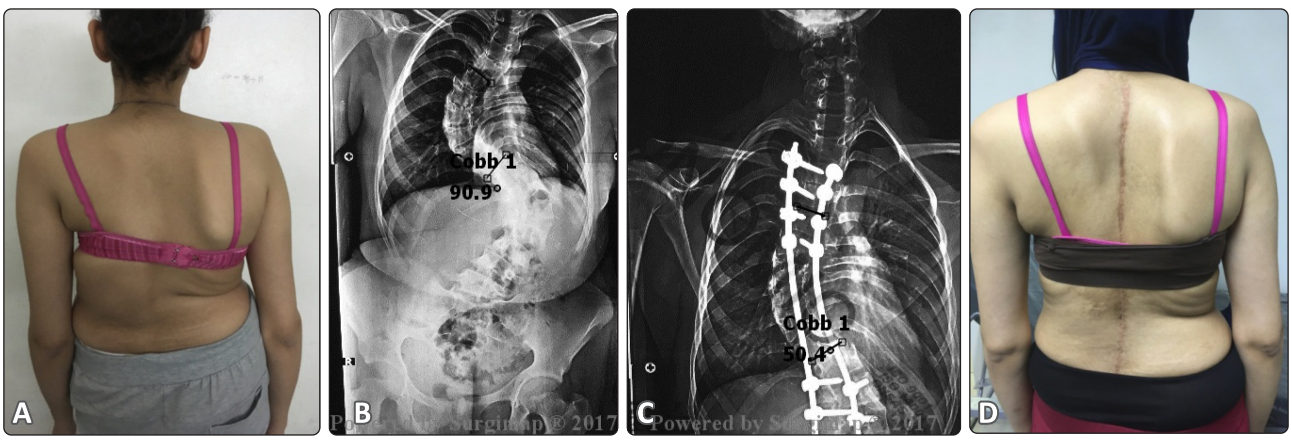

Figure 1. (A) 17-year-old female with RT rib hump and waist line asymmetry. (B) Plain X-ray film of the whole spine showing double major adolescent idiopathic scoliosis with a main thoracic curve to 91 degrees. (C) Postoperative plain X-ray film showing satisfactory correction of the main thoracic curve to 51 degrees via a single posterior operation. (D) Postoperative clinical photo with satisfactory correction waist line asymmetry but with residual rib hump.

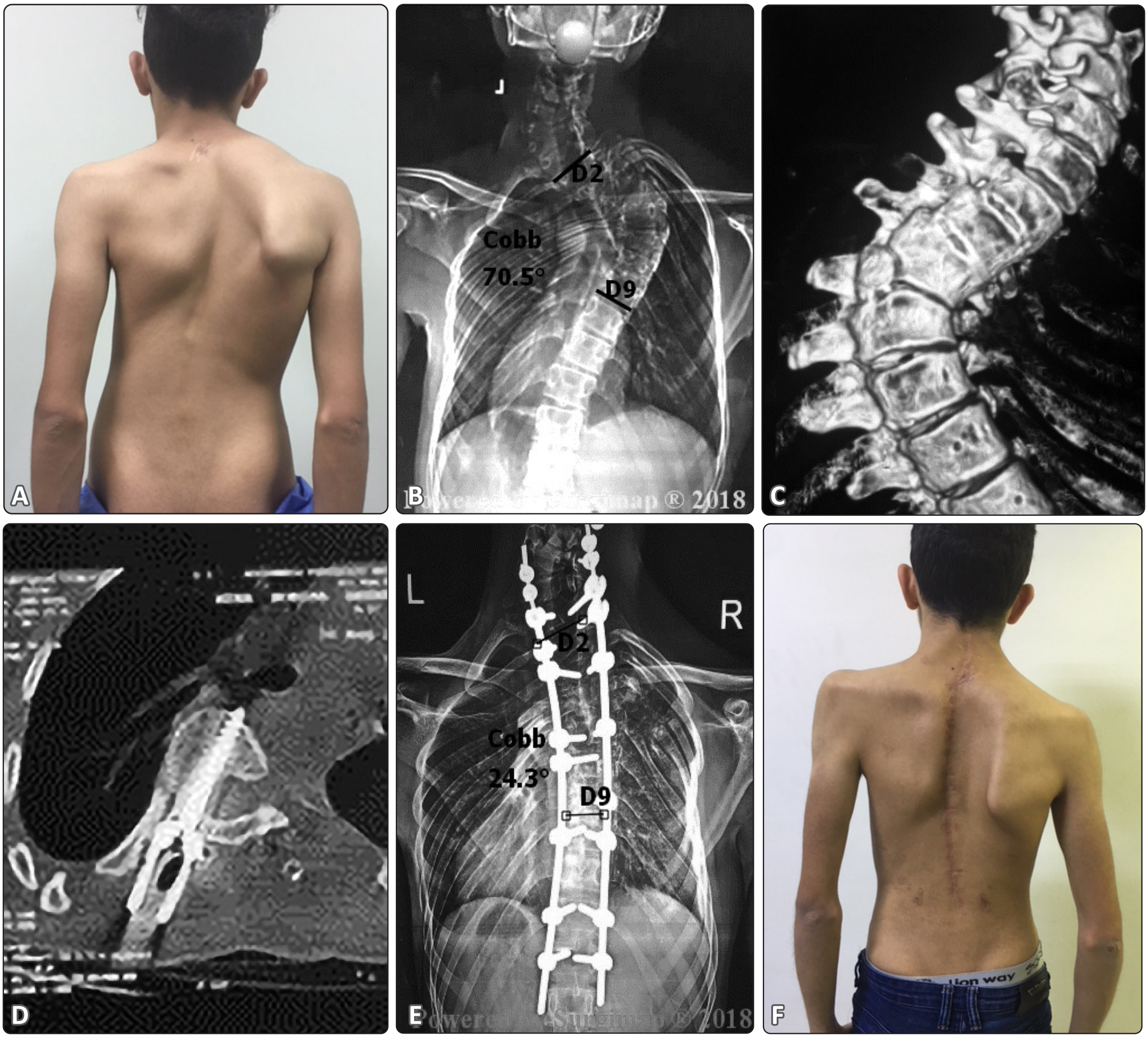

Figure 2. (A) 17-year-old male patient complaining of right rib hump. (B) Plain X-ray film of the cervical and thoracic spine showing cervicothoracic scoliosis. (C) 3D CT reconstruction of the deformity showing a hemivertebra at the apex of the deformity (D5-6) with fused intervertebral discs in the adjacent proximal segment. (D) Axial CT cut after the first operation showing one of the malpositioned screws that was corrected in the second session without sequelea. (E) Postoperative plain X-ray showing satisfactory correction after removal of the apex in the second session. (F) Postoperative clinical photo with satisfactory correction of the rib hump but with unbalanced shoulders (cosmetic complication).

DISCUSSION

Complex spine procedures are often long and difficult procedures with a higher rate of complications compared to traditional spine surgery.[9,12] Usually, surgeons operate on complex deformities on an elective basis depending on the magnitude of the curve, the cosmetic appearance of the patients, and the existence of any neurological or pulmonary problems. Therefore, in the stage of decision-making, the surgeons must consider the risk-benefit ratio of any surgical approach.[20] Surgeons who favor single-stage surgery believe that there is less total operating time, less blood loss, and less time of exposure to anaesthesia. This will reduce the cardiopulmonary stress together with the postoperative hospital stay leading to lower morbidity and mortality rates.[5,15,18] On the other hand, staging complex spine procedures may have some advantages.

Less Hemodynamic Stress. In a study performed by Edwards CC et al.[4] to assess the morbidity associated with single-stage versus multistage posterior-only complex spinal surgery, the staged group had shorter operative time and less blood loss per stage than the single-stage group. Lower operative time and blood loss per stage led to reducing cardiopulmonary stress resulting from excessive parentral fluids and blood transfusion.[6] Matching with Edwards CC et al.,[4] our results revealed that the staged group had statistically significant shorter operative time and less blood loss per stage than the single-stage group.

Surgeon Fatigue. Neurosurgical practice is physically and mentally stressful. Moreover, there is no room for minute error or mistake during operation on neurosurgical patients. Excellence in performance is needed during a long complex spine operation. There are no data available to directly evaluate the impact of surgeon fatigue on clinical outcome. Furthermore, translation of fatigue into physical and mental impairment with subsequent increased morbidity is a relationship to be studied. In long complicated operations, both surgeon and patient may be completely worn out at some stage of surgery. In the case of complex spinal operations, one of the most critical steps in the operation is the correction, usually taking place near the end of the procedure. By staging the operation, a rested surgeon could perform the most critical steps of complex procedures by eliminating the subtle factor of surgeon fatigue, which involves not only mental fatigue, which is hard to quantify, but also physical fatigue that increases with long operations.[1,19] In this study, correction was done in the 2nd stage of staged operations, and there were no significant differences between correction rates of both groups. However, neurological complications and malpositioned screws were encountered only in one-stage operations. Although those rates failed to reach statistical significance, it should be taken into consideration that these complications could be indirectly related to both surgeon and patient tolerance.

Neurological Complications. Neurological deficit is one of the most devastating operative complications of deformity surgery. Such deficits may range from reversible partial deficits to irreversible complete paralysis.[16] Hamilton et al.[8] conducted a retrospective review of a multicenter database to calculate the morbidity rates of newly developed neurologic injury related to spine surgery. They cited postoperative neurologic deficits at a rate of 0.73% in pediatric idiopathic cases, including cord and nerve root injuries. Qiu Y reported postoperative neurological deficits at a rate of 1.06% based on data collected after analysis of 1373 cases at one Chinese institution.[14] Comprehensive knowledge and management of various types and causes of neurological injury are crucial. Prevention of neurological insults should start before surgery by optimizing the general condition of the patient, in addition to proper positioning to avoid any form of compressive neuropathies.[17,10] After initiation of the procedure, the use of intraoperative neuromonitoring is beneficial in terms of early detection of minor deficits. Such early detection could offer the patient a great chance as it allows surgeons to manage potential complications in time.[16] Vitale et al.[21] had reviewed the data of 162 spine deformity patients including 78 cases of adolescent idiopathic scoliosis and found that the use of intraoperative neuromonitoring has a sensitivity of 100% in addition to a specificity of 88% in the detection of potential deficits. Moreover, they found that every patient who experienced a true electrophysiological change had a detectable intraoperative factor and, with timely intervention, most of these changes were reversed without sequelae.

The causes of postoperative neurological deficits include mechanical compression of the spinal cord during instrumentation, cord distraction during the correction, rapid correction, and vascular insults.[2,3] Neurological deficits may be also due to nerve roots irritation associated with pedicle screws insertion.[6,11,13]

Dividing the procedure will distribute the mechanisms involved in neurological deficits over two stages, in addition to the advantage of correction of any malpositioned screws done in the first stage which may affect the degree of correction or compress the underlying cord or nerve roots. There were no neurological complications in the staged group compared to 16.7% in one-stage group (two cases). Neurological complications were directly related to operative time, average blood loss, and mean postoperative Hb (Table 8). These complications were met early at the beginning of the study (2nd and 4th patient by time ranking) which may suggest the effect of the learning curve. One of the patients suffered from irreversible spastic paraplegia, while the second patient suffered from spastic paraparesis but recovered partially within one year of follow-up. These patients were examined radiologically in the immediate postoperative period to detect any malpositioned screws, but the screws were all in place which may suggest the effect of cord perfusion during the correction. Although total operative time and total blood loss in one-stage operations were always less than the corresponding values in staged operations, dividing the procedure into two stages yielded a statistically significant shorter operative time and less blood loss per stage than the single-stage group. Consequently, postoperative Hb after the 1st and 2nd stages was always higher than postoperative Hb after single-stage operations (Tables 4 and 6).

Apart from neurological complications which are associated with long and/or bloody operations, surgeon preference seems to be the main determinant factor in choosing and individualizing surgical technique, as the morbidity rates of staged procedures are similar to single-stage operations. (case illustration: Figure 1(A-D) represents a patient from Group 1; Figure 2(A-F) represents a patient from Group 2)

The shortcomings of this study are the small number of cases included, and the relatively short period of follow-up. Further studies with more cases and longer periods of follow-up are needed.

CONCLUSION

Our data suggest that staging complex spine procedures should be considered in any lengthy spinal operations (≥415 min) and operations with excessive blood loss (≥4100 ml) to protect against irreversible neurological insults. Surgeon preference also seems to be a decisive factor in staging of complex spine procedures.

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الملخص العربي

جراحات العمود الفقري المعقده علي مراحل. هل هناك اختلاف؟

البيانات الخلقيه: تمثل جراحة العمود الفقري المعقده شكلاً من أشكال الجراحة الصعبة التي يجب إجراؤها من قِبل كبار جراحي العمود الفقري من أجل تصحيح التشوهات المعقدة. قد تكون هذه الإجراءات التصحيحية صعبة ، وتتطلب عادة عمليات طويلة الأمد ، مع ارتفاع معدلات المضاعفات اللاحقة عند مقارنتها بعمليات العمود الفقري العادية. تحتوي المراجع العلميه على بيانات قليلة تقارن نتائج المرحله الواحدة مقابل مرحلتين لجراحة العمود الفقري المعقدة. دراسة البيانات السريرية والإشعاعية المتعلقة بجراحة العمود الفقري المعقدة ، سوف تكون مفيدة في تحديد سلامة وفعالية تنظيم عمليات تصحيح التشوهات المعقدة في العمود الفقري.

الغرض: تهدف هذه الدراسة إلى مقارنة النتائج خلال العملية الجراحية، والنتائج المحيطة بالجراحة ، وخلال فترة سنة واحدة من اجراع الجراحه عن طريق مرحلة واحدة مقابل مرحلتين لتصحيح تشوهات العمود الفقري المعقدة.

تصميم الدراسه: تحليل البيانات عن طريق دراسة الحالات السريرية المحتمله

المرضي والطرق: عينة المرضي : تم تضمين مجموعه 22 مريضا من حالات تشوه العمود الفقري المعقد مريض12 مرحلة واحدة (مجموعه 1) 10 مرضي مرحلتين (مجموعه 2)

المرضي والطرق: تم حساب المعلومات إحصائياً لتقييم البيانات المتعلقة بالاعتلال والوفيات أثناء العمليات الجراحية والبيانات السريرية والإشعاعية اثناء وبعد الجراحة لمدة عام. وشملت البيانات فقدان الدم ، والوقت المنطوق ، والنسبة المئوية لتصحيح التشوه ومعدل المضاعفات لمدة عام واحد.

النتائج: تم تضمين مجموعه 22 مريضا من حالات تشوه العمود الفقري المعقد 12 مرحلة واحدة و 10 مرحلتين. المعاملا الجراحيه: هناك فروق ذات دلالة إحصائية بين المجموعتين فيما يتعلق بفقدان الدم الكلي وزمن الجراحه الكلي (فقدان الدم وزمن الجراحه الكلي في مجموعه 1اقل من مجموعه 2) ومع ذلك، فان فقدان الدم وزمن الجراحه لكل مرحله علي حده من مراحل مجموعه 2 اقل من مجموعه 1 وذات دلاله احصائيه. المعاملات الاشعاعيه: لم يتم العثور على فروق ذات دلالة إحصائية بين المجموعتين فيما يتعلق بزاويه Cobb قبل العمليه وبعد العمليه مباشره وبعد العمليه بسنه. لم يتم العثور على فروق ذات دلالة إحصائية بين المجموعتين فيما يتعلق بالمضاعفات الكليه. المضاعفات التجميليه كانت الاكثر وجودا. المضاعفات العصبية 16.7% والمسامير الموضوعه بطريقه خاطئه 25 % تم رؤيتها في عمليات المرحلة الواحدة فقط ، ومع ذلك ، كان هذا غير ذات دلالة إحصائية عند مقارنتها مع المعدلات المقابلة في العمليات المرحلية. كانت المضاعفات العصبية مرتبطة ارتباطًا مباشرًا بالوقت التشغيلي (P=0.033) ، وفقدان الدم في المتوسط (P=0.014) ، ونسبه الهيموجلوبين بعد العمليه .(P=0.002)

الاستنتاج: تشير بياناتنا إلى أنه ينبغي النظر في تقسيم عمليات العمود الفقري المعقده في أي عمليات طويلة للعمود الفقري (اكثر من 415 دقيقه) والعمليات ذات فقدان الدم المفرط (اكثر من 4100 مل) للحماية من المضاعفات العصبية التي لا رجعة فيها.