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Perioperative Outcomes and Complications of Pedicle Subtraction Osteotomy in Cases With Single Versus Two Attending Surgeons

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Abstract

Study Design: Retrospective case series.
Objective: To assess the perioperative morbidity of pedicle subtraction osteotomy (PSO) based on the presence of 1 versus 2 attending surgeons.
Background Summary: Pedicle subtraction osteotomies are challenging cases with high complication rates and substantial physiological burden on patients. The literature supports the benefits of 2-surgeon strategies in complex cases in other specialties.
Methods: We reviewed a single institution database of all pedicle subtraction osteotomies (78 cases) from 2005−2010 and divided the cohort into single versus 2-surgeon groups (42 vs. 36 cases, respectively). We performed subset analysis after excluding cases before 2007 and excluding patients with staged anterior and posterior procedures. We analyzed cases for estimated blood loss, length of surgery, length of stay, radiographic analysis, rate of return to the operating room within 30 days, and medical and neurological complications.
Results: The groups were similar when comparing mean number of posterior levels fused, levels decompressed and revision rates, however, the average age of the single surgeon and 2 surgeon groups was 57.6 and 64.3 years, respectively ($p = .02$). The 2 groups had comparable correction of radiographic parameters. Mean percent estimated blood loss for single versus 2 surgeons was 109% versus 35% ($p < .001$) and estimated blood loss was 5,278 versus 2,003 mL ($p < .001$). Average surgical time for single versus 2 surgeons was 7.6 versus 5.0 hours ($p < .001$). A total of 45% of single-surgeon patients compared with 25% of 2-surgeon patients experienced at least 1 major complication within 30 days. In the single-surgeon group, 19% had unplanned surgery within 30 days, versus 8% in the 2-surgeon group.
Conclusions: The use of 2 surgeons at an experienced spine deformity center decreases the operative time and estimated blood loss, and may be a key factor in witnessed decreased major complication prevalence. This approach also may decrease the rate of premature case termination and return to operating room in 30 days.

Keywords: Pedicle subtraction osteotomy; Multiple surgeons; Spinal deformity; Perioperative outcomes; Blood loss

Introduction

Fixed sagittal deformity can result in significant pain and functional impairment [1]. Typically sagittal imbalance develops as a result of iatrogenic flat-back syndrome, posttraumatic kyphosis, degenerative lumbar kyphosis, ankylosing spondylitis, or postlaminectomy kyphosis. The goal of surgery is to restore sagittal balance for an improved energy efficient gait without the use of compensatory mechanisms such as knee flexion, hip extension, or pelvic retroversion.

Pedicle subtraction osteotomy (PSO) is a recognized technique used to restore sagittal balance. It is especially useful for large corrections and in instances where a Smith-Petersen osteotomy offers insufficient correction or is not possible because of a prior interbody fusion [2]. Pedicle subtraction osteotomy is a technically demanding operation with a significant risk of intraoperative, perioperative, and postoperative complications [3-16].

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The purpose of this study was to report the impact on the perioperative complication rate and outcome measures of 2 experienced attending spine surgeons simultaneously performing a PSO for adult deformity versus a single attending surgeon alone. The utility and efficacy of 2 attending surgeons working simultaneously has been described in the literature for procedures such as bilateral anterior cruciate ligament reconstruction, laparoscopic nephrectomy, and esophagectomy [17-19]. Our investigation focused on the impact on outcome measures including estimated blood loss, operative time, length of stay, intraoperative neuromonitoring, radiographic analysis, and neurological and medical complication rates.

Methods

We performed a retrospective chart review of patients who underwent thoracic or lumbar spine PSO at 1 institution between February 2005 and July 2010. We identified 78 patients, 42 of whom had a PSO performed by a single attending surgeon, and 36 by 2 attending surgeons operating simultaneously. We evaluated the 2 groups for the following outcome measures: estimated blood loss (EBL), percent estimated blood volume loss (%EBV), duration of surgery, length of stay, radiographic outcome, medical complications, and neurological complications (both intraoperatively via neuromonitoring and postoperatively via clinical assessment). We calculated %EBV as EBL divided by the total estimated blood volume, where total estimated blood volume was estimated as weight in kilograms multiplied by either 75 mL/kg for men or 65 mL/kg for women. Radiographic outcome included measurement of preoperative and postoperative sagittal vertical axis, lumbar lordosis, pelvic tilt, pelvic incidence, and sacral slope.

We included 5 surgeons in the study, all of whom possessed at least 10 years of experience performing high-complexity spinal deformity surgeries at a tertiary care center. When operating without a second attending, they were assisted by an orthopaedic or neurosurgical spine fellow. All 5 surgeons performed single-surgeon operations exclusively from 2005 to 2007. The combined 2-surgeon team program started in 2007, when 2 of the initial 5 surgeons operated exclusively as a 2-surgeon team, whereas the other 3 surgeons comprised the single-surgeon group. When operating as a team, each attending surgeon worked simultaneously on opposite sides of the patient. We performed a subset analysis for all patients who had procedures performed from January 2007 to July 2010. A total of 28 patients had a PSO performed by a single attending surgeon, and 36 by 2 attending surgeons during this period. We evaluated these groups of patients for the same outcome measures.

We performed a second subset analysis after excluding all patients who underwent a PSO together with a staged anterior approach during the same hospitalization. Of these remaining 56 patients who underwent only a PSO during hospitalization, 33 had a PSO performed by a single attending surgeon, and 23 by 2 attending surgeons.

We based intraoperative neurological complication rates on neuromonitoring staff interpretation of electromyography, motor, and somatosensory evoked potentials. Intraoperative changes of less than 80% loss in the transcranial motor evoked potential (TcMEP) amplitude in at least 1 myotome of the bilateral lower extremities was designated as a threshold for possible intraoperative neurological compromise. The surgical team routinely made postoperative neurological assessments in the postoperative period. Complications were based on operative reports, discharge summaries, and available follow-up clinic dictations. We classified complications noted within 30 days of the original procedure as major or minor based on the consensus of study group surgeons using the work of Glassman et al. [20] as a guideline. We excluded from analysis complications directly attributable to other surgical procedures during the 30-day period (e.g., vascular injury during anterior procedure).

We performed all statistical processing with STATA software, version 11 (StataCorp, College Station, TX). For statistical analyses of continuous variables, we used Student *t* tests to investigate differences in the distributions between subsets of patients classified by categorical data. We used chi-square testing to investigate differences between categorical variables grouped by patient subsets. Statistical analyses were 2-sided; $p \leq .05$ was considered statistically significant and was reported.

Results

Patients in the single-surgeon group and the 2-surgeon group were demographically similar, except that the average age of the single-surgeon and 2-surgeon groups was 57.6 and 64.3 years, respectively ($p = .019$) (Table 1). The vast majority of patients in both groups underwent revision of a prior surgery (34/42 vs. 32/36). Patients in the 2 groups also underwent comparable surgical procedures in terms of number of levels of posterior spinal fusion (8.7 vs. 8.4), decompression (2.5 vs. 3.2), number of patients undergoing simultaneous interbody fusion (2 vs. 7), and levels at which the PSO occurred (Table 1).

The single-surgeon and 2-surgeon groups had similar starting deformities and comparable correction of radiographic parameters postoperatively (Table 2). Radiographic measures and subsequent postoperative correction were similar for the single versus 2-surgeon groups: sagittal vertical axis correction (72.2 vs. 61.1 mm; $p = .30$), lumbar lordosis correction (30.8° vs. 29.3°; $p = .73$), pelvic tilt correction (8.7° vs. 9.1°; $p = .93$), and sacral slope correction (8.5° vs. 8.8°; $p = .98$). As expected, neither group had a significant change in pelvic incidence (0.2° vs. 0.2; $p = .98$).

Comparing the single-surgeon and 2-surgeon groups, there was significantly higher mean %EBV (109 vs. 35%;

Table 1
Patient demographics for patients undergoing PSO from 2005 to 2010

	Single surgeon	2 surgeons
Dates	2005 to July 2010	2007 to July 2010
Patients (n)	42	36
Female/male	27 F/15 M	18F/18 M
Average age (years)*	57.6*	64.3*
Revision of prior surgery	34/42	32/36
Level of PSO (n):		
T1	1	1
T3	2	0
T4	1	0
T5	0	1
T12	1	0
L1	2	1
L2	7	4
L3	22	22
L4	6	7
Mean PSF levels	8.74	8.39
Mean laminectomy levels	2.49	3.22
Simultaneous interbody fusion (transforaminal lumbar interbody fusion) (n)	2	7

Abbreviations: PSO, pedicle subtraction osteotomy; PSF, posterior spinal fusion.
* $p = .019$.

$p < .0001$), EBL (5,279 vs. 2,003 mL; $p < .0001$), and longer operative time (7.6 vs. 5.0 hours; $p < .0001$) (Table 3). A trends was seen toward longer postoperative length of stay for the single versus 2-surgeon group (8.9 vs. 7.8 days; $p = .14$). Intraoperatively, for the single-surgeon and 2-surgeon groups, 9 of 42 patients versus 6 of 36 patients ($p = .60$) had greater than 80% loss in the TcMEP amplitude in at least 1 myotome intraoperatively; this deficit remained at the end of the case in 2 versus no patients, respectively. We did not note somatosensory evoked potential changes in either group, and electromyography changes for the single-surgeon and 2-surgeon groups occurred simultaneous with TcMEP decreases in 3 of 9 patients versus 1 of 6 patients.

Table 2
Radiographic outcomes measures

	Single surgeon	Two surgeons	p value
Preoperative (mean)			
SVA (mm)	149.9	120.6	.02
LL (°)	19.1	28.4	.07
PT (°)	32.9	31.8	.63
PI (°)	58.5	58.3	.94
SS (°)	25.6	26.8	.54
Postoperative (mean)			
SVA (mm)	77.7	59.6	.11
LL (°)	49.9	57.4	.01
PT (°)	24.2	22.7	.46
PI (°)	58.4	58.1	.91
SS (°)	34.1	35.6	.47
Correction (mean)			
SVA (mm)	−72.2	−61.1	.30
LL (°)	30.8	29.3	.73
PT (°)	−8.7	−9.1	.93
PI (°)	−0.2	−0.2	.94
SS (°)	8.5	8.8	.98

Abbreviations: SVA, sagittal vertical axis; LL, lumbar lordosis; PT, pelvic tilt; PI, pelvic incidence; SS, sacral slope.

Table 3
Perioperative characteristics: blood loss, operative duration, intraoperative neuromonitoring, and hospital length of stay

	Single surgeon	2 surgeons	p value
%EBV (%)			
Mean	109.1	35.0	<.0001
Standard error of mean	15.2	4.11	
Range	12.5–411	3–109	
EBL (mL)			
Mean	5,278.6	2,002.5	<.0001
Standard error of mean	649.3	256.5	
Range	500–16,000	200–8,000	
Operative time (minutes)			
Mean	453.7	297.1	<.0001
Standard error of mean	23.9	12.0	
Range	239–1,018	198–465	
Days postoperative at discharge			
Mean	8.9	7.8	.136
Standard error of mean	0.7	0.6	
Range	4–22	3–20	
Intraoperative neuromonitoring			
>80% loss TcMEP in ⩾1 myotomes	21% (9)	17% (6)	.595
Simultaneous tonic EMG changes	3/9	1/6	.383
Persistent >80% loss TcMEP at end of case	5% (2)	0%	.497
SSEP changes	0%	0%	1.0

%EBV, percent estimated blood volume loss; EBL, estimated blood loss; TcMEP, transcranial motor evoked potential; EMG, electromyelogram; SSEP, somatosensory evoked potential.

We stratified perioperative medical and neurological complications as major or minor for each group (Table 4). The total number of major complications for the single and 2-surgeon groups was 24 versus 9. In the 1-surgeon and 2-surgeon groups, 23 of 42 patients (55%) versus 27 of 36 patients (75%) did not experience a major complication during the 30-day postoperative period ($p = .063$). Figures 1 and 2 show a timeline for each group with the dates of the major complications. These figures demonstrate the types of major complication experienced in each group, as well as the relatively consistent distribution of complications over time. In addition, they show that several patients experienced multiple major complications, which further emphasizes the high morbidity associated with this procedure.

Nine patients (21%) in the single-surgeon group and 3 (8%) in the 2-surgeon group had additional unplanned surgery within 30 days of the original PSO operation ($p = .110$). Of the 9 patients in the single-surgeon group, 3 returned for completion of the operation after the procedure was terminated early because of prolonged operative time and excessive blood loss with concerns for intraoperative coagulopathy and physiological compromise. The remaining 6 returned to the operating room for evacuation of an epidural hematoma causing severe

Table 4
Major and minor perioperative complications

	Single surgeon (n = 42)	2 surgeons (n = 36)
Major complication: % patients (instances)		
Excessive blood loss/OR time[a]	7.1% (3)	0%
Deep wound infection	7.1% (3)	5.6% (2)
Positive intraoperative wound culture	7.1% (3)	0%
Wound dehiscence	0%	2.8% (1)
Hardware failure/revision <1month postoperative	4.8% (2)	0%
PJK with vertebral fracture <1month postoperative	0%	2.8% (1)
Seizure	2.4% (1)	0%
New spinal cord or cauda equina deficit[b]	2.4% (1)	2.8% (1)
New combined motor + sensory deficit	4.8% (2)	0%
New motor deficit[c]	14.3% (6)	5.6% (2)
Pneumonia	4.8% (2)	2.8% (1)
Cardiovascular (demand ischemia w/SVT)	2.4% (1)	0%
Severe intraoperative transfusion reaction[a]	0%	2.8% (1)
Total major complications (n)	24	9
Minor complication: % patients (instances)		
Superficial wound infection	2.4% (1)	2.8% (1)
New sensory deficit	4.8% (2)	0%
Radicular pain	0%	5.6% (2)
Durotomy	28.6% (12)	36.1% (13)
Delirium	14.3% (6)	5.6% (2)
Postoperative blood transfusion	33.3% (14)	36.1% (13)
Urinary tract infection	4.8% (2)	0%
Positional headaches	0%	2.8% (1)
Other[d]	2.4% (1)	8.3% (3)
Total minor complications (n)	38	35
Patients with no major complications	54.8% (23)	75.0% (27)
Unscheduled return to OR within 30 days	21.4% (9)	8.3% (3)
Neurological complication[e]	19.0% (8)	13.9% (5)
Deficit resolved at follow-up[f]	85.7% (6/7)	100% (4/4)

OR, operating room; PJK, Proximal junction kyphosis; SVT, supraventricular tachycardia.
[a] Required staging of procedure.
[b] Both cases required emergent reoperation and resulted from epidural hematoma and cerebrospinal fluid leak in the single- and 2-surgeon groups, respectively.
[c] One case in the single-surgeon group required reoperation for revision of instrumentation placement.
[d] Mild transfusion reaction, gout, prolonged ileus, and pneumothorax from subclavian line (no chest tube required).
[e] New weakness, bowel/bladder dysfunction, sensory deficit, or radicular pain at discharge.
[f] Two patients (1 from each group) without follow-up records after new 4+/5 iliopsoas weakness and possible neurogenic bladder at discharge.

neurological impairment, instrumentation failure with deep wound infection, 1 washout, instrumentation misplacement causing weakness and sensory deficit, instrumentation misplacement with a screw near the aorta (found incidentally on computed tomography scan for operative planning of an unrelated procedure), and revision after proximal level fracture and new onset neurological deficit. In the 2-surgeon group, 1 of the 36 cases was terminated prematurely and subsequently staged as the result of an intraoperative transfusion reaction. The remaining 2 patients in the 2-surgeon group who returned to the operating room were taken back for a wound revision and for repair of a cerebral spinal fluid leak.

Neurological complication rates (defined as any new weakness, bowel or bladder dysfunction, sensory deficit, or radicular pain at the time of discharge) for the single versus 2 surgeons were 19% and 14%, respectively (p = .542) (Table 4). All neurological deficits resolved at clinical follow-up, with the exception of those in 3 patients. One single-surgeon patient had remaining unilateral lower extremity weakness at 4 years of follow-up. The remaining 2 patients (1 in each group) had residual deficits at discharge but did not return for follow-up; therefore, no documentation of outcome was available for review.

We excluded patients who underwent a staged PSO and subsequent second procedure (anterior lumbar interbody fusion or extreme lateral lumbar interbody fusion) during the same hospitalization and patients who underwent procedures before 2007, for 2 subset analyses (Table 5). The demographics of these 2 subsets of patients remained comparable with regard to sex, frequency of cases with prior surgeries, levels of posterior spinal fusion, decompression, and simultaneous interbody fusions however differed in average patient age. The %EBV, EBL, and operative length remained statistically less for the 2-surgeon group compared with the single-surgeon group for both subset analyses. Radiographic analysis demonstrated no difference between the 2 groups with comparable changes of sagittal vertical axis, lumbar lordosis, pelvic tilt, pelvic incidence, and sacral slope (data not shown). In addition, both subgroups showed a trend for single-surgeon procedures to have an increased number of major complications, fewer patients without a major complication, and more unscheduled returns to the operating room within 30 days.

Discussion

Use of a PSO for correction of sagittal deformity is a powerful technique that has been well described in the literature [4-7,9,11,13,21]. As the awareness of the significance of sagittal balance is better understood, the use of a PSO as a technique to obtain physiological sagittal balance is becoming more common. However, this remains a technically challenging and lengthy operation with high blood loss, a long postoperative recovery, and high risk for complications [4-5,8,10-16,21-24]. This can place a significant burden on patients, with an overall complication rate of nearly 40% [4]. Originally, at our institution our goal had been to minimize the physiological burden and the subsequent complication rates on the highest-risk patients by having 2 experienced attending spinal deformity surgeons perform these surgeries simultaneously.

Evidence for using multiple surgeons in complex spine cases is supported by precedence. Blam et al. [25]

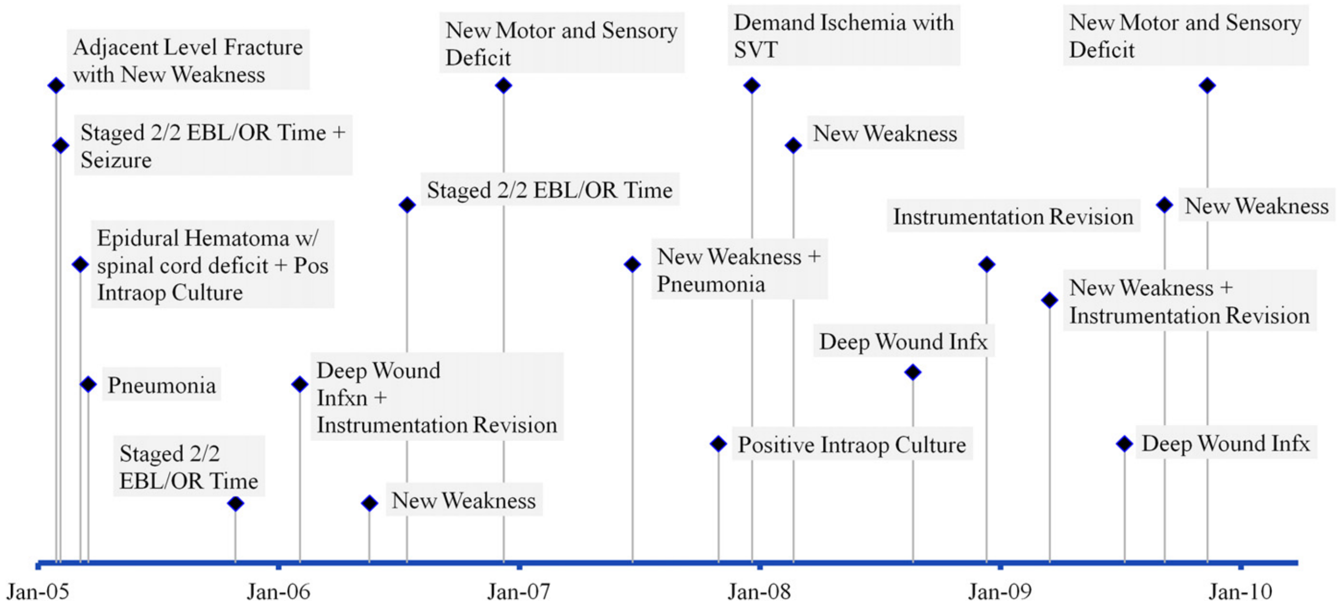

Fig. 1. Single-surgeon major complication timeline. Types of major complication by date for the single-surgeon group. Each data point represents an individual patient. EBL = estimated blood loss; OR = operating room; Pos = positive; Intraop = intraoperative; SVT = supraventricular tachycardia; Infxn, Infx = infection.

investigated the risk factors for surgical site infection after spine surgery and found that the odds ratio for post-operative infection of an orthopedic team alone or neurosurgery team alone compared with a combined team was 6.65 and 4.87, respectively. Two-surgeon approaches have been explored in other operative settings as well. Saithna et al. [18] reported on a small series of patients who underwent simultaneous bilateral anterior cruciate ligament reconstructions by 2 surgical teams and found the procedure to be safe and able to be followed by accelerated rehabilitation compared with the traditional staged or single-setting approach. Gurtner et al. [17] used a 2-team approach for esophagectomy and found significantly decreased operating time and length of hospital stay versus the traditional 2-stage approach. In addition, Skinner et al. [19] attributed decreased operative times and lower complication rates to 2 surgeons working together on laparoscopic retroperitoneal nephrectomies [19].

Our series demonstrated that with 2 attending spine surgeons, the most significant impact was intraoperative blood loss and duration of operative time. Mean %EBV was reduced from 105% to 35% ($p < .0001$), EBL was reduced from 5,279 to 2,003 mL ($p < .0001$), and mean operative time was reduced from 7.6 to 5.0 hours ($p < .0001$). Based on the literature, the reported mean EBL and operative room time for a PSO is 2,420 mL and

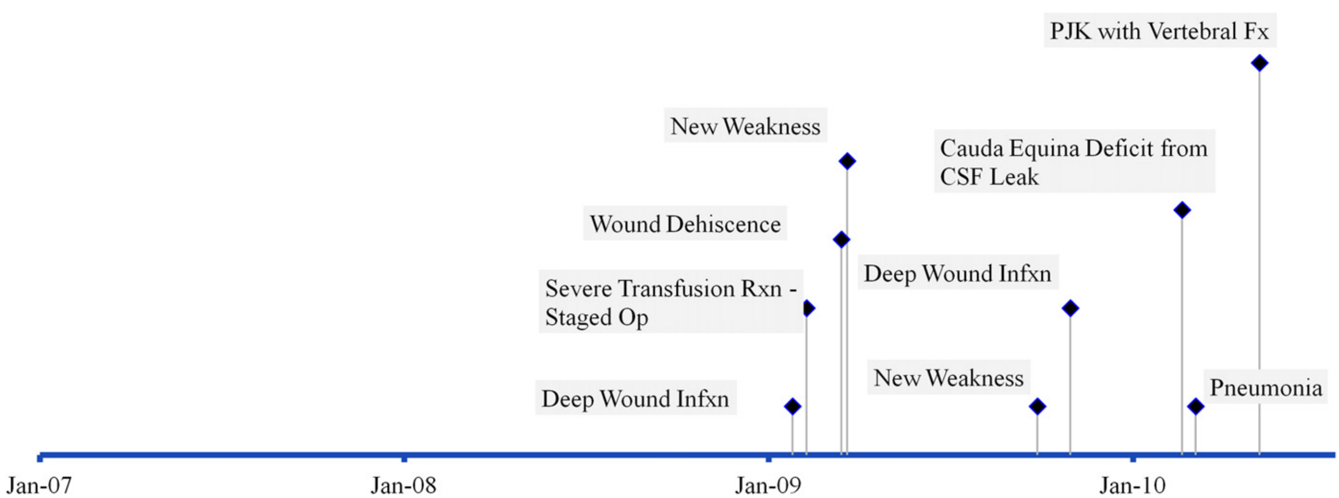

Fig. 2. Two-surgeon major complication timeline. Types of major complication by date for the 2-surgeon group. Each data point represents an individual patient. PJK = proximal junction kyphosis; Rxn = reaction; Op = operative; Infxn = infection; Fx = fracture; CSF = cerebrospinal fluid.

Table 5
Subset analysis of planned single-stage procedures and cases between January 2007 and July 2010

	Planned single-stage subset		January 2007 to July 2010 subset	
	Single surgeon	2 surgeons	Single surgeon	2 surgeons
Patients (n)	33	23	28	36
Age*	56.2*	65.8*	57.1*	64.3*
Sex	21F/12 M	12 F/11 M	18 F/10 M	18 F/18 M
%EBV (%)	106.0*	35.1*	80.8*	35.0*
EBL (mL)*	5,100*	2,037*	4,278*	2,003*
Operative time (minutes)*	456*	307*	425*	297*
Days postoperative at discharge	8	7.7	7.36	7.8
Total major complications (n)	20	7	15	9
Patients with no major complication	17 (515%)	16 (69.6%)	15 (53.6%)	27 (75.0%)
Unscheduled return to operating room <30 days	9 (27.2%)	3 (13.0%)	3 (10.7%)	3 (8.3%)

Abbreviations: F, female; M, male; other abbreviations as in Table 3.
* $p < .05$.

7.3 hours, respectively [5,8,10-16,22] (Table 6). Our 2 experienced surgeons working simultaneously were able to reduce the operative time by close to 2.5 hours and the EBL by close to half a liter compared with what has been reported in the literature.

Intraoperative factors such as operative time and blood loss can have an impact on the patient's postoperative course and risk of complications. The use of minimally invasive spine surgery has resulted in reduced blood loss, operative time, and soft tissue trauma, and resulted in earlier mobilization, shorter hospital stay, and faster return to work [26-34]. In numerous reports, operative time greater than 5 hours has been associated with higher rates of infection [35,36]. There are also reports that increased blood loss may put patients at higher risk of infection [37], although other reports have not found blood loss to be a significant risk factor [35]. Watanabe et al. [38] investigated risk factors for surgical site infection after spine surgery and found that both EBL and duration of an operation tend to increase the risk of infection. The significance of blood loss and duration of operative time in perioperative complication rates needs to be better understood.

Table 6
Literature comparison of PSO cases with reported EBL/operative time

Author, year	PSO (n)	Mean EBL (mL)	Mean operative time (minutes)
Lehmer et al., 1994 [22]	38	1,850	294
Chen et al., 2001 [12]	78	1,150	225
Murrey et al., 2002 [8]	37	2,874	
Bridwell et al., 2003 [10]	66	2,386	732
Cho et al., 2005 [13]	41	2,617	726
Lazennec et al., 2006 [15]	13	1,850	128
van Loon et al., 2006 [16]	11	3,800	250
Yang et al., 2006 [9]	35	5,800	948
Ikenaga et al., 2007 [5]	67	1,988	277
Kiaer and Gehrchen, 2009 [14]	36	2,450	180
Literature mean	42	2,420	440
Two-surgeon mean	36	2,003	297

In our series, %EBV and EBL reduction and reduced operative time were significant factors resulting in a decreased incidence of patients requiring surgery to be staged. Three of the 42 patients in the single-surgeon group and none of the 36 patients in the 2-surgeon group required case termination and a return to the operating room at a later date for completion of the PSO for the specific reason of excessive blood loss and prolonged operative time. This lack of staged procedures contributed to a decrease in the observed rate of unscheduled returns to the operating room within 30 days of the initial procedure from the 1-surgeon to 2-surgeon groups (21% vs. 8%, respectively).

Originally, the idea for 2 surgeons working together was to reduce the physiological toll on higher-risk patients in the hopes of reducing perioperative complications. There was a statistically higher average age in the 2-surgeon group (as well as the single-stage cohort) and proportionally more revision operations (88% vs. 81%; $p = .33$). However, the 2-surgeon group had fewer patients with major complications within 30 days (9 of 36 for the 2-surgeon group vs. 19 of 42 for the 1-surgeon group; $p = .063$). Consistent with the studies cite above, this may have been a direct result of the decreased physiological stress experienced by patients in the 2-surgeon group because of less blood loss and shorter operative duration [35-38]. Although this study did not formally address long-term outcomes, we noted that all patients who received some amount of follow-up had resolution of any neurological deficits in both groups.

We performed 2 subset analyses to further elucidate the impact of 2 surgeons, with a minimal number of possible variables. The first subset of patients included only patients who had planned single-stage procedures, thereby excluding patients who underwent anterior lumbar interbody fusion or extreme lateral lumbar interbody fusion during the same hospital stay. The second subset looked at only procedures performed after January 2007; the rational was that improvements in anesthesia techniques, more operative experience, and increased implementation of tools such as Amicar (Aminocaproic acid, Xanodyne Pharmaceuticals: Newport, KY), an inhibitor of fibrinolysis, may have resulted in better outcomes at later dates. Interestingly however, in both subgroups the findings were the same as in the overall patient group: %EBV, EBL, and operative time remained significantly lower in the 2-surgeon group, and we noted trends toward decreased complication rate and unplanned returns to the operating room within 30 days when 2 attending surgeons participated.

There are several biases inherent to this study, mostly related to the nature of a retrospective case review. The ideal study design would have been a randomized controlled trial matching patients with single surgeons or two attending surgeon while also distributing the surgeons among the 2 groups. In addition, a treatment bias exists because different surgeons operated in each group. Nevertheless, we do not think this had a significant role in the outcomes presented. All providers represent the highest caliber surgeons with vast experience operating on complex deformity cases for over a decade at a tertiary care facility. Despite these study limitations, we believe that the findings presented warrant additional study and that they could potentially be implemented in a variety of surgical environments to the benefit of patients.

Conclusion

The technique of having 2 experienced deformity surgeons work simultaneously performing a PSO has a significant impact on the extent of blood loss and operative time. Higher intraoperative EBL and case length have been previously linked to higher rates of perioperative complications in complex surgery. The use of 2 surgeons at an experienced spine deformity center may also have contributed to a decreased rate in major complications, decreased rate in premature case termination, and decreased rate of returns to the operating room with 30 days.

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