Staged Versus Same-Day Surgery in Circumferential Minimally Invasive Deformity Correction

John Paul G. Kolcun, MD *, Richard G. Fessler, MD, PhD*, Pierce D. Nunley, MD‡, Robert K. Eastlack, MD§, Praveen V. Mummaneni, MD, MBA‖, David O. Okonkwo, MD, PhD¶, Juan S. Uribe, MD#, Kai-Ming Fu, MD, PhD, Michael Y. Wang, MD††, Adam S. Kanter, MD‡‡, Neel Anand, MD§§, Gregory M. Mundis Jr, MD§, Peter G. Passias, MD‖‖, Dean Chou, MD¶¶ International Spine Study Group**

*Department of Neurological Surgery, Rush University Medical Center, Chicago, Illinois, USA; ‡Spine Institute of Louisiana, Shreveport, Louisiana, USA; §Department of Orthopedic Surgery, Scripps Health, La Jolla, California, USA; ‖Department of Neurosurgery, University of California, San Francisco, San Francisco, California, USA; ¶Department of Neurosurgery, University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania, USA; #Department of Neurosurgery, Barrow Neurological Institute, Phoenix, Arizona, USA; **Department of Neurological Surgery, Weill-Cornell Medical Center, New York, New York, USA; ††Department of Neurological Surgery, University of Miami, Miami, Florida, USA; ‡‡Department of Neurosurgery, Hoag Specialty Clinic, Newport Beach, California, USA; §§Department of Orthopaedics, Cedars-Sinai Medical Center, Los Angeles, California, USA; ‖‖Department of Neurosurgery, New York University, New York, New York, USA; ¶¶Department of Neurological Surgery, The Och Spine Hospital, Columbia University, New York, New York, USA

Correspondence: John Paul G. Kolcun, MD, Department of Neurological Surgery, Rush University Medical Center, 1520 W Harrison St, Chicago, IL 60607, USA. Email: JohnPaul_G_Kolcun@rush.edu

Received, November 28, 2023; **Accepted,** March 21, 2024; **Published Online,** May 24, 2024.

Neurosurgery 95:1040–1045, 2024 https://doi.org/10.1227/neu.0000000000003000

BACKGROUND AND OBJECTIVES: We sought to compare long-term clinical and radiographic outcomes in patients who underwent staged vs same-day circumferential minimally invasive surgery (cMIS) for adult spinal deformity (ASD).

METHODS: We reviewed staged and same-day cMIS ASD cases in a prospective multi-institution database to compare preoperative and 2-year clinical and radiographic parameters between cohorts.

RESULTS: A total of 85 patients with a 2-year follow-up were identified (27 staged, 58 same-day). Staged patients had more extensive surgeries and greater hospital length of stay (all $P < .001$). There were no significant differences in preoperative or 2-year postoperative clinical metrics between cohorts. Patients in the staged cohort also had greater preoperative coronal deformity and thus experienced greater reduction in coronal deformity at 2 years (all $P < .01$).

CONCLUSION: Patients undergoing staged or same-day cMIS correction had similar outcomes at 2 years postoperatively. Staged cMIS ASD correction may be more appropriate in patients with greater deformity, higher frailty, and who require longer, more extensive surgeries.

KEY WORDS: Scoliosis, Deformity, Minimally invasive surgery, Staged surgery

For adult spinal deformity (ASD), circumferential minimally invasive surgery (cMIS) techniques can achieve durable correction in appropriate patients whose age or frailty may prove to be a significant deterrent to conventional open procedures.[1-3] Advances in technique and implant technology have expanded the capabilities of the cMIS approach to correct major deformity.[4-6] With the introduction of the MIS deformity (MISDEF) algorithm and the subsequently expanded MISDEF2, surgeons now have a reliable decision matrix for patient selection and surgical planning.[7,8]

Many surgeons approach cMIS surgeries in a staged fashion, and a standard paradigm has been described previously, consisting of Stage I: diskectomy and interbody device placement, generally through anterior and/or lateral interbody fusion, and Stage II: posterior pedicle screw fixation with/without MIS decompressions, as needed.[9] Strategic factors in deciding whether to stage cMIS procedures include the degree of correction required in both planes, feasibility of treating all demonstrated pain generators, and the patient's physiological tolerance for anesthesia/surgical stress. Tactical aspects include technical efficiency and operative time, confidence in interpreting alignment changes after interbody device placement, and the requirement for certain imaging studies before posterior fixation and/or decompressions.[10]

The clinical and radiographic impact of staging cMIS procedures has not been well-studied in our literature. In this article, we compare long-term clinical and radiographic outcomes in patients who underwent staged vs same-day cMIS surgery.

ABBREVIATIONS: ASD, adult spinal deformity; **cMIS,** circumferential minimally invasive surgery; **MISDEF,** MIS deformity.

METHODS

We reviewed cases in a prospective multi-institution database to identify adult (≥18 years) patients undergoing staged or same-day cMIS correction of ASD with a minimum 2-year follow-up. For enrollment in this database, all patients must have had lumbar scoliosis ≥20°, sagittal vertical axis >5 cm, pelvic tilt >20°, and ≥10° pelvic incidence-lumbar lordosis mismatch.

We compared preoperative and 2-year postoperative clinical metrics between cohorts, including Oswestry Disability Index, numeric ranking scale for back/leg pain, EuroQol-5 dimension (EQ-5D) including visual analog scale, Short Form Survey-36 (SF-36) physical/mental component scores, and Scoliosis Research Society-22 (SRS-22). We compared radiographic outcomes between cohorts for significant differences, including Cobb angles, pelvic incidence and PI-lumbar lordosis mismatch, coronal vertical axis, and sagittal vertical axis.

For statistical analysis, univariate comparisons were performed using t-tests and nonparametric tests. Categorical variables were compared using Fisher's exact test. *P*-values ≤.05 were considered significant. This study was approved by our institutional review board (IRB21033003). All patients were consented for surgery and enrollment in the prospective database at each respective site.

RESULTS

Eighty-five patients with a 2-year follow-up were identified, with 27 patients in the staged cohort and 58 patients in the same-day cohort. In the staged cohort, an average 3.4 ± 4.1 days elapsed between stages. Patients in the staged cohort had significantly greater frailty scores (P = .044). Otherwise, there were no significant differences in demography or medical history (Table 1). Patients in the staged cohort underwent more extensive surgeries, with more total levels of both interbody and posterior fusion, and greater total blood loss, operative time, and hospital length of stay (all P < .001). Staged patients generally required more blood transfusions than same-day patients (51.9% vs 12.1%). Patients in the staged cohort also experienced more complications, as compared with the same-day cohort (P = .018) (Table 2).

Overall, there were no significant differences in preoperative or 2-year postoperative clinical metrics between cohorts. There were trends toward greater baseline disability in the staged cohort, which did not achieve significance (Oswestry Disability Index: 46.5 ± 13.2 vs 51.5 ± 15.6, P = .066; SRS-22: 2.8 ± 0.5 vs 2.7 ± 0.6, P = .096). Patients in the staged cohort did experience significantly greater positive change in SRS-22 postoperatively (0.5 ± 0.6 vs 0.8 ± 0.7, P = .015) (Table 3).

Patients in the staged cohort had greater baseline coronal Cobb angles in the lumbar spine and at maximum curvature (P < .001 and P = .004, respectively). There was no difference in any postoperative radiographic parameters between cohorts. Patients in the staged cohort did experience greater postoperative reduction in coronal Cobb angles (thoracolumbar: −3.1 ± 6.2 vs −11.9 ± 14.0, P = .019; lumbar: −6.0 ± 8.4 vs −14.9 ± 12.4, P = .003; maximum: −5.3 ± 7.8 vs −15.1 ± 13.7, P = .001) (Table 4).

DISCUSSION

In patients with ASD undergoing cMIS, clinical and radiographic outcomes were equivalent at 2 years postoperatively between patients who underwent staged vs same-day procedures.

Notably, this study exists within the framework of the MISDEF2 approach to surgical planning. Specifically, the data in the current analysis apply to patients who fall into MISDEF2 Class III

TABLE 1. Same-Day vs Staged Cohort Group Characteristics

Characteristic	Same-day cohort	Staged cohort	*P* value
No. of patients	58	27	
Age (y)	69.0 ± 10.9	68.7 ± 8.3	.451
Sex	M: 20 (34.5%)	M: 5 (18.5%)	.104
	F: 38 (65.5%)	F: 22 (81.5%)	
Smoker?	2 (3.5%)	0	.510
Previous surgery?	30 (51.7%)	13 (41.2%)	.470
BMI	29.7 ± 6.7	28.3 ± 5.0	.171
CCI	2.3 ± 1.5	2.1 ± 1.6	.318
Frailty score	3.4 ± 1.4	4.0 ± 1.2	.044[a]

BMI, body mass index; CCI, Charlson comorbidity index.
[a]Denotes a statistically significant value.
Continuous values are shown as mean ± SD; categorical variables are shown as N (%).

TABLE 2. Operative Outcomes and Hospital Course

Characteristic	Same-day cohort	Staged cohort	*P* value
OR time (min)	314.0 ± 150.9	628.6 ± 165.2	<.001[a]
EBL (cc)	214.6 ± 186.0	769.8 ± 611.5	<.001[a]
No. of PSF levels	3.5 ± 2.2	7.0 ± 2.9	<.001[a]
No. of IBF levels	2.6 ± 1.3	4.3 ± 1.2	<.001[a]
No. of ALIF levels	0.7 ± 1.0	1.4 ± 0.8	<.001[a]
No. of LLIF levels	1.7 ± 1.3	2.7 ± 1.6	.001a
No. of TLIF levels	0.2 ± 0.6	0.1 ± 0.3	.426
LOS (d)	4.2 ± 2.4	9.2 ± 4.0	<.001[a]
Complications	30 (51.7%)	21 (77.8%)	.018[a]

ALIF, anterior lumbar interbody fusion; EBL, estimated blood loss; IBF, interbody fusion; LLIF, lateral lumbar interbody fusion; LOS, length of stay; OR, operating room; PSF, posterior spinal fusion; TLIF, transforaminal lumbar interbody fusion.
[a]Denotes a statistically significant value.
Continuous values are shown as mean ± SD; categorical variables are shown as N (%).

TABLE 3. Clinical Comparisons

	Same-day cohort	Staged cohort	*P* value
ODI			
Preoperative	46.5 ± 13.2	51.15 ± 15.6	.066
Postoperative	27.8 ± 19.5	31.4 ± 22.0	.236
Δ	−18.5 ± 16.7	−20.8 ± 23.2	.335
NRS back			
Preoperative	7.0 ± 2.2	7.5 ± 1.9	.183
Postoperative	4.2 ± 2.9	3.9 ± 3.6	.351
Δ	−2.9 ± 3.0	−3.4 ± 4.1	.267
NRS leg			
Preoperative	6.0 ± 3.1	5.0 ± 3.2	.099
Postoperative	3.1 ± 2.9	2.1 ± 2.6	.078
Δ	−3.0 ± 3.7	−3.0 ± 4.4	.474
EQ-5D			
Preoperative	0.8 ± 0.1	0.7 ± 0.1	.243
Postoperative	0.8 ± 0.1	0.8 ± 0.1	.317
Δ	0.04 ± 0.1	0.1 ± 0.1	.090
EQ-5D VAS			
Preoperative	59.5 ± 21.0	56.2 ± 23.1	.283
Postoperative	71.3 ± 20.2	68.3 ± 19.7	.276
Δ	8.5 ± 22.7	8.6 ± 24.5	.497
PCS			
Preoperative	28.8 ± 6.2	27.7 ± 7.1	.253
Postoperative	37.9 ± 10.3	36.3 ± 11.0	.276
Δ	10.0 ± 10.5	7.8 ± 8.0	.192
MCS			
Preoperative	45.2 ± 12.4	41.9 ± 12.5	.143
Postoperative	50.7 ± 12.1	49.7 ± 11.5	.360
Δ	5.0 ± 11.4	6.0 ± 11.8	.360
SRS-22			
Preoperative	2.8 ± 0.5	2.7 ± 0.6	.096
Postoperative	3.3 ± 0.7	3.4 ± 0.8	.301
Δ	0.5 ± 0.6	0.8 ± 0.7	.015[a]

ODI, Oswestry disability index; MCS, mental component score (Short Form Survey-36); NRS, numeric ranking scale; PCS, physical component score (Short Form Survey-36); SRS-22, Scoliosis Research Society-22; VAS, visual analog scale.
[a]Denotes a statistically significant value.
Continuous values are shown as mean ± SD.

TABLE 4. Radiographic Comparisons

	Same-day cohort	Staged cohort	*P* value
CVA			
Preoperative	26.0 ± 25.4	30.5 ± 28.4	.230
Postoperative	23.3 ± 23.6	28.2 ± 19.9	.179
Δ	−2.6 ± 18.8	−2.3 ± 32.3	.483
T-L Cobb			
Preoperative	18.2 ± 15.3	22.1 ± 14.2	.211
Postoperative	15.7 ± 15.1	10.4 ± 6.0	.109
Δ	−3.1 ± 6.2	−11.9 ± 14.0	.019[a]
Lumbar Cobb			
Preoperative	23.1 ± 11.3	35.8 ± 14.9	<.001[a]
Postoperative	17.1 ± 13.4	21.0 ± 12.6	.140
Δ	−6.0 ± 8.4	−14.9 ± 12.5	.003[a]
Maximum Cobb			
Preoperative	24.9 ± 15.0	24.5 ± 15.9	.004[a]
Postoperative	19.7 ± 16.8	19.6 ± 14.2	.487
Δ	−5.3 ± 7.8	−15.1 ± 13.7	.001[a]
PI			
Preoperative	55.7 ± 14.8	54.3 ± 13.6	.340
Postoperative	55.7 ± 14.9	56.2 ± 14.2	.438
Δ	0.03 ± 1.9	1.9 ± 6.1	.062
PT			
Preoperative	21.6 ± 9.7	22.8 ± 8.9	.284
Postoperative	20.8 ± 10.2	21.3 ± 9.3	.417
Δ	−0.7 ± 6.5	−1.7 ± 6.7	.261
PI-LL			
Preoperative	12.3 ± 14.0	16.8 ± 19.3	.114
Postoperative	6.2 ± 12.8	6.0 ± 14.9	.472
Δ	−6.0 ± 10.8	−10.9 ± 17.4	.097
SVA			
Preoperative	62.3 ± 53.9	58.3 ± 65.8	.383
Postoperative	43.7 ± 48.2	34.3 ± 55.2	.213
Δ	−18.5 ± 38.9	−24.0 ± 58.2	.329

CVA, coronal vertical axis; PI, pelvic incidence; PI-LL, PI-lumbar lordosis mismatch; PT, pelvic tilt; SVA, sagittal vertical axis; T-L, thoracolumbar.
[a]Denotes a statistically significant value.
Continuous values are shown as mean ± SD; categorical variables are shown as N (%).

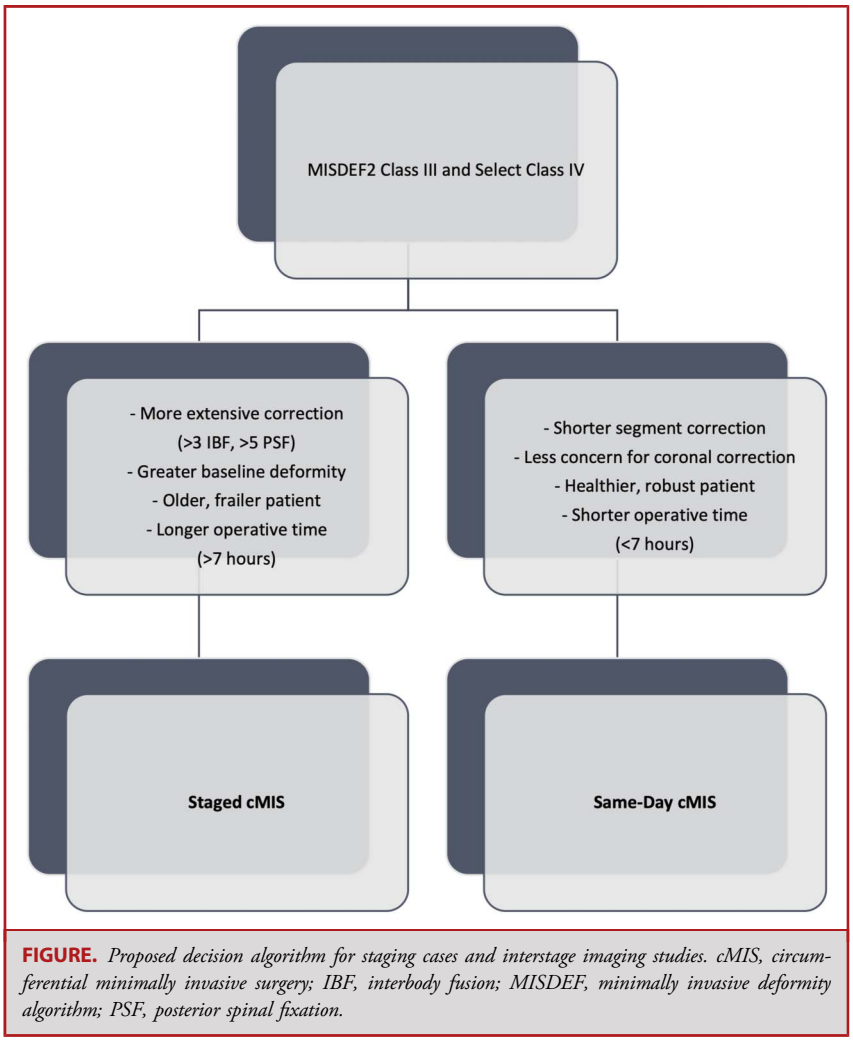

FIGURE. *Proposed decision algorithm for staging cases and interstage imaging studies. cMIS, circumferential minimally invasive surgery; IBF, interbody fusion; MISDEF, minimally invasive deformity algorithm; PSF, posterior spinal fixation.*

and even some Class IV (ie, severe sagittal and coronal deformities, without pre-existing multilevel instrumentation).[8] Class III was a novel aspect of the MISDEF2 algorithm, reflecting the greater capacity for sagittal correction afforded by novel techniques and implants, including anterior column realignment and expandable interbody devices.[4,6] With a refined consensus of which patients are appropriate for major corrections using cMIS techniques, we now ask which of these patients are most appropriate for staged surgery.

The safety profile and efficacy of cMIS deformity correction have been studied previously. Anand et al[11] reported patients with ASD treated by cMIS who were followed for an average of 90 months and had a low rate of clinically significant hardware failure (3.04%), rod fractures (2.2%), and hardware prominence (2.3%). The same group found durable improvements in clinical and radiographic parameters at an average of 82.8-month follow-up, with an acceptable rate of major complications (1.4% intraoperative, 8.9% perioperative, 19.1% postoperative), which the authors argue is lower than published complication profiles in conventional open ASD cohorts.[12] They have also recently reported the crucial application of interstage imaging in the treatment of selective thoracolumbar fusions in major double-curve ASD. Specifically regarding staged deformity cases, the authors reported that staging may be safer with cMIS approaches than with "hybrid" approaches (consisting of MIS interbodies with conventional open posterior screw/rod fixation) because they found a significantly greater complication rate in staged hybrid cases (75% staged vs 28.6% un-staged, $P < .001$), whereas there was no difference in complication profile between staged vs same-day cMIS cases (33.3% stages vs 29.6% un-staged, $P = .770$).[13] Furthermore, staged cMIS patients may be more likely to require inpatient discharge, as opposed to discharge home.[14]

In our cohorts, patients in the staged cohort had higher frailty scores on average. This likely reflects selection for staged surgery to limit continuous anesthesia/operative time, to allow patients time for recovery. Staged patients also had more severe coronal

deformity at baseline although cohorts had similar baseline sagittal alignment. Most strikingly, patients in the staged cohort had much more extensive surgeries, with roughly double the number of levels treated by both interbody fusion and posterior fixation (both $P < .001$). Given the more extensive surgeries, staged patients also had significantly greater operative times and blood loss (both $P < .001$) and longer hospital stays (also reflecting the interstage period). These findings likely explain the higher complication rate and transfusion requirements in the staged cohort. These trends may also explain the tendency toward in-patient discharge after staged cMIS procedures described in the study above.

In sum, we suggest a reasonable generalized decision matrix for staged vs same-day MISDEF correction:

Frailer patients who may be at greater risk under prolonged anesthesia/surgical stress, or patients who require longer, more extensive surgeries, may be more appropriate for staged MISDEF correction. Based on the characteristics of our same-day cohort, we propose conservative measures of >7 hours anticipated operating time, >3 interbody levels, and >5 posterior fixation levels as grounds to consider staging. By contrast, MISDEF2 Class III patients in better general health, with less severe deformity, and who require less extensive surgery may be more appropriate for same-day procedures (Figure).

Limitations

The primary limitation of this study is that it is a retrospective review of data collected prospectively in a multisite registry. As such, we can draw inferences as to the real-time decision-making reflected in these data, but a prospective record of why each case was selected for staged vs same-day surgery would be more powerful. We acknowledge the inherent selection bias in our cohorts because patients were offered staged or same-day procedures as deemed clinically appropriate by their surgeon. However, our conclusions regarding long-term outcomes presuppose *appropriately selected* patients for either approach, and the selected nature of these cohorts in fact enables our characterization of thresholds to consider a staged approach. Although we present a decision-making schema derived from these data, formal recommendations would require more extensive consideration by a panel of experts convened for that purpose.

CONCLUSION

Patients undergoing staged vs same-day minimally invasive deformity correction have similar clinical and radiographic outcomes at 2 years postoperatively. At baseline, patients who were selected for staged procedures had higher frailty and more severe deformity. Patients in the staged cohort underwent more extensive surgeries, with longer constructs and greater operative time and blood loss. We suggest a generalized decision matrix for which cases to perform staged vs same-day surgery.

Funding

This study did not receive any funding or financial support.

Disclosures

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article. Robert K. Eastlack is a consultant for Globus, SI Bone, SeaSpine, Medtronic, Depuy, Spinal Elements, Neo, Silony, Spine Innovation, Alphatec, Aesculap, OsteoCentric, and Kuros. Praveen V. Mummaneni is a consultant for ISSGF, DePuy-Synthes, Globus, NuVasive, Stryker, BK Medical, Brainlab, SI Bone, NREF, AO Spine, PCORI, SLIP II, Pacira, Spinicity/ISD, DiscGenics, Springer Publisher, Thieme Publisher, and NIH. David O. Okonkwo is a consultant for NuVasive and ZimVie. Kai-Ming Fu is a consultant for Bioventus and ATEC. Michael Y. Wang is a consultant for DePuy-Synthes, Stryker, Spineology, NuVasive, Pacira, ISD, Kinesiometrics, and Medical Device Partners. Neel Anand is a consultant for Medtronics, Orthofix, SeaSpine, and Elsevier. Gregory M. Mundis is a consultant for Carlsmed, NuVasive, SeaSpine, SI-Bone, Viseon, Stryker, Alphatec Spine, and Orthofix Scientific. Peter G. Passias is a consultant for Cerepedics, Cervical Scoliosis Research Society, Globus Medical, Medtronic, Royal Biologics, Spine, Spinevision, Spine Wave, and Terumo. Dean Chou is a consultant for Globus, Medtronic, and Orthofix.

REFERENCES

1. Ames CP, Scheer JK, Lafage V, et al Adult spinal deformity: epidemiology, health impact, evaluation, and management. *Spine Deform.* 2016;4(4):310-322.
2. Chan AK, Eastlack RK, Fessler RG, et al Two- and three-year outcomes of minimally invasive and hybrid correction of adult spinal deformity. *J Neurosurg Spine.* 2022;36(4):595-608.
3. Anand N, Agrawal A, Burger EL, et al The prevalence of the use of MIS techniques in the treatment of adult spinal deformity (ASD) amongst Members of the Scoliosis Research Society (SRS) in 2016. *Spine Deform.* 2019;7(2):319-324.
4. Anand N, Cohen RB, Cohen J, Kahndehroo B, Kahwaty S, Baron E. The influence of lordotic cages on creating sagittal balance in the CMIS treatment of adult spinal deformity. *Int J Spine Surg.* 2017;11(3):23.
5. Lovecchio FC, Vaishnav AS, Steinhaus ME, et al Does interbody cage lordosis impact actual segmental lordosis achieved in minimally invasive lumbar spine fusion? *Neurosurg Focus.* 2020;49(3):e17.
6. Kandwal P, Goswami A, Vijayaraghavan G, et al Staged anterior release and posterior instrumentation in correction of severe rigid scoliosis (Cobb angle >100 degrees). *Spine Deform.* 2016;4(4):296-303.
7. Mummaneni PV, Shaffrey CI, Lenke LG, et al The minimally invasive spinal deformity surgery algorithm: a reproducible rational framework for decision making in minimally invasive spinal deformity surgery. *Neurosurg Focus.* 2014;36(5):e6.
8. Mummaneni PV, Park P, Shaffrey CI, et al The MISDEF2 algorithm: an updated algorithm for patient selection in minimally invasive deformity surgery. *J Neurosurg Spine.* 2019;32(2):221-228.
9. Anand N, Kong C, Fessler RG. A staged protocol for circumferential minimally invasive surgical correction of adult spinal deformity. *Neurosurgery.* 2017;81(5):733-739.
10. Kolcun JPG, Kelly RM, Wolfson DI, et al Interstage imaging in staged minimally invasive spinal deformity surgery. *J Minim Invasive Spine Surg Tech.* 2023;8(Suppl 1):S85-S91.
11. Anand N, Chung A, Kong C, et al Prevalence and modes of posterior hardware failure with a staged protocol for circumferential minimally invasive surgical correction of adult spinal deformity: a 13-year experience. *Int J Spine Surg.* 2022;16(3):481-489.

12. Anand N, Alayan A, Kong C, et al Management of severe adult spinal deformity with circumferential minimally invasive surgical strategies without posterior column osteotomies: a 13-year experience. *Spine Deform.* 2022;10(5):1157-1168.
13. Than KD, Park P, Tran S, et al Analysis of complications with staged surgery for less invasive treatment of adult spinal deformity. *World Neurosurg.* 2019;126:e1337-e1342.
14. Eastlack RK, Ledesma JB, Tran S, et al Home versus rehabilitation: factors that influence disposition after minimally invasive surgery in adult spinal deformity surgery. *World Neurosurg.* 2018;118:e610-e615.

Acknowledgments

Author Contributions: Kolcun—conception, manuscript composition, editing. Fessler—conception, supervision, critical review, editing. Nunley—conception, data analysis, critical review, editing. Eastlack, Mummaneni, Okonkwo, Uribe, Fu, Wang, Kanter, Anand, Mundis, Passias, and Chou—critical review, editing. Compliance with ethical standards: all research was conducted on prospectively collected deidentified data in compliance with local and international ethical standards for clinical/medical research.

COMMENTS

This manuscript thoughtfully compares the clinical and radiographic outcomes in adult spinal deformity patients undergoing either staged or same-day circumferential MIS (cMIS) deformity correction. The authors importantly underscore that there were no significant differences in clinical or radiographic metrics at a 2-year follow-up between the cohorts. The authors appropriately acknowledge the inherent selection bias of a retrospectively reviewed prospective database in which same-day vs. staged correction was based on the surgeon's discretion.

Patients selected for staged surgery had higher frailty scores and greater coronal deformity. In essence, patients requiring larger corrections or those thought to be less likely to tolerate prolonged anesthesia were offered staged surgery. The appropriate selection of these patients in the current study serves as the basis for the decision-making schema ultimately proposed by the authors. Certainly, many clinical and nonclinical factors can influence the decision to perform a staged correction and the timing of those stages, e.g. approach surgeon availability, etc. It is also important to note that the staged procedures were not generally performed on subsequent days with a mean 3.4 days between stages, certainly significantly contributing to the observed LOS differences. There were significant higher blood loss, OR time, and LOS in the staged cohort, not fully accounted for by the differences in the extent of deformity correction. More granular future analyses could aid in the development of strategies to reduce these differences to support staged cMIS surgical approaches.

We commend the authors on their work and agree that more rigorous review of the factors influencing the decision to offer same-day vs. staged correction will potentially allow for a more robust decision-making tool in the preoperative assessment of patients considered for cMIS deformity correction.

Trent A. VanHorn, Steve H. Monk, and Christopher M. Holland
Charlotte, North Carolina, USA