



Staging in Circumferential Spinal Fusion in Adult Spinal Deformity: Systematic Review and Meta-Analysis

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Disclosure

I have no disclosures to report

Adult Spinal Deformity (ASD)

Affects up to 68% of the elderly population

Complex spectrum of spinal pathologies

Presented in patients >60 years

Treatment Modalities

Non-Operative

 Pain Management and Physical Therapy

Operative

Circumferential Spinal Fusion

Surgical Intervention

Circumferential Spinal Fusion

- Indications of Surgery: progressive curvature of spine with sagittal or coronal imbalance, significant loss of pulmonary function caused by the misalignment and deformity, loss of function due to pain associated with spinal curvature
- Increases stability granted by both anterior and posterior fixation of the spinal column
- Attempts to remedy the limitations of lateral approaches, such as the need for an intraoperative patient repositioning, which increases operative time and puts the patient at risk for complication due to longer time under anesthesia

Staged vs Same-Day Fusion

Staged

- Occurs two distinct operative days
- Determined by surgeon's preference and case complexity

Same-Day

Occurs within a single session

Purpose

This study aimed to investigate the differences in outcome between staged and un-staged circumferential spinal fusion for ASD correction.

Methodology

Protocol Registration Eligibility and PICO Framework Search Strategy Data Selection and Extraction Data Synthesis

Protocol Registration

Design and reporting were supported by Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) and Preferred Reporting Items for Systematic review and Meta-Analysis Protocols (PRISMA-P) Registered on Prospero (CRD42022339764) and published on JMIR Research Protocols (PRR1-10.2196/42331)

Eligibility and PICO Framework

Population

 Adults with adult spinal deformity

Intervention

Staged CF Surgery

Comparison

Same-Day Surgery

Outcomes

 Perioperative outcomes

Data Extraction and Synthesis

Databases

 MEDLINE, Embase, Cochrane Central Register of Controlled Trials (CENTRAL), Web of Science, and Scopus

Screening and Data-Extraction

• Performed on Covidence: 2 independent reviewers with a 3rd resolving conflicts

Quantitative analysis

 Utilization of using RevMan Web (Cochrane)

Figure 1. Study Selection

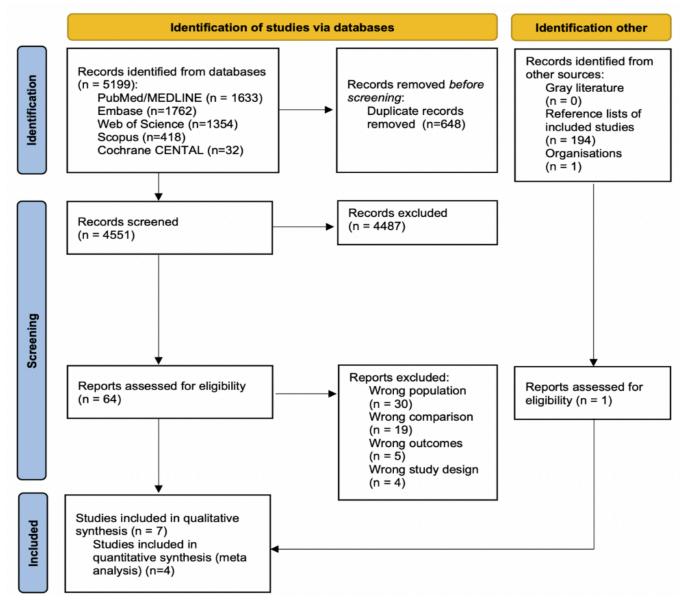


Table 1. Study characteristics and comparative results between Staged and Same-Day CF

Author Information	No. of Patients	Age (mean, range, median)	Study type	Population details and differences	Surgery details	Outcomes
Anand et al., 2014 United States	50	61 (20-85)	Retrospective cohort study	Patients with adult idiopathic scoliosis corrections undergoing cMIS, Cobb angle of greater than 30 but less than 75 degree	Staged DLIF and L5-S1 XLIF with PSF; mean vertebrae fused: 7 (range 4-15)	Staged: (n=37), EBL 763ml (25-2500), OR Time 482min (83-546)
	ground.		Securit manages can test take 10 degree	Same Day DLIF and L5-S1 XLIF with PSF; mean vertebrae fused: 7 (range 4-15)	Same-Day: (n=13), EBL 613ml (150-1500), OR Time 351min (176-510)	
Anand et al., 2013	71	64	Retrospective cohort study	Adults with scoliosis undergoing cMIS, 2 or more levels	Staged DLIF and XLIF with PSF; mean vertebrae fused: 4.4	Staged: (n=36), EBL 671ml, OR Time 426min
United States					Same-Day DLIF and XLIF with PSF; mean vertebrae fused: 4.4	Same-Day: (n=35), EBL 412ml, OR Time 291min
Arzeno et al., 2019	92	68 (61-78)	Retrospective cohort study	Patients with ASD, undergoing anterior (including lateral and anterolateral	Staged CF (ALIF, PSF), Ponte osteotomy n=39, three-column osteotomy n=7,	Staged: (n=45), mean LOS 9d, REOP n=5, READ n=1, POI
United States	Officed States			approaches) and PSF of at least 5 levels	Decompression n=34; mean vertebrae fused: 8 (95% CI 5-9)	n=2, AAE n=12
				Groups differ in: approach, Ponte osteotomy, three-column osteotomy, O-arm,	Same-Day CF (ALIF, PSF), Ponte osteotomy n=24, three-column osteotomy	Same day: (n=47), mean LOS 6d, REOP n=7, READ n=6,
				neuromonitoring, decompression, no. of posterior levels fused, no. of osteotomy levels, no. of decompression levels	n=1, decompression n=16; mean vertebrae fused: 9 (95% CI 9-9)	POI n=3, AAE n=7
Harris et al., 2021	87	61 (11)	Retrospective cohort study	Patients with ASD who underwent long PSF (more than five levels fused, with fusion to	Staged CF (ALIF, PSF); mean vertebrae fused: 8.7 (SD 0.48)	Staged: (n=41), ODI 45±17, SRS-22r 2.8±0.6
United States				the pelvis)	Same-Day CF (ALIF, PSF); mean vertebrae fused: 7.4 (SD 2.4)	Same-Day: (n=46), ODI 48±15, SRS-22r 2.8±0.6
				Groups differ in: previous spine surgery, scoliosis/kyphosis, pseudarthrosis, pelvic incidence		
Masuda et al., 2023	287	72.3	Retrospective cohort study,	Patients with ASD, ≥four fused levels and at least one level using LLIF, and presence of at	Staged CF (LLIF, PSF); mean vertebrae fused: 7.7 (SD 2.3)	Staged: (n=101), EBL 642.5ml (550.5), OR Time 541.3min
Japan			Propensity score weighted	least one spinal deformity marker: scoliosis Cobb angle≥20°, sagittal vertical axis≥5 cm, pelvic tilt≥25°, pelvic incidence minus		(124.1), LOS 42d (25), IOAE n=11, POAE n=11, REOP n=11, POI n=4, AAE n=22
				lumbar lordosis angle≥10°, and/or thoracic kyphosis≥60°	Same-Day CF (LLIF, PSF); mean vertebrae fused: 6.2 (SD 2.4)	Same-Day: (n=186), EBL 722.2ml (612.6), OR Time 479.9min (128.5), LOS 34.1d (18.2), IOAE n=17, POAE n=23, REOP n=19, POI n=5, AAE n=40

Continuation of Table 1. Study characteristics and comparative results between Staged and Same-Day CF

Albayar et al., 2023	100	58.8 (9.0)	Retrospective cohort study,	Patients >18 years at the time of surgery and diagnoses of ASD undergoing (ALIF), and	Staged ALIF, and open posterior lumbar or thoracolumbar PSF; mean vertebrae	Staged: (n=44), 1351.7ml (869), LOS 10.5d (5), IOAE
United States		Inverse probability	open posterior lumbar or thoracolumbar (PSF)	fused: 10 (SD 3.9)	n=6, POAE n=30, REOP n=10, POI n=5, READ n=10	
			weighted		Same-Day ALIF, and open posterior lumbar or thoracolumbar PSF; mean vertebrae fused: 7.3 (SD 3.1)	Same-Day: (n=56), EBL 1127.6ml (945.4), LOS 6.2d (3.1), IOAE n=2, POAE n=30, REOP n=8, POI n=1, READ n=8
Than et al., 2019	54	67.3	Retrospective cohort study	Patients with ASD, coronal Cobb angle >20, SVA > 5 cm, PT> 20, PI-LL> 10, and/or	Staged MIS LLIF and/or MIS TLIF with PSF; mean vertebrae	Staged: (n=27) REOP n=4, POI n=0, AAE n=9
United States				thornois lambosis >60	freed: 5.4	
filled States				thoracic kyphosis >60	fused: 5.4	S D (27) BEOD7
					Same-Day MIS LLIF and/or	Same-Day: (n=27) REOP n=7
					MIS TLIF with PSF; mean vertebrae	READ n=1, POI n=1, AAE
					fused: 5.3	n=8

AAE = any adverse event; ALIF = anterior lumbar interbody fusion; ASD = adult spinal deformity; CF = circumferential fusion; DLIF = direct lumbar interbody fusion; EBL = estimated blood loss; IOAE = intraoperative adverse event; LLIF = lateral lumbar interbody fusion; LOS = length of stay; MIS = minimally invasive surgery; POAE = postoperative adverse event; POI = postoperative infection; PSF = posterior spinal fixation; READ = readmission; REOP = re-operation; TLIF = transforaminal lumbar interbody fusion; XLIF = extreme lumbar interbody fusion

Figure 2. Estimated Blood Loss

		Staged			Same			Mean difference	Mean difference
Study or Subgroup	Mean [days]	SD [days]	Total	Mean [days]	SD [days]	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
✓ Masuda 2023	42	25	101	34.1	18.2	186	22.1%	7.90 [2.37 , 13.43]	
✓ Santangelo et al., 2023	10.5	5 5	44	6.2	3.1	56	77.9%	4.30 [2.61 , 5.99]	-
Total (95% CI)			145	j		242	100.0%	5.10 [2.17 , 8.02]	
Heterogeneity: Tau ² = 2.13	; Chi ² = 1.49, d	f = 1 (P = 0.2	2); I ² = 33	3%					
Test for overall effect: Z = 3	3.41 (P = 0.000	6)							-10 -5 0 5 10
Test for subgroup difference	es: Not applica	ble						Favours	[experimental] Favours [control]

Figure 3. Intraoperative Complications

.22 [0.55 , 2.71]	M-H, Random, 95% CI
.22 [0.55 , 2.71]	
26 [0.82 , 22.27]	
83 [0.58 , 5.84]	
0.0	01 0.1 1 10 100
	experimental] Favours [control]
	83 [0.58 , 5.84]

Test for subgroup differences: Not applicable

Figure 4. Operative Time

	;	Staged			Same			Mean difference	Mean diff	erence
Study or Subgroup	Mean [min]	SD [min]	Total	Mean [min]	SD [min]	Total	Weight	IV, Random, 95% CI	IV, Random	n, 95% CI
Masuda 2023	541.3	124.1	101	479.9	128.5	186	100.0%	61.40 [30.96 , 91.84]		•
Total (95% CI) Heterogeneity: Not ap	plicable		101			186	100.0%	61.40 [30.96 , 91.84]	55 57	•
Test for overall effect: Test for subgroup diffe								Favour	-200 -100 0	100 200 Favours [control]

Figure 5. Post Operative Complications

	Stag	ged	Sar	ne		Odds ratio	Odds ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI	M-H, Random, 95% CI
Masuda 2023	11	101	23	186	54.1%	0.87 [0.40 , 1.86]	
Santangelo et al., 2023	30	44	33	56	45.9%	1.49 [0.65 , 3.42]	-
Total (95% CI)		145	;	242	100.0%	1.11 [0.63 , 1.95]	•
Total events:	41		56				
Heterogeneity: Tau ² = 0.	00; Chi ² = (0.90, df =	1 (P = 0.3	4); I ² = 0%	6	0.01	0.1 1 10 100
Test for overall effect: Z	= 0.37 (P =	0.71)					perimental] Favours [contro
Test for subgroup differe	nces: Not a	applicable	9				

Figure 6. Perioperative Complications

	Stag	jed	San	ne		Odds ratio	Odds ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI	M-H, Random, 95% CI
Arzeno et al., 2019	12	45	7	47	18.4%	2.08 [0.73 , 5.88]	
Masuda 2023	22	101	40	186	44.4%	1.02 [0.56 , 1.83]	
Santangelo et al., 2023	36	44	35	56	21.9%	2.70 [1.06, 6.90]	
Than 2019	9	27	8	27	15.4%	1.19 [0.38 , 3.75]	
Total (95% CI)		217	,	316	100.0%	1.47 [0.91 , 2.38]	
Total events:	79		90				_
Heterogeneity: Tau ² = 0.	05; Chi ² = 3	3.66, df =	3 (P = 0.30)	0); I ² = 18	3%	(0.01 0.1 1 10 100
Test for overall effect: Z	= 1.57 (P =	0.12)					s [experimental] Favours [control]

Test for subgroup differences: Not applicable

Figure 7. Hospital Length of Stay

		Staged			Same			Mean difference	Mean di	fference
Study or Subgroup	Mean [days]	SD [days]	Total	Mean [days]	SD [days]	Total	Weight	IV, Random, 95% CI	IV, Rando	m, 95% CI
Arzeno et al., 2019	9.2	4.826363	45	6.3	3.06528	47	45.9%	2.90 [1.24 , 4.56]		-
Masuda 2023	42	25	101	34.1	18.2	186	8.8%	7.90 [2.37, 13.43]		
Santangelo et al., 2023	10.5	5 5	44	6.2	2 3.1	56	45.3%	4.30 [2.61 , 5.99]		-
Total (95% CI)			190)		289	100.0%	3.98 [2.23 , 5.72]		•
Heterogeneity: Tau ² = 1.	01; Chi ² = 3.57	df = 2 (P = 0)).17); l² =	44%						_
Test for overall effect: Z	= 4.46 (P < 0.0	0001)							-10 -5	0 5 10
Test for subgroup differe	nces: Not appli	cable						Favou	irs [experimental]	Favours [control

Figure 8. 30-day readmission

	Stag	jed	San	ne		Odds ratio	Odds	ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI	M-H, Rando	om, 95% CI
Arzeno et al., 2019	1	45	6	47	42.3%	0.16 [0.02 , 1.35]		_
Santangelo et al., 2023	10	44	8	56	57.7%	1.76 [0.63 , 4.93]	_	•
Total (95% CI)		89		103	100.0%	0.63 [0.06 , 6.93]		
Total events:	11		14					
Heterogeneity: Tau ² = 2.	32; Chi ² = 4	4.11, df =	1 (P = 0.04	4); I ² = 76	8%		0.01 0.1	10 100
Test for overall effect: Z	= 0.38 (P =	0.71)					s [experimental]	Favours [control]

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Test for subgroup differences: Not applicable

Figure 9. Reoperation

	Stag	jed	San	ne		Odds ratio	Odds ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI	M-H, Random, 95% CI
Arzeno et al., 2019	5	45	7	47	17.6%	0.71 [0.21 , 2.44]	
Masuda 2023	11	101	19	186	43.1%	1.07 [0.49 , 2.36]	
Santangelo et al., 2023	10	44	. 8	56	25.1%	1.76 [0.63 , 4.93]	
Than 2019	4	27	7	27	14.2%	0.50 [0.13 , 1.95]	
Total (95% CI)		217	,	316	100.0%	1.01 [0.61 , 1.70]	
Total events:	30		41				Ť
Heterogeneity: Tau ² = 0.	00; Chi ² = 2	2.50, df =	3 (P = 0.4	8); I ² = 09	%	(0.01 0.1 1 10 10
Test for overall effect: Z	= 0.06 (P =	0.95)					s [experimental] Favours [conti

Penn Medicine

Test for subgroup differences: Not applicable

Study Limitations

Reduced statistical power of the metaanalysis due to limited literature Limited generalizability of results due to poorly reported continuous variable

Only one group presented patient reported outcomes, such as ODI, which are a standardized clinical variable that can be useful to measure subjective pain and disability.

Potential for bias

Future Goals

Standardize the variables being reported

Additional level I and II Randomized Control Trials should be conducted

Conclusion

OR Time and hospital LOS were significantly lower in Same-Day CF surgery

There are no differences in intra/postoperative, REOP, and READ

EBL and perioperative complications also trending towards significance.

Difficult to conclude whether either Same-Day or Staged CF provides a clinical advantage for patient outcomes.

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