Are we getting better at Achieving Optimal Lumbar Segmental Sagittal Alignment in adult spine deformity surgery?

Tobi Onafowokan, Christopher Ames, Neel Anand¹, Robert Shay Bess, Douglas C Burton², Alan H Daniels³, Bassel Diebo, Robert Kenneth Eastlack, Jonathan Charles Elysee⁴, Jeffrey Gum⁵, Munish C Gupta⁶, D. Kojo Hamilton⁷, Robert A Hart⁸, Richard A Hostin, Khaled M Kebaish⁹, Han Jo Kim, Eric O Klineberg¹⁰, Renaud Lafage¹¹, Virginie Lafage¹¹, Lawrence G Lenke¹², Stephen J Lewis¹³, Breton G Line¹⁴, Jeffrey P Mullin, Praveen Mummaneni, Gregory Michael Mundis, Pierce Dalton Nunley¹⁵, David Okonkwo, Themistocles Stavros Protopsaltis¹⁶, Justin K Scheer¹⁷, Frank J Schwab¹¹, Christopher I Shaffrey¹⁸, Justin S Smith¹⁹, Alexandra Soroceanu, Jay D. Turner²⁰, Juan Santiago Uribe²¹, Michael Y Wang²², Mitsuru Yagi²³, Anthony Yung¹⁸, Max Ray Fisher¹⁸, Jamshaid Mir, International Spine Study Group, Peter Gust Passias¹⁸

¹Cedars Sinai Medical Center, ²Univ of Kansas Med Ctr, ³University Orthopedics, Inc., ⁴Hospital For Special Surgery, ⁵Norton Leatherman Spine Center, ⁶Dept. of Orthopedics, ⁷University of Pittsburgh School of Medicine, ⁸Swedish Neuroscience Institute, ⁹Johns Hopkins University, ¹⁰Uthealth Houston, ¹¹Lenox Hill Hospital, ¹²Columbia University/Allen Hospital, ¹³Tornoto Western Hospital, ¹⁴Denver International Spine Center, ¹⁵Spine Institute Of Louisiana, ¹⁶NYU Hospital For Joint Disorders, ¹⁷University of California, San Francisco, ¹⁸Duke University, ¹⁹University of Virginia, ²⁰Barrow Neurological Institute, ²¹University Of South Florida, ²²University of Miami Miller School of Medicine, ²³Keio University School of Medicine

INTRODUCTION: The understanding of sagittal spine alignment and ASD management continues to advance. However, it remains unknown how these advances have influenced lumbar segmental alignment changes.

METHODS: Patients undergoing primary thoracolumbar fusion for ASD were stratified based on enrolment in two distinct multicenter registries; forming an 'Early cohort' (2009-2018) and a 'Recent cohort' (2019-present). Patients were isolated by the recent dataset's enrolment criteria (T1-pelvic angle \geq 30 or pelvic incidence-lumbar lordosis mismatch \geq 25 or sagittal vertical axis >15cm). Patients were further stratified based on pelvic incidence (PI) and Roussouly type. Segmental alignment was determined based on Pesenti et al's published values of asymptomatic individuals. Pelvic incidence-based alignment and Roussouly-based alignment were determined as per Pesenti et al's and Chung et al's published normative values respectively. Means comparisons tests and multivariate analyses compared segmental & regional parameters between groups.

RESULTS: 1240 patients were reviewed. The mean age was 61.4 ± 14.5 years, the mean body mass index (BMI) was 28.0 ± 5.8 kg/m², and the mean Charlson comorbidity index (CCI) was 1.55 ± 1.70 . 70.2% of patients were female gender. 622 patients formed the early cohort (EARLY), and 618 patients formed the recent cohort (RECENT). At baseline, RECENT had lower BMI (26.8 vs 27.8 kg/m², p<0.002) and lower CCI magnitude (1.00 vs 1.85, p<0.001). In terms of baseline pelvic incidence, EARLY had 20.2% low PI patients, 42.2% average PI patients and 37.7% high PI patients, compared with RECENT which had 24.5% low PI, 43.3% average PI and 32.3% high PI (p=0.029). By Roussouly type, EARLY had 0.2% type 1, 60.3% type 2, 26.8% type 3 and 12.6% type 4 patients, while RECENT had 0.2% type 1, 55.9% type 2, 27.6% type 3 and 16.3% type 4 patients (p=0.417). RECENT consistently displayed better L5-S1 segmental alignment across all pelvic incidence categories and Roussouly types (p=0.001) However, EARLY demonstrated better L4-L5 segmental alignment (p=0.001). These trends in rates of matching L4-L5 and L5-S1 segmental alignment were similarly present when comparing both groups without stratification by pelvic incidence or Roussouly type. Both cohorts demonstrated low rates of matching L4-S1 regional and overall lumbar lordosis L1-S1 alignment, with no differences between both groups. By lordosis distribution index, both groups had predominantly hyperlordotic maldistribution postop, but EARLY had more 'Aligned' patients (15.9 vs 11%, p<0.001).

DISCUSSION AND CONCLUSION: Over the past 15 years, ASD surgeons are better at restoring ASD patients' ideal L5-S1 segmental sagittal alignment. However, achieving optimal L4-5 and more cephalad lumbar sagittal alignment has not increased accordingly. Thus, opportunity still exists for improvements in these critical measures

	Cohort	L4-5	L5-S1	L1-81	L4-8
Low PI (<45)	Early, %	27.7	33.1	0.5	1.5
	Recent, %	19.4	40.0	0.4	0.4
	Sig.	0.001	0.017	0.805	0.067
Average PI (45-60)	Early, %	21.5	33.7	0	0.3
	Recent, %	13.8	40.2	0	0.2
	Sig.	< 0.001	0.026		0.672
High PI (>60)	Early, %	24.2	41.4	0	1.5
	Recent, %	16.4	51.0	0	0.4
	Sig.	0.001	0.001		0.067

	Cohort	L4-5	L5-S1	L1-S1	L4-51
Roussouly Type 1	Early, %	23.5	17.2	0.3	0
	Recent, %	17.6	25.0	0.3	0.2
	Sig.	0.016	0.001	0.995	0.316
Roussouly Type 2	Early, %	25.9	15.9	0	0.8
	Recent, %	20.8	23.6	0	0.2
	Sig.	0.048	0.001		0.103
Roussouly Type 3	Early, %	17.9	14.0	0	0
	Recent, %	11.8	22.8	0	0.2
	Sig.	0.005	<0.001		0.316
Roussouly Type 4	Early, %	16.2	24.9	0	0
	Recent, %	12.0	37.2	0	0.2
	Siz.	0.048	< 0.001		0.316

Rates of matching segmental alignment post-operatively before PI/ Roussouly-stratification

Parameter	Early	Recent	
L4-L5	50.9%	36.6%	<0.001
L5-S1	71.1%	78.8%	0.004
L4-S1	42.1%	24.0%	<0.001
Surgical Approach	Early	Recent	Sig
ALIE	27.76/	01.00/	0.040
	21.176	21.070	0.018
TLIF/ PLIF	18.2%	7.4%	<0.001