Thoracic Compensation After Pediatric Lumbar Spinal Fusion: Adaptions in the Sagittal Plane

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INTRODUCTION:

Optimizing the sagittal plane is associated with improved outcomes, lower complications, and improved pain after spinal surgery. Sagittal plane spinal adaptations after thoracic or complete spinal fusion are established predictors of these outcomes. However, these changes after isolated lumbar fusion for pediatric idiopathic scoliosis are unknown. Understanding how the sagittal plane compensates after surgery will allow surgeons to optimize their surgical technique leading to an improved sagittal plane. This study aims to determine the thoracic compensation and the change in other sagittal plane variables after isolated lumbar fusion, shedding light on a critically important and currently underrepresented segment of spine surgery.

METHODS:

Pediatric patients age <18 with idiopathic scoliosis with lumbar major patterns that underwent isolated lumbar fusion (UIV T10 or below) were retrospectively reviewed. Spinal radiographs were reviewed at 3 timepoints: pre-operative, 6 weeks post-operative, and 2 years post-operative to assess sagittal-plane parameters (C2-C7, T2-T5, T5-T10, T5-T12 T10-L2, L1-S1, SVA (mm), C2Tilt, C2PA, T4PA, T9PA, L1PA, Sacral Slope, Pelvic Tilt, Pelvic Incidence, and UIV- Junctional Angle). Linear mixed effect analysis was used to identify differences across these timepoints (significance $p<0.05$). Regression analysis was used to identify pre- and peri-operative predictors of select variables representing thoracic and lumbar curvature (T5-T10, T5-T12 T10-L2, L1-S1).

RESULTS:

45 consecutive patients with idiopathic scoliosis patients were included. The median age was 15 (range 11-18). The thoracic spine became significantly more kyphotic after lumbar surgery (M diff. pre-op to 2 years T5-T10 = 4.7°, $p<0.05$). Additionally, the lumbar segments became increasingly more lordotic after surgery (M diff. L1-S1 pre-op to 2 years = -5.6°, $p<0.05$). L1-Pelvic angle increased in magnitude 6 weeks after surgery (M = 4.5°, $p<0.05$). Other measures of sagittal plane alignment were not different after 2 years of follow-up. Age and number of fused segments did not associate ($r = -0.07$, and $r = 0.02$ respectively) with significant increases in thoracic or lumbar change post-operatively.

DISCUSSION AND CONCLUSION:

Isolated lumbar fusion for pediatric idiopathic scoliosis is associated with significant sagittal plane adaptions. Specifically, the thoracic spine becomes more kyphotic, and the lumbar region becomes more lordotic. These effects are independent of the amount of fusion and age at surgery and become pronounced in patients with low sagittal-plane pre-operative curvature. Anticipating these adaptions will help guide surgical planning and allow for optimizing the sagittal plane.

Figure 1.

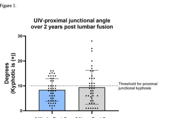

Figure 1: The mean and standard deviation for UIV-proximal junctional angle, threshold for proximal junctional kyphosis marked.

Figure 2.

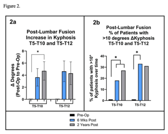

Figure 2: (a) Post-lumbar fusion thoracic change over time, measured by the T5-T10 and T5-T12 sagittal angles. (b) Percent of patients who experience >10° of kyphosis at each time point.

Figure 3.

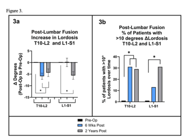

Figure 3: (a) Post-lumbar fusion lumbar change over time, measured by the T10-L1 and L1-S1 sagittal angles. (b) Percent of patients who experience >10° of lordosis at each time point.

Figure 4.

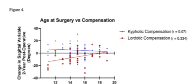

Figure 4: Age at surgery relative to degree of thoracic kyphotic (blue) or lumbar lordotic (red) compensation.

Figure 5.

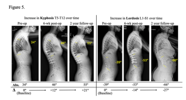

Figure 5: Representative examples of sagittal plane thoracic and lumbar changes over time.

Table 1: Mean values for each sagittal plane measurement across all 3 timepoints, along with the differences and significance of each post-operative timepoint relative to pre-operative values. Significant values are bolded, based on a p<0.05.

	C2-C7	T2-T5	T5-T10	T5-T12	T10-L2	L1-S1	SVA (mm)	C2 Tilt	C2PA	T4PA	T9PA	L1PA	Sacral Slope	Pelvic Tilt	Pelvic Incidence
Pre-Operative Measurement (°)	8	14.8	19.4	24.1	8.9	-53.7	-15.5	11.5	7.9	2.5	0.5	2.1	38.3	9.1	47.4
6 Week Post-Operative Measurement (°)	8.6	14.9	23.1	28.7	3	-53.6	-11.6	9.4	10.9	4.9	3.1	6.6	35.9	12.7	48.7
2 Year Post-Operative Measurement (°)	7.7	13.9	24.1	28.4	4.5	-59.3	-23.2	11.2	6.1	0.9	-0.1	3.4	40.8	8.2	48.9
Difference between 6 Week and Pre-Op	0.6	0.1	3.6	4.6	-5.9	0.1	3.9	-2.1	2.9	2.4	2.6	4.5	-2.3	3.6	1.3
p-value of above difference	0.80	0.96	0.10	0.09	**0.001**	0.98	0.64	0.26	0.18	0.20	0.13	**0.004**	0.17	0.07	0.60
Difference between 2 Year and Pre-Op	-0.3	-1.0	4.7	4.3	-4.4	-5.6	-7.8	-0.3	-1.8	-1.6	-0.6	1.2	2.5	-1.0	1.5
p-value of above difference	0.87	0.54	**0.05**	0.14	**0.02**	**0.04**	0.29	0.86	0.35	0.33	0.70	0.35	0.15	0.58	0.50