Risk Factors of Proximal Junctional Kyphosis in Pediatric Patients Undergoing Posterior Spinal Fusion after Halo Gravity Traction

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BACKGROUND

Proximal Junctional Kyphosis (PJK) is a complication after long level posterior spinal fusion (PSF) and has been defined as "a proximal junctional sagittal Cobb angle (UIV+2); between the lower end plate of the upper instrumented vertebra (UIV) and the upper end plate of the two supra-adjacent vertebrae of ≥10° and at least 10° greater than the preoperative measurement". PJK has been estimated to have an incidence of 0% to 55% in the pediatric population. PJK mostly likely has multifactorial etiology with several contributing risk factors, but there is lack of literature characterizing the relationship between Halo Gravity Traction (HGT) and PJK after PSF, suggesting this study is novel. HGT is routinely used peri-operatively to reduce curve magnitude. This study aimed to identify risk factors of PJK in patients undergoing PSF after HGT.

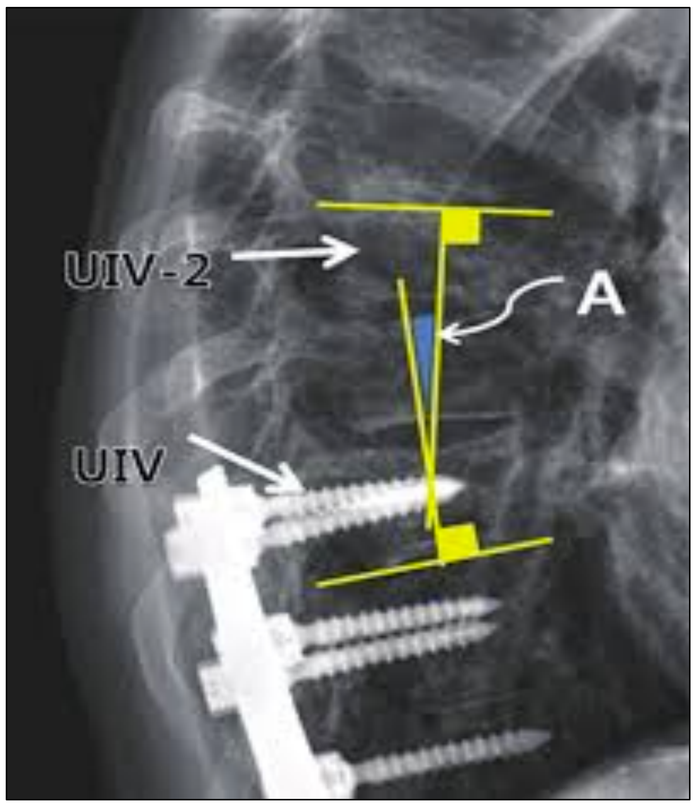

Figure 1: UIV+2 Radiographic Measurement

METHODS

Data were retrospectively collected from a single-center cohort of 25 consecutive patients (16 girls and 9 boys) receiving posterior spinal fusion after halo gravity traction between January 2008 and June 2018 with a minimum of two-year-follow-up. Radiographic data, operative notes, clinical progress documentation, neuromonitoring reports, and anesthesia notes were reviewed for all patients. Radiographic data were collected at four seminal time points including pre-traction, mid-traction(just prior to surgery), postoperative, and last follow-up. Measured radiographic parameters included primary coronal curve magnitude, C2/C7 coronal sagittal (SVA) translations, cervical lordosis, thoracic kyphosis, and lumbar lordosis. 3 vertebral levels of interest were identified: Upper Instrumented Vertebrae (UIV), Upper End Vertebrae (UEV; level most angled from horizontal), and Most Level Vertebrae (MLV; level most parallel to the horizontal). Translational SVA and slope from horizontal were measured for each of these three levels. Binary correlational models and student's t-tests were employed for analysis using IBM SPSS software.

	Pre-Traction to Traction Interval			Traction to Post-Operative Interval			Post-Operative to Last Follow Up Interval		
Variable	No PJK (mean±SD)	PJK (mean±SD)	Significance	No PJK (mean±SD)	PJK (mean±SD)	Significance	No PJK (mean±SD)	PJK (mean±SD)	Significance
Δ UIV Slope (°)	-4.43 ± 7.50	-10.14 ± 19.95	0.349	-0.52 ±14.19	-0.38 ± 12.47	0.984	-1.25 ± 7.29	-1.66 ± 5.28	0.890
Δ UIV SVA (mm)	-2.23 ± 23.97	-2.92 ± 21.56	0.955	14.34 ±35.13	-1.83 ± 39.45	0.368	-21.56 ± 33.15	-43.94 ± 39.30	0.168
Δ UIV+2 (°)	2.09 ± 7.25	-5.79 ± 18.69	0.177	6.77 ±16.64	6.72 ± 10.53	0.995	0.53 ± 18.64	11.16 ± 13.22	0.162
Δ Most Level Vertebrae Slope (°)	-1.12 ± 6.06	-12.83 ± 12.29	**0.008**	2.60 ±10.24	1.10 ± 5.69	0.742	0.67 ± 6.73	0.20 ± 6.52	0.871
Δ Most Level Vertebrae SVA (mm)	-0.01 ± 40.44	4.42 ± 24.10	0.882	9.75 ± 47.21	-11.25 ± 43.79	0.36	-17.85 ± 43.75	-37.44 ± 44.36	0.331
Δ Upper End Vertebrae Slope (°)	-6.12 ±10.33	-7.65 ± 18.60	0.811	2.23 ±15.05	-7.16 ± 16.28	0.221	-3.09 ± 4.97	2.69 ± 6.31	**0.020**
Δ Upper End Vertebrae SVA (mm)	0.06 ± 26.33	-9.39 ± 29.33	0.856	20.13 ±37.87	15.22 ± 40.29	0.795	-27.98 ± 44.40	-39.22 ± 35.71	0.559
Δ C2 SVA (mm)	-12.81 ± 34.22	-28.80 ± 40.49	0.444	35.44 ± 35.77	9.90 ± 28.21	0.143	-26.06 ± 39.71	-44.74 ± 44.45	0.334
Δ C7 SVA (mm)	-2.39 ± 28.94	-10.81 ± 29.53	0.619	19.61 ±37.02	5.60 ± 37.84	0.451	-24.79 ± 44.13	-44.54 ± 43.60	0.328
Δ Major Coronal Curve (°)	-14.88 ± 14.90	-25.20 ± 33.59	0.332	-38.44 ±13.15	-25.11 ± 27.76	0.145	0.37 ± 4.26	-0.10 ± 3.59	0.792
Δ Cervical Lordosis (°)	3.50 ± 13.03	-13.99 ± 15.60	**0.031**	8.38 ±15.99	-18.31 ± 25.11	**0.012**	-14.57 ± 19.84	5.41 ± 24.09	0.053
Δ Thoracic Kyphosis(°)	-6.82 ± 12.27	39.51 ± 24.37	0.154	-4.62 ±16.13	-56.98 ± 21.92	0.342	2.14 ± 7.06	1.95 ± 6.67	0.949
Δ Lumbar Lordosis (°)	-5.38 ± 10.84	-6.51 ± 14.73	0.846	-4.37 ±12.37	7.16 ± 9.04	0.053	4.71 ± 10.89	2.86 ± 8.58	0.693

RESULTS

25 patients were identified (16F: 9M) with a mean age of 13.6 ± 3.1 years. Patients received HGT for 42 ± 37 days. 8 (32%) patients developed radiographic PJK and 1 (4%) developed proximal junctional failure requiring revision surgery. The most common diagnosis was AIS (84%), followed by neuromuscular (12%) and congenital scoliosis (4%). Patients who developed PJK had a greater decrease in the slope of the MLV($p<0.01$) and greater loss of cervical lordosis ($p<0.05$) during traction. Overall, the PJK group had a continued decrease in cervical lordosis from pre-op to in-traction to post-op ($p<0.05$). The pre-traction UEV levelled more in the PJK group from pre-operative to post-operative (-16.3 ± 14.4° vs -3.6 ± 12.8°, $p<0.05$) but then increased in the PJK group from post-operative to last follow up (2.7 ± 6.3° vs -3.1 ± 5.0°, $p<0.05$). Selection of UIV based on which vertebra were most level either pre-traction or in traction, in addition to positioning of UEV and MLV relative to UIV, were not associated with PJK development ($p>0.05$).

CONCLUSIONS

We sought to investigate factors associated with PJK in patients having undergone halo-gravity traction prior to spinal fusions. 8 of 25 (32%) patients developed radiographic PJK and 1 (4%) patient had proximal junctional failure requiring revision surgery. In-traction radiographic changes of decreased cervical lordosis and decreased slope of the most level vertebra, as well as post-operative changes in increased levelling of the upper end vertebra were associated with developing the PJK group. These findings may have implications for level selection and risk of PJK development in this cohort.

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