Elevated Postoperative T1 Slope is Reflective of Poor Surgical Correction of Cervical Deformity

Themistocles Stavros Protopsaltis, Akil Saivenkat Paturi[1], Fares Ani, Alexandra N Yiachos, Robert Kenneth Eastlack, Justin S Smith, D. Kojo Hamilton, Han Jo Kim, Eric O Klineberg, Peter Gust Passias, Robert Shay Bess, Christopher I Shaffrey, Frank J Schwab, Virginie Lafage, Christopher Ames, International Spine Study Group
[1]Orthopedic Spine

INTRODUCTION: High T1S is a marker of underlying thoracolumbar deformity. T1S has been proposed as a parameter to determine the cervical lordosis necessary in CD corrections. A high preoperative T1 slope is a risk factor for poor postoperative alignment. Few studies have focused on outcomes from changes in T1 slope after CD surgery.

METHODS: CD patients were classified as increased or decreased T1S following surgical correction. Preoperative and postoperative radiographic parameters, including in-construct angles (C2-T4 sagittal angle, C2-T10 sagittal angle), were analyzed with surgical data such as the use of 3COs, approach and fusion levels. A sub-analysis of patients with low, medium and high preoperative T1S (<24, 24-39, >40) was performed. Health-related quality of life was assessed using the NDI, mJOA, and EQ-5D. Chi-square and ANOVA analyses were used with a significance set at $p<0.05$.

RESULTS: Of the 106 patients included, 27(25.5%) experienced reduced T1S, while 79(74.5%) had increased T1S at one year postoperatively. Patients with reduced T1S had greater baseline deformity (cSVA, C2 slope, CTPA, in-construct angles, all $p<0.05$), longer fusions ($p=0.001$), more 3CO utilization ($p=0.005$), greater postoperative corrections by in-construct angles (change in C2T4 SA and C2T10 SA, $p<0.001$) and better postoperative alignment by C2-T10 SA ($p<0.05$). Patients who had longer fusions with all posterior approach and LIV below T2 had the largest decrease in T1S. In the subanalysis, as the T1S increased, there was worse baseline and postoperative cervical alignment by cSVA, C2Slope, CTPA (all $p<0.001$) and thoracolumbar alignment by C2PA ($p<0.05$). High T1S patients had less improvement in NDI than low and mid T1S (-4.99 vs -13.9 and -13.8, $p<0.05$).

DISCUSSION AND CONCLUSION: T1 slope is an important parameter in cervical deformity correction. Improvement in T1S correlated with larger corrections and better postoperative alignment. Worsening T1S resulted from insufficient corrections. Patients with high baseline T1S had worse baseline and postoperative cervical and thoracolumbar alignment and less improvement in NDI, demonstrating the clinical impact of the parameter.

Table 1. Main Cohort

Measurement Units	Reduced T1S (n=27)	Increased T1S (n=79)	P-Value
Cervical Parameters			
Preoperative cSVA (mm)	48.71 ± 19.22	34.40 ± 18.43	<0.001
1-Year cSVA (mm)	46.05 ± 15.47	38.39 ± 17.60	0.054
Δ cSVA (mm)	-14.15 ± 14.53	-2.57 ± 17.57	0.035
Preoperative C2 Slope (°)	45.77 ± 26.56	34.60 ± 18.85	0.017
1-Year C2 Slope (°)	29.73 ± 13.72	27.21 ± 12.99	0.491
Δ C2 Slope (°)	-16.04 ± 23.26	-7.39 ± 17.71	0.042
Preoperative C2-T10 Pelvic Angle (°)	14.95 ± 6.50	11.48 ± 5.04	<0.001
1-Year C2-T10 Pelvic Angle (°)	13.75 ± 5.99	13.27 ± 5.77	0.722
Δ C2-T10 Pelvic Angle (°)	-0.77 ± 3.82	1.65 ± 3.54	<0.001
Preoperative T1 Slope(°)	47.69 ± 15.55	24.85 ± 13.49	<0.001
1-Year T1 Slope (°)	37.05 ± 14.99	37.02 ± 14.82	0.994
Δ T1 Slope (°)	-10.64 ± 8.36	12.17 ± 8.35	<0.001
In-Construct Angles			
Preoperative C2–T4 Sagittal Angle	20.14 ± 14.82	4.66 ± 12.08	<0.001
1-Year C2–T4 Sagittal Angle	6.19 ± 9.89	1.55 ± 9.43	0.038
Δ1-Year C2–T4 Sagittal Angle	-13.29 ± 13.70	-2.98 ± 11.15	<0.001
Preoperative C2–T10 Sagittal Angle	33.74 ± 15.42	21.15 ± 12.02	<0.001
1-Year C2–T10 Sagittal Angle	27.85 ± 11.50	22.97 ± 10.20	0.047
Δ1-Year C2–T10 Sagittal Angle	-5.64 ± 10.92	1.14 ± 7.36	0.001
Surgical Characteristics			
Number of Levels fused	4.81 ± 6.48	1.75 ± 2.99	0.001
3CO	9(32.1%)	8(9.8%)	0.005

Table 2. Tertile groups

Measurements	Low T1S	Mid T1S	High T1S	P-Value
Preoperative cSVA (mm)	23.02 ± 13.01	41.32 ± 18.37	56.93 ± 11.39	<0.001
1-Year cSVA (mm)	27.52 ± 16.08	44.62 ± 14.90	51.38 ± 13.16	<0.001
Δ cSVA (mm)	1.67 ± 13.64	-5.63 ± 21.24	-16.18 ± 14.42	<0.001
Preoperative C2 Slope (°)	27.77 ± 14.10	36.94 ± 18.42	53.34 ± 22.19	<0.001
1-Year C2 Slope (°)	21.03 ± 10.14	29.44 ± 14.08	34.13 ± 12.14	<0.001
Δ C2 Slope (°)	-5.89 ± 14.03	-5.61 ± 18.90	-20.18 ± 23.44	0.001
Δ NDI Score	-13.92 ± 19.34	-13.77 ± 16.87	4.99 ± 12.95	0.033