T1 Slope Minus Cervical Lordosis (TS-CL), the Cervical Analog of PI-LL Defines Cervical Sagittal Deformity in Patients Undergoing Thoracolumbar Osteotomy

Themistocles S. Protopsaltis, MD, New York, New York
Jamie S. Terran, BS, New York, New York
Nicolas Bronsard, MD, Nice, France
Justin S. Smith, MD, PhD, Charlottesville, Virginia
Eric O. Klineberg, MD, Sacramento, California
Gregory Mundis, MD, La Jolla, California
Han Jo Kim, MD, New York, New York
Robert A. Hart, MD, Portland, Oregon
Christopher I. Shaffrey, MD, Charlottesville, Virginia
Shay Bess, MD, Denver, Colorado
Christopher P. Ames, MD, San Francisco, California
Frank J. Schwab, MD, New York, New York
Virginie Lafage, PhD, New York, New York
International Spine Study Group, NA, Brighton, Colorado

Introduction: C2-C7 plumbline (CPL) is an established descriptor of cervical sagittal deformity (CSD) and CPL>4cm is associated with poor HRQOL. However, reciprocal change in CPL has been demonstrated in patients undergoing thoracolumbar deformity (TLD) correction. We utilized the T1 Slope minus cervical lordosis (TS-CL), the cervical analog to PI-LL (Figure 1), to define cervical sagittal deformity after TLD lumbar PSO to differentiate patients with reciprocal change and those with CSD. We also introduce a novel global sagittal angular parameter, the Cervical-Thoracic Pelvic Angle (CTPA) that quantifies cervical sagittal balance (Figure 2). The purpose of this study was to investigate the development of CSD utilizing TS-CL to define cervical sagittal deformity and to identify factors contributing to CSD following PSO. We further correlate TS-CL and CTPA with CPL.

Methods: Multicenter, retrospective, analysis of consecutive TLD patients undergoing PSO. Preoperative and postoperative radiographic parameters of cervical sagittal balance were investigated. Since global sagittal correction decreases reciprocal cervical sagittal malalignment, postoperative values were utilized in a linear regression analysis to determine that CPL of 4cm corresponds to a TS-CL threshold of 17 deg. Patients were classified into those with cervical sagittal deformity (CSD: TS-CL>17) or those with reciprocal sagittal alignment (RSA: TS-CL<17).

Results: 166 TLD patients (mean age 59.1) were identified. CTPA correlated with CPL (preop r=.85, postop r=.91). TS-CL correlated with CTPA (preop r=.53, postop r=.47) and CPL (preop r=.57; postop r=.48). CSD had greater preoperative CPL (4.5 vs. 3.4 p<0.001) and CTPA (3.4 vs. 2.3 p<0.001) and greater 1year CPL (4.7 vs. 3.2 p<0.001) and CTPA (4.3 vs. 2.9 p<0.001). RSA patients had a decrease in TS-CL (10.2 to 8.0) with SVA correction whereas CSD patients had an increase in TS-CL (22.3 to 26.8) with all p<0.001. Reciprocal change was demonstrated in RSA as CL decreased with SVA correction (r=.39) but there was no such correlation in CSD. Using linear regression analysis, UIV above T4 and preop TS-CL mismatch were identified as risk factors for postoperative CSD.
Conclusions: Risk factors for developing cervical sagittal deformity in TLD patients undergoing PSO included preop TS-CL mismatch and UIV above T4. The latter may result from disruption of the cervical paraspinal muscle attachments to the upper thoracic spine during exposure and instrumentation. CTPA correlated strongly with established sagittal balance measures. While reciprocal change in cervical and thoracolumbar alignment was demonstrated in RSA patients, CSD patients had progression of their cervical deformities after lumbar PSO.

Figure 1. Representative thoracolumbar deformity patient after PSO with UIV above T4 who developed cervical sagittal deformity. T1 Slope minus cervical lordosis (TS-CL) is 72 deg.

Figure 2. CTPA is a global angular measure of cervical sagittal balance and a correlate of C2C7 plumpline. CTPA is the angle of a line from center of C2 to femoral heads (FH) and a line from FH to center of T1. CPA is a measure of global sagittal balance and a correlate of C2S1 plumpline.

- The FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an “off label” use). See inside back cover for full information.