Characterization of Distribution of Segmental Changes in Cervical Alignment After Lumbar Pedicle Subtraction Osteotomy

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Introduction

Adult spinal deformity (ASD) patients with positive sagittal malalignment develop compensatory cervical hyperlordosis to maintain horizontal gaze, which spontaneous improves following lumbar PSO. We sought to characterize the segmental distribution and characteristics of these reciprocal changes in a similar patient group.

Methods

Change in cervical radiographic measures from baseline to 6 weeks postop in 27 patients who underwent lumbar PSO for correction of sagittal malalignment was assessed. Parameters included: C2-7 sagittal vertical axis (C2-7 SVA), C2-S1 SVA, C7-S1 SVA, pelvic incidence-lumbar lordosis mismatch (PI-LL) pelvic tilt (PT) and T1 and T9 spino-pelvic inclination (SPI). The cobb method was used for: occiput(C0)-C2, C2-T1, C2-C7. Harrison method for: Segmental angles between C2-T1. Vertebral body slopes were measured at the occiput (C0S), axis (C2S), T1 (T1S) and S1 (SS).

Results

All thoracolumbar parameters significantly improved to below established alignment thresholds: C2-S1 SVA (146/47mm), C7-S1 SVA (119/17mm), PI-LL (34.9/1.3 deg), PT (30.2/19.7 deg) ($p<0.001$). C2-7 SVA did not significantly change. Mean cervical lordosis (C2-7) decreased (19.9-14.1,$p=0.05$, range 27.4, -40.9). Majority of the reciprocal decrease in C2-7 occurred at C3-4 (59.1%) and C4-5 (27.2%, Figure) with little at C5/6 (13.6%) and none at C6/7. Mean lordosis increased 1 deg at C2/3. There was an additional 1.3 deg decrease at C7-T1, accounting for 16.5% of the total decrease in C2-T1 angle (-6.9 deg). The C0-C2 angle increased 1.6 degrees. C2S and SS increased 5.8 and 10.3 deg, respectively ($p<0.005$) whereas C0S and T1S did not change significantly.

Segmental changes in cervical alignment after lumbar pedicle subtraction osteotomy

Segment (s)	Mean	Max	Min	Range	Segmental % of decrease in angle from C2-7	Segmental % of decrease in angle from C2-T1
C2-T1	-6.9	27.4	-40.9	68.2	-	**100**
C2-7	-5.6	29.0	-40.0	69.0	**100**	**70.9**
C2-3	1.0	15.8	-23.3	39.1	-	-
C3-4	-3.9	12.0	-16.8	28.9	**59.1**	**49.4**
C4-5	-1.8	9.6	-16.7	26.3	**27.2**	**22.8**
C5-6	-0.9	16.9	-14.3	31.2	**13.6**	**11.4**
C6-7	0.0	13.0	-11.5	24.5	**0**	**0**
C7-T1	-1.3	16.0	-30.3	46.3	-	**16.5**

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Conclusions

Following successful correction of positive sagittal malalignment, reciprocal changes in cervical alignment ensue. The majority of relaxation in hyper-lordosis occurs at C3-4 and C4-5. The angle between the occiput and C2 increased slightly to maintain head balance in response to decreased subaxial lordosis.

Learning Objectives

By the conclusion of this session, participants should be able to:

- 1) understand reciprocal cervical changes after lumbar PSO,
- 2) look for relaxation in hyper-lordosis at C3-4 and C4-5, and
- 3) take into account the angle between the occiput and C2 to understand changes in compensatory mechanisms.