Cross-sectional-area of Deep Extensor Muscles at C2-C3 is Correlated with Sagittal Alignment of the Cervical Spine

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Introduction

- Appropriate sagittal alignment of cervical spine is crucial for essential functions, including mastication, breathing, phonation, shock absorption when walking
- While optimal degree of cervical lordosis (CL) remains variable, kyphotic change is known to be associated with chronic neck pain
- Two-line Cobb method between C2-C7 is a proxy for cervical sagittal alignment
  - Studies have shown that a greater difference between the angles measured in flexion versus extension is an indicator of loss of CL
- Using this method, we examined the association between sagittal alignment and cervical spine muscle health
  - Aim was to determine if muscle preservation or strengthening can aid in preventing kyphotic deformity and its associated repercussions

Methods

- Retrospective cohort study using patients of a single surgeon at a NY health system
- Patients included if available cervical spine MRI and flexion/extension range-of-motion (ROM) radiographs
- Axial, T2-weighted MRIs used to:
  - Assess Goutallier classification at C2-C3 and C5-C6 disc spaces
  - Measure cross-sectional-area (CSA) of bilateral deep flexor (i.e. longus colli and longus capitis) and deep extensor (i.e. semispinalis cervicis and multifidus) muscles at C2-C3 and C5-C6 disc spaces
- Using lateral x-rays taken in flexion and extension, we measured Cobb angle between the C2 and C7 inferior endplates
  - Primary outcome, the flexion-extension gap (gROM), was the difference between the two angles
- Univariate analysis: Student's t-tests, Pearson's correlations, Spearman's correlations
- Multivariate analysis: Linear regression model

Results

- 61 patients, mean gROM of 19.4°
- Age, sex, race, ethnicity, BMI, and Goutallier classification had no statistically significant impact on gROM
- CSA of the deep extensors at C2-C3 was significantly correlated with gROM, with a correlation coefficient of -0.301 ($p = 0.018$)
- Controlling for demographic factors and BMI, multivariate analysis demonstrated that neither muscle CSA nor Goutallier classification were significant predictors of gROM

Table 1. Patient sample characteristics and radiograph measurements	
	N=61
Demographics and BMI	***N* (%)**
Age (years), mean ± SD	53.6 ± 15.1
Female sex	38 (62.3%)
White race	31 (57.4%)
Hispanic ethnicity	6 (11.1%)
BMI, mean ± SD	27.9 ± 6.2
Muscle Cross-sectional-area	**mean ± SD**
C2-C3 Deep Flexors CSA	192.95 ± 74.78
C2-C3 Deep Extensors CSA	400.06 ± 242.53
C5-C6 Deep Flexors CSA	144.74 ± 59.44
C5-C6 Deep Extensors CSA	477.68 ± 259.47
Goutallier Classification	***N* (%)**
C2-C3 Disc Space	
Grade 0	12 (19.7%)
Grade 1	21 (34.4%)
Grade 2	19 (31.1%)
Grade 3	7 (11.5%)
Grade 4	2 (3.3%)
C5-C6 Disc Space	
Grade 0	15 (24.6%)
Grade 1	27 (44.3%)
Grade 2	18 (29.5%)
Grade 3	1 (1.6%)
Grade 4	0 (0.0%)
Lateral Flexion/Extension X-rays	**mean ± SD**
Flexion ROM Cobb Angle	19.2 ± 12.9
Extension ROM Cobb Angle	24.9 ± 14.7
Flexion-Extension Gap (gROM)	19.4 ± 11.0
Bold values indicate statistical significance ($p<0.05$). SD, standard deviation. BMI, body mass index.	

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Table 2. Univariate analysis assessing correlation with cervical flexion-extension gap		
Demographics and BMI	**Mean difference ± SE**	***p*-value**
Age (Correlation Coefficient, 95% CI)	0.041 (-0.213, 0.290)	0.752
Female sex	-4.180 ± 2.878	0.152
White race	-3.727 ± 3.000	0.220
Hispanic ethnicity	3.643 ± 4.824	0.453
BMI (Correlation Coefficient, 95% CI)	-0.168 (-0.403, 0.088)	0.196
Muscle Cross-sectional-area	**Pearson Correlation Coefficient (95% CI)**	***p*-value**
C2-C3 Deep Flexors	-0.137 (-0.376, 0.119)	0.294
C2-C3 Deep Extensors	-0.301 (-0.514, -0.054)	**0.018**
C5-C6 Deep Flexors	-0.003 (-0.255, 0.249)	0.981
C5-C6 Deep Extensors	-0.017 (-0.268, 0.236)	0.896
Goutallier Classification	**Spearman Correlation Coefficient (95% CI)**	***p*-value**
C2-C3 Disc Space	0.182 (-0.081, 0.421)	0.161
C5-C6 Disc Space	0.080 (-0.182, 0.332)	0.539
Bold values indicate statistical significance ($p<0.05$). CI, confidence interval. SE, standard error. BMI, body mass index.		

Table 3. Multivariate analysis assessing impact of muscle CSA and Goutallier grade on flexion-extension gap		
Muscle Cross-sectional-area	**Linear Regression Coefficient (95% CI)**	***p*-value**
C2-C3 Deep Flexors	0.011 (-0.044, 0.066)	0.692
C2-C3 Deep Extensors	-0.011 (-0.025, 0.003)	0.114
C5-C6 Deep Flexors	0.040 (-0.017, 0.098)	0.166
C5-C6 Deep Extensors	0.006 (-0.007, 0.018)	0.372
Goutallier Classification		***p*-value**
C2-C3 Disc Space	1.120 (-2.193, 4.432)	0.500
C5-C6 Disc Space	0.500 (-4.043, 5.044)	0.826
Bold values indicate statistical significance ($p<0.05$). CI, confidence interval.		

Conclusion

- Correlation between the CSA of the C2-C3 deep extensors and gROM demonstrates that as CSA increases, gROM decreases
- Suggests that strengthening the semispinalis cervicis and multifidus in the more cranial segments of the cervical spine may be beneficial in preventing or reversing kyphotic change
- This finding also has implications for spine surgeons
  - Preserving the deep musculature in the C2-C3 region during operative intervention may be vital for maintaining optimal sagittal alignment