

Adjacent Segment Cervical Kinematics: The Role of Construct Length, the Dorsal Tension Band and the Thoracic Rib Cage

Andrew T Healy MD; PRASATH Mageswaran; Daniel Lubelski; Richard P. Schlenk MD
Cleveland Clinic Department of Neurosurgery



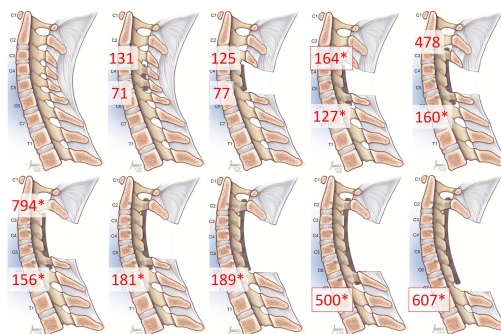
Introduction

Lateral mass fixation stabilizes the cervical spine with minimal morbidity and high fusion rates. With 2-year follow-up, ~6% of posterior cervical fusions have worsening kyphosis or symptomatic adjacent segment disease. We sought to quantify the role of construct length and the interspinous musculature and supraspinous ligaments (ISL) in the adjacent segment kinematics of the subaxial cervical spine.

Methods

In vitro flexibility testing performed on six human cadaveric specimens, C2-T7. An industrial robot was utilized to apply pure moments with measurement of segmental motion at each level. We tested the intact state, followed by nine post-surgical permutations of laminectomy and lateral mass fixation spanning C2-C7 (hybrid model). Tukey-Kramer analysis was utilized for multiple comparisons.

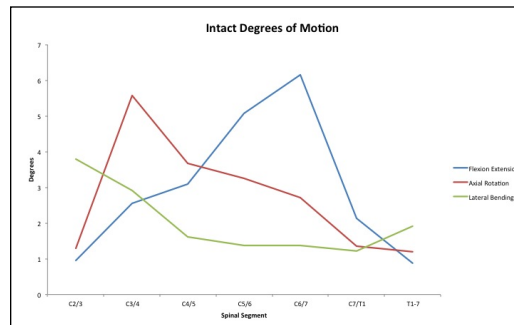
Percent Change in ROM from Native



Surgical conditions A-J with %change in segmental flexion-extension ROM listed at each corresponding level. Asterisk (*) indicates statistical significance ($p < 0.05$) as compared to intact and boxed values are those with statistical difference ($p < 0.05$) as compared to the previous condition.

Results

- Constructs spanning a single level exerted no significant effects on immediately adjacent segment motion ($p > 0.05$)
- The addition of a second immobilized segment, created significant changes in flexion-extension ROM at the supradjacent level (+164%, $p = 0.03$)
- Regardless of construct length, resection of the terminal dorsal ligaments did not greatly affect adjacent level motion except at C2/3 and C7/T1 (+794%, $p = 0.02$ and +607%, $p = 0.01$, respectively).



%Change in Flexion-Extension ROM

Condition	Level	Flexion-Extension						
		C2/3	C3/4	C4/5	C5/6	C6/7	C7/T1	T1-T7
B	p-value*	0.26	0.21	-	0.07	0.02	0.01	0.02
	%Incr	254%	131%	-	71%	117%	136%	146%
	SD	298%	46%	-	31%	12%	19%	35%
	p-value**	0.26	0.21	-	0.07	0.02	0.01	0.02
C	p-value*	0.30	0.26	-	0.10	0.04	0.00	0.02
	%Incr	295%	125%	-	77%	119%	131%	144%
	SD	416%	44%	-	29%	17%	15%	30%
	p-value**			-				
D	p-value*	0.25	0.03	-	-	0.04	0.08	0.02
	%Incr	421%	164%	-	-	127%	199%	200%
	SD	607%	53%	-	-	32%	109%	72%
	p-value**	0.17	0.01	-	-	0.35	0.17	0.04
E	p-value*	0.08	-	-	-	0.01	0.01	0.04
	%Incr	478%	-	-	-	160%	261%	268%
	SD	535%	-	-	-	73%	142%	151%
	p-value**	0.29	-	-	-	0.13	0.13	0.21
F	p-value*	0.02	-	-	-	0.03	0.01	0.05
	%Incr	794%	-	-	-	156%	266%	251%
	SD	1204%	-	-	-	67%	160%	141%
	p-value**	0.31	-	-	-	0.31	0.61	0.12
G	p-value*	-	-	-	-	0.01	0.01	0.13
	%Incr	-	-	-	-	181%	351%	385%
	SD	-	-	-	-	101%	253%	390%
	p-value**	-	-	-	-	0.14	0.12	0.25
H	p-value*	-	-	-	-	0.02	0.01	0.15
	%Incr	-	-	-	-	189%	349%	365%
	SD	-	-	-	-	109%	270%	386%
	p-value**	-	-	-	-	0.10	0.83	0.02
I	p-value*	-	-	-	-	-	0.01	0.02
	%Incr	-	-	-	-	-	500%	707%
	SD	-	-	-	-	-	255%	428%
	p-value**	-	-	-	-	-	0.03	0.00
J	p-value*	-	-	-	-	-	0.01	0.03
	%Incr	-	-	-	-	-	607%	616%
	SD	-	-	-	-	-	318%	428%
	p-value**	-	-	-	-	-	0.02	0.00

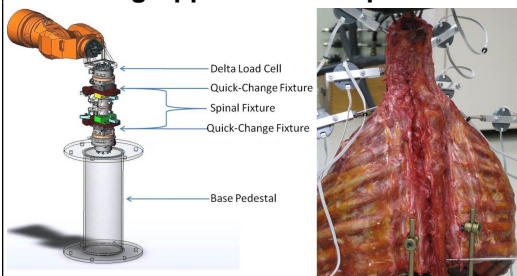
Conclusions

- Construct length was found to significantly increase adjacent level ROM when fixing two or more cervical segments
- All cervical segments experienced ROM increases even when not immediately adjacent to fusion constructs. The C2/3 segment was the most susceptible, followed by C7/T1
- Dorsal elements at terminal ends of a cervical construct contribute the greatest stability to the C2/3 segment, followed by C7/T1. At other subaxial cervical levels, the contribution of these structures was marginal
- Extending constructs to a cervical level with intact dorsal elements counterproductively created significant increases in adjacent segment motion from levels C3/4 to C6/7
- It is important to maintain the C2/3 dorsal ligamentous structures when possible and to always consider C2/3 segment alignment in preoperative planning

References

Sekhon LHS: Posterior cervical decompression and fusion for circumferential spondylotic cervical stenosis: review of 50 consecutive cases. J Clin Neurosci 13:23-30, 2006.

Testing Apparatus and Specimen



Schematic (left). Photograph of specimen C2-T7 loaded with optoelectric sensors in place (right).

Learning Objectives

- 1) Describe the effect of construct length
- 2) Describe the effect of the terminal ISL
- 3) Understand the importance of the C2/3 cervical segment as well as the cervicothoracic junction when considering adjacent segment disease