The Effects of Single Versus Double-Level Arthrodesis on Adjacent Segment Motion 1 Year Post ACDF Surgery

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Introduction

Background

- Over 150,000 anterior cervical discectomy and fusion (ACDF) surgeries are performed each year in the US[1] with 25% of ACDF patients developing symptomatic adjacent segment disease within 10 years of the initial surgery[2].
- Biomechanical testing of cadaver specimens indicates single-level arthrodesis increases adjacent segment stress[3-5], and double-level arthrodesis exacerbates these effects[6-7].
- *In vitro* range of motion (ROM) of the adjacent levels increased after arthrodesis[8].
- ROM can be used to infer the effects of arthrodesis on adjacent segment loading.

Aim

- Determine if the number of fused motion segments affects the fused or adjacent segment ROM *in vivo*.

Hypotheses

- Adjacent segment ROM would increase from pre-surgery (PRE) to one year post surgery (1YR-POST).
- The increase in adjacent segment ROM would be greater after double-level arthrodesis.
- The motion at the operated C5/C6 segment would be greater after double-level arthrodesis compared to single-level.

Methods

Data Collection

- 23 patients who received either C5/C6 (7), C4/C5/C6 (6), or C5/C6/C7 (10) arthrodesis have provided informed consent to participate in this IRB-approved study (12 M, 11 F; average age: 50±5 years).
- Participants performed 3 full flexion/extension trials and 3 axial rotation trials while biplane radiographs were collected both PRE and 1YR-POST (Figure 1).
- CT scans (0.35x0.35x1.25mm) of the cervical spine were acquired for each participant.

Data Processing

- Bone kinematics were obtained using a previously validated volumetric model-based tracking system[9] (Figure 1 E,F).
- Because cervical spine mechanics are level-dependent[10], intervertebral ROM was compared at corresponding adjacent motion segments (Figure 2).

Data Analysis

- Differences from PRE to 1YR-POST were assessed using a Wilcoxon signed-rank test with significance set at $p < 0.05$.
- Differences between groups in the change in adjacent and operated C5/C6 segment ROM were analyzed with Wilcoxon rank-sum test with significance set at $p < 0.05$.

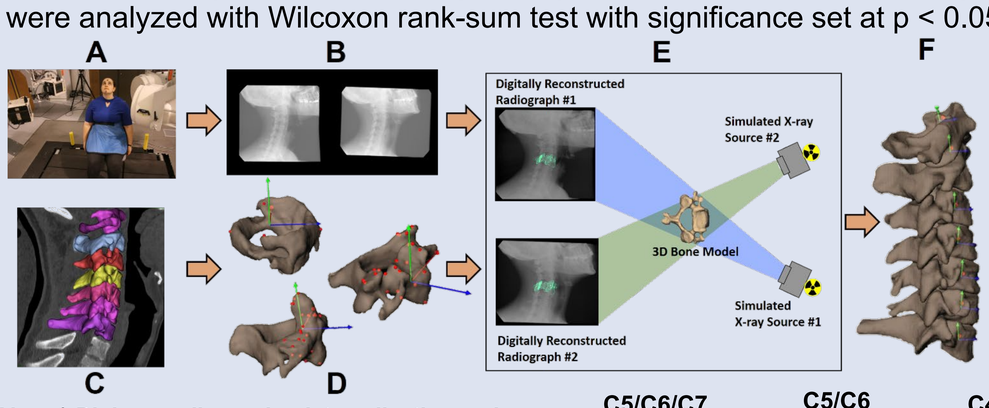

Figure 1: (Above) Biplane radiography data collection and processing. (A) *Participants performed full ROM flexion/extension and axial rotation movements while* ***(B)*** *synchronized biplane radiographs were collected at 30 images per second (70kV, 125mA, 2.5ms pulse width).* ***(C)*** *C1 to C7 CT scans were collected and* ***(D)*** *used to create 3D bone models.* ***(E)*** *3D vertebral kinematics were determined using a validated CT model-based tracking process.* ***(F)*** *Six DOF kinematics were calculated throughout the full ROM.*

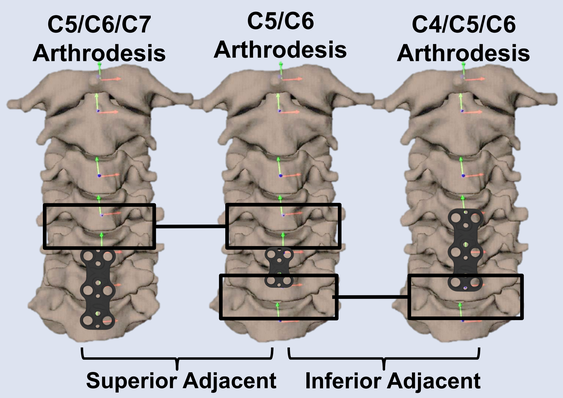

Figure 2: (Right) Corresponding adjacent motion segments. *C4/C5 ROM was evaluated when comparing superior adjacent effects at C5/C6 or C5/C6/C7 arthrodesis, and the C6/C7 ROM was evaluated when comparing inferior adjacent segment effects after C5/C6 or C4/C5/C6 arthrodesis.*

Results

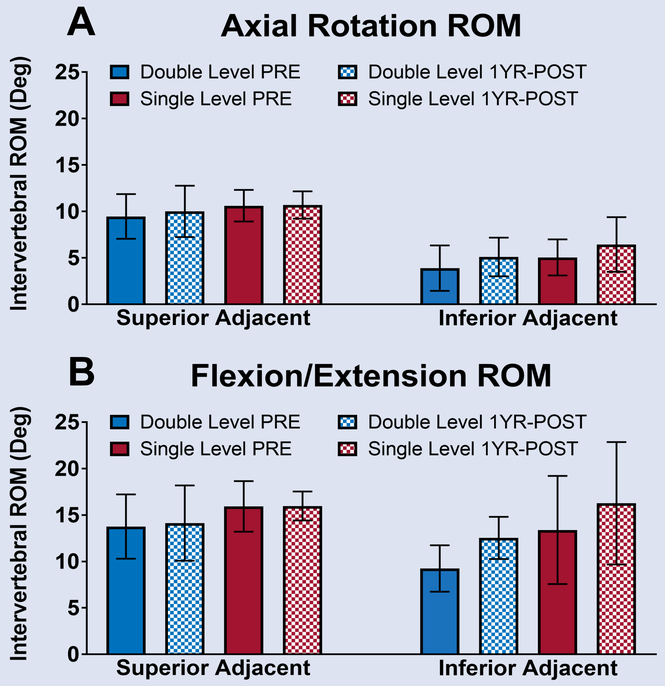

Figure 3: Adjacent level intervertebral ROM pre-surgery and 1 Year Post ACDF surgery. *(A) Adjacent level axial rotation ROM. (B) Adjacent level flexion/extension ROM. Error bars are ± 1 SD.*

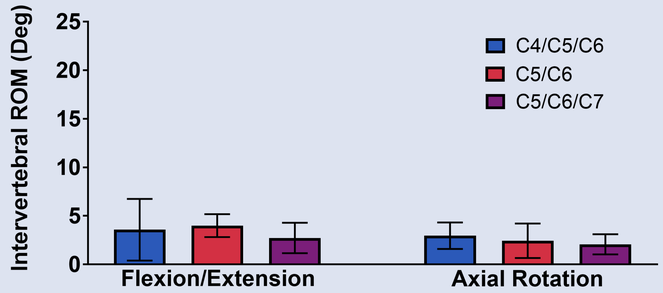

Figure 4: C5/C6 intervertebral ROM 1 Year Post ACDF surgery. *Error bars are ± 1 SD.*

- Adjacent segment ROM increased from PRE to 1YR-POST, though not significantly (all $p > 0.091$) (Figure 3).
- No differences were found in the change in adjacent segment ROM from PRE to 1YR-POST between single and double-level arthrodesis groups (all $p > 0.67$) (Figure 3).
- No differences were found in the amount of motion remaining at the C5/C6 arthrodesis segment between single and double-level arthrodesis groups (all $p > 0.1$) (Figure 4).

Residual C5/C6 Motion

Discussion

- We failed to find a significant change in adjacent segment ROM from pre-surgery to 1 year after surgery in either single or double-level arthrodesis groups.
- We were unable to detect a difference in the change in adjacent segment ROM between single and double-level arthrodesis groups.
- These results contradict the widely-reported increase in adjacent segment motion after arthrodesis based upon cadaveric tests[3-7], suggesting current *in vitro* biomechanical testing fails to replicate the *in vivo* condition[11].
- The **strength** of this study is that corresponding adjacent motion segments were used to compare single and double-level arthrodesis *in vivo*.
- **Limitations** include the small sample size and lack of age-matched controls to provide context for what is excessive motion at the C4/C5 and C6/C7 motion segments.

Clinical Significance

- **Double-level arthrodesis does not appear to increase adjacent segment ROM more than single-level arthrodesis 1 year after ACDF.**

References and Acknowledgements

1. Olgesby et al., *Spine*, 2013. 2. Lawrence et al., *Spine*, 2012. 3. Schwab et al., *Spine*, 2006. 4. Park et al. *Spine,* 2011. 5. Robertson et al., *J Neurosurg Spine*, 2005. 6. Prasarn et al., *J Neurosurg Spine*, 2011. 7. Lopez-Espina, *Spine*, 2006. 8. Cunningham et al. *Spine J*, 2012 9. Anderst, et al., *Spine*, 2011. 10. Anderst et al., *J Biomech*, 2015. 11. Volkheimer et al., *Eur Spine J*, 2015.

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