The Effect of Iatrogenic Factors on Anterior Cervical Discectomy and Fusion Adjacent Segment Kinematics

Richard A. Wawrose, Clarissa M. LeVasseur, Samuel W. Pitcairn, William F. Donaldson, Joon Y. Lee, William J. Anderst

Biodynamics Lab, Department of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh, PA, USA

Biodynamics Lab website: bdl.pitt.edu

Introduction

Background

- Anterior cervical discectomy and fusion (ACDF) remains the standard of surgical care for cervical spondylotic radiculopathy[1].
- Approximately 25% of patients who undergo ACDF will develop adjacent segment disease (ASD), and two-thirds of patients who develop ASD will require reoperation[2].
- The etiology of ASD remains unclear, but it has been theorized it may be prompted by iatrogenic factors[3].

Aim

- Determine the effect iatrogenic factors have on adjacent segment kinematics.

Hypothesis

- Adjacent segment kinematics will be affected by graft height and sagittal alignment at the operated site but not by fusion plate placement or graft type.

***Figure 1**: Post-surgical radiograph of a patient who has undergone ACDF.*

Methods

Data Collection

- 27 participants (13M, 14F; avg. age 49.6 ± 5.3 years; 11 single-level arthrodesis, 16 double-level arthrodesis) were imaged using dynamic biplane radiography before surgery and 1-year after surgery.
- C2-C7 Cobb angle, fusion mass Cobb angle, graft height, and plate placement were measured on 1-year post-op sagittal radiographs. All measures were performed by two observers and inter-rater reliability was very good (κ: 0.89-0.97).

Data Processing

- A validated model-based tracking process[4] was used to match subject-specific bone models derived from CT to the dynamic radiographs (**Figure 2**).
- Intervertebral rotations were calculated using ordered rotations of anatomic coordinate systems created within each vertebra[5].

Data Analysis

- The change in adjacent segment motion during dynamic full ROM movements was compared between autograft (n = 9) and allograft (n = 18) using Student's t-test.
- Pearson's correlation coefficients were calculated to identify relationships between the change in adjacent segment ROM and the following factors: the change in sagittal balance, graft heights, and plate-to-disc distances.
- Results were considered significant if $p < 0.05$.

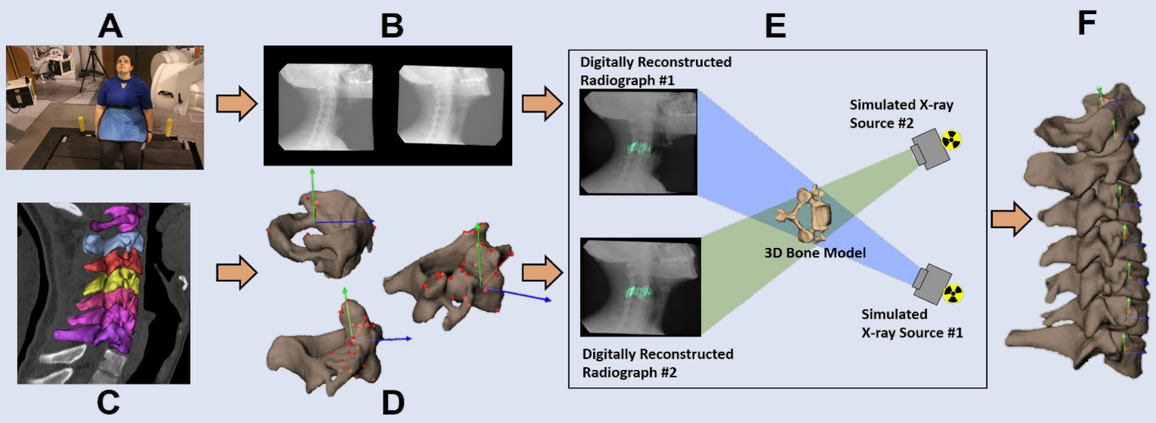

***Figure 2: Biplane radiography data collection and processing. (A)** Participants performed full ROM flexion/extension and axial rotation movements while **(B)** synchronized biplane radiographs were collected at 30 images per second (70kV, 125mA, 2.5ms pulse width). **(C)** C1 to C7 CT scans were collected and **(D)** used to create 3D bone models. **(E)** Bone motion was determined using a validated CT model-based tracking process. **(F)** Six DOF kinematics were calculated throughout the full ROM.*

Results

- **Autograft vs. Allograft:** Patients with autografts demonstrated a greater increase in superior adjacent segment axial rotation ROM than those with allograft ($p = 0.01$) (**Figure 3**). There were no noted differences in the change in inferior adjacent axial rotation or flexion/extension ROM at either the superior or inferior adjacent segment (all $p > 0.64$).

- **Graft Height:** There was a negative relationship between graft height and change in flexion/extension ROM of the inferior adjacent segments, (Pearson's correlation coefficient = -0.566, $p = 0.03$) (**Figure 4**). No other relationships were identified between graft height and change in adjacent segment ROM.

- **Sagittal Balance and Fusion Plate Placement:** There was no significant correlation between sagittal balance or fusion plate placement and change in flexion/extension or axial rotation ROM at either the superior or inferior adjacent segments (all $p > 0.11$).

The Effect of Graft Type on Superior Adjacent ROM during Axial Rotion

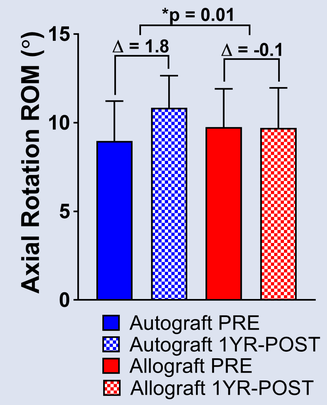

***Figure 3**: Change in superior adjacent segment axial rotation ROM by graft type.*

The Effect of Graft Height on Inferior Adjacent ROM during Flexion/Extension

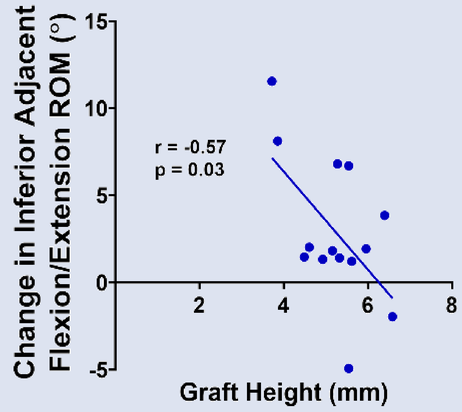

***Figure 4**: Change in inferior adjacent flexion/extension ROM vs. graft height.*

Discussion

- The main findings of this study are that fusion plate placement and change in sagittal balance do not affect adjacent segment flexion/extension or axial rotation range of motion one year after ACDF, but graft height and graft type do affect adjacent segment kinematics .
- **Strengths:** Direct *in vivo* tracking of cervical segments.
- **Weaknesses**: Small sample size and relatively short follow-up.
- **Future Studies:** A larger sample from this ongoing study will be required to increase confidence in these results, and longer follow-up is underway to assess the effects of these iatrogenic factors on the development of ASD.

Clinical Significance

- **Surgeons may be able to personalize several iatrogenic factors based upon surgeon preference and anatomic restrictions without affecting postoperative superior and inferior adjacent segment range of motion.**

References and Acknowledgements

1) Oglesby, M, et al., *Spine,* 2013. 2) Hilibrand, A, et al., *JBJS,* 1999. 3) Anderst, W, et al., *JOR*, 2016. 4) Anderst et al., *Spine,* 2017. 5) Anderst et al. *Med Eng Phys,* 2017.

This work was supported by NIH grant #R01AR069543.

National Institutes of Health