

The Effect of Patient-Specific Factors on Adjacent Segment Range of Motion One Year After Anterior Cervical Discectomy and Fusion

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INTRODUCTION: Increased adjacent segment motion after anterior cervical arthrodesis is believed to develop as a result of overload following arthrodesis, potentially leading to adjacent segment disease and the subsequent need for additional surgery¹. Although biomechanical testing of cadavers consistently demonstrates increased range of motion (ROM) after arthrodesis, recent literature suggests that *in vitro* test paradigms may fail to replicate the *in vivo* condition². Prospective *in vivo* research suggests that adjacent segment motion may increase, decrease or remain unchanged after arthrodesis³. Furthermore, no patient-specific factors have been identified that can predict the change in adjacent segment ROM following arthrodesis. Therefore, the objective of this study was to identify patient-specific factors that may be associated with increased adjacent segment ROM after surgery. We tested the effects of sex, age, BMI, patient-reported pain and function, and ROM at the operated level on the change in adjacent segment ROM from pre to post-surgery.

METHODS: 27 patients provided informed written consent and completed pre-surgical and 1-year post-surgical testing in this IRB-approved study (13 M, 14 F; Average Age: 49.6 ± 5.3 ; Average BMI: 31.7 ± 5.9). 11 patients underwent single-level arthrodesis (1 at C4-C5, 7 at C5-C6, 3 at C6-C7) and 16 underwent two-level arthrodesis (6 at C4-C6, 10 at C5-C7) via standard anterior approach with rigid plate fixation. All participants performed dynamic full ROM flexion/extension (3 trials) while biplane radiographs were collected at 30 images/s for 3 seconds (imaging parameters: 70 kV, 160 mA, 2.5 ms exposure per image) (**Figure 1**). Three-dimensional vertebral motion was determined with sub-millimeter accuracy using a validated tracking process that matched subject-specific bone models from CT to the biplane radiographs.⁴ Based on pre-operative *in vivo* kinematic analysis, patients were grouped into either a Low-Motion Group (ROM at the operated level was more than 1 standard deviation below the average ROM at that motion segment found in a large database of age-matched healthy controls)⁵ or Normal-Motion Group (all other participants). Additionally, patients were also grouped into high and low groups based upon BMI (BMI > 30 or < 30), age (> 50 or < 50 years), preoperative pain (pain score on SF-36 < 30 or > 30), preoperative disability (Neck Disability Index < 50 or > 50), and sex. Changes in intervertebral flexion/extension ROM at motion segments adjacent to the arthrodesis were then evaluated from pre to 1-year post-operative within each group using the Mann-Whitney *U* test, with significance set at $p < 0.05$.

RESULTS: Patients with low operated-site motion pre-operatively (N=14) demonstrated a greater increase in flexion/extension ROM at the superior adjacent segment than those with normal or higher operated-site motion pre-operatively (1.74° vs -0.35° , $p = 0.01$). This difference trended towards significance at the inferior adjacent segment (4.35° vs 1.56° , $p = 0.17$) (N=13) (**Figure 2**). Furthermore, there was no significant difference in preoperative SF-36 pain scores between the patients with low vs. normal operated-site motion (30.8 vs. 26.1, $p = 0.32$). There was no difference in the change in adjacent segment ROM in the high vs. low BMI groups (all $p > 0.79$), the young vs. old groups (all $p > 0.21$), the low vs. high preoperative pain groups (all $p > 0.90$), the high vs. low preoperative disability groups (all $p > 0.15$), and in the male vs. female groups (all $p > 0.41$).

DISCUSSION: The main finding of this study is that patients with low pre-operative motion at the operated level demonstrated a greater increase in adjacent segment ROM at 1-year post ACDF than those with normal pre-operative motion at the operated level. These results suggest that operative segment motion affects the change in adjacent motion segment after arthrodesis. A potential explanation of these findings is that patients who are farther along in their natural history of spondylosis will demonstrate smaller ROM prior to surgery, leading to exacerbation of altered motion at adjacent levels after arthrodesis. Longer-term follow up is underway to determine if the change in adjacent segment ROM after arthrodesis is related to the development of ASD.

SIGNIFICANCE: Pre-surgical ROM at the operated motion segment may be used to prospectively identify ACDF patients that are more likely to demonstrate increased adjacent segment motion one year after arthrodesis.

REFERENCES: 1) Baba *et al.* (1993) Spine. 2) Wilke *et al.* (2015) Eur Spine J. 3) Reitman *et al.* (2004) Spine. 4) Anderst *et al.* (2012) Spine. 5) Liu *et al.* (2015) J Neurosurg Spine.

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FIGURES:



Figure 1: Positioning of the patient within the biplane radiography system.

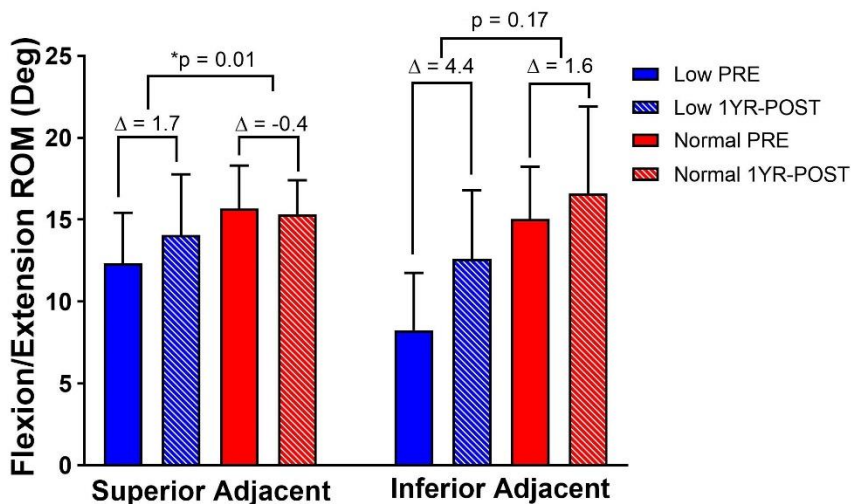


Figure 2: Preoperative and postoperative motion at the superior and inferior adjacent segments in patients who had low and high pre-op motion at the operated site.