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Adjacent Level Biomechanics Following Single vs Multi-Level Cervical Spine Fusion

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INTRODUCTION:

Cervical spondylosis is a degenerative disorder resulting in upper extremity pain. Anterior cervical discectomy and fusion (ACDF) is a common treatment, however, studies suggest an increased rate of adjacent segment disease (ASD) resulting from the procedure, requiring additional surgery. A correlation linking greater motion at a given motion segment unit (MSU), to an increased risk of developing ASD has been found. The purpose of this study is to identify altered biomechanics affecting levels adjacent to a single versus double level ACDF.

METHODS:

Ten fresh-frozen human cervical spines, stripped of musculature, from C3-T1 were used in this study. C3-C4 and T1 were potted and mounted, inverted and tilted so that T1 would achieve a 14 degree tilt (Foley, K. et al.)[1]. The spines were randomized into two groups of five specimens each. One group underwent a single level ACDF at the C5-6 level first, while the other group underwent a single level ACDF at the C6-7 level first. Both groups then had a double level ACDF at the C5-7 levels, see Figure 1.

Each specimen was tested in flexion and extension, established under stroke control using 30 degrees flexion and 15 degrees extension at a maximum load of 50 N. Specimens were tested three times: 1) intact, 2) after single-level fusion and 3) after double-level fusion. In order to induce coupled flexion and extension motion, the spine was initially set up with a 2.0 N·m preload in flexion, using an appropriate lever arm and mass to achieve the load. A roller attached to the cross head of the MTS machine was then applied to the lever arm with the flexion-extension axis of the spine placed eccentric to the load axis of the actuator, see Figure 2.

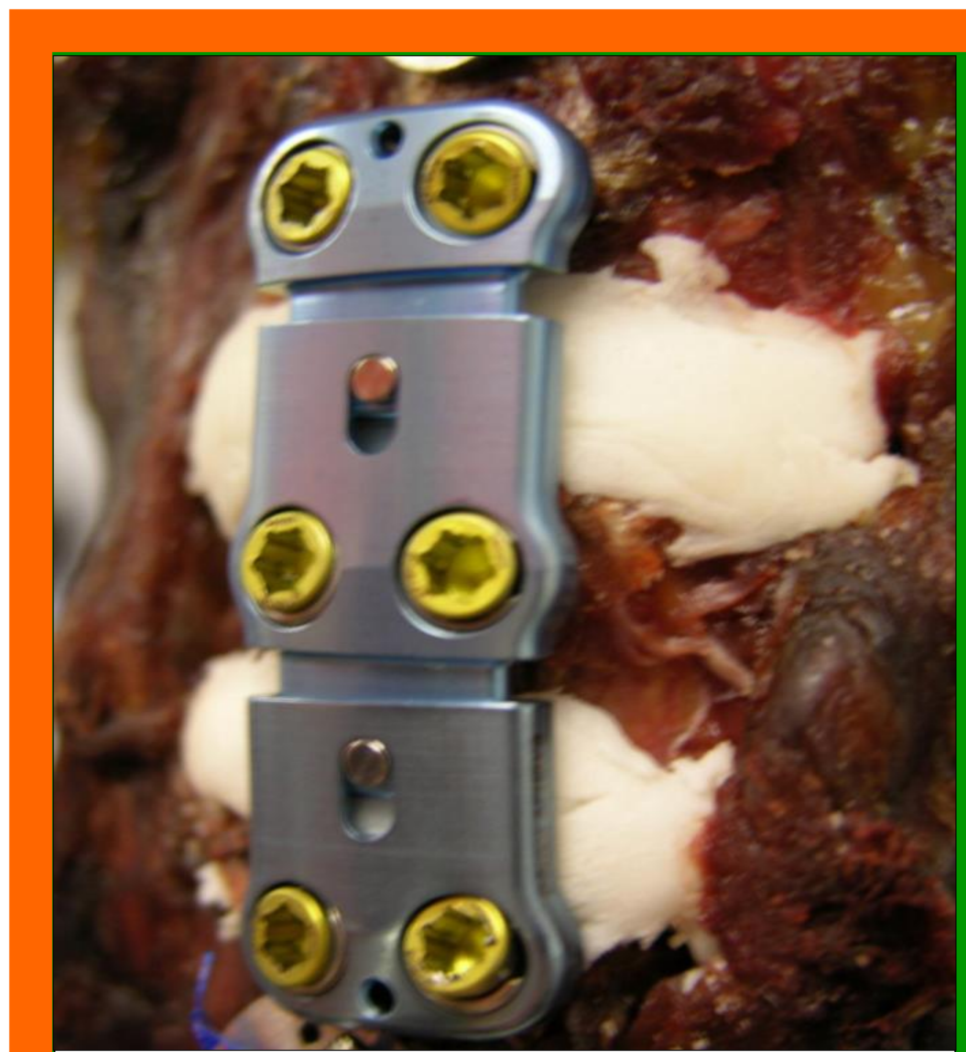

Figure 1: Double level fusion, C5-C7.

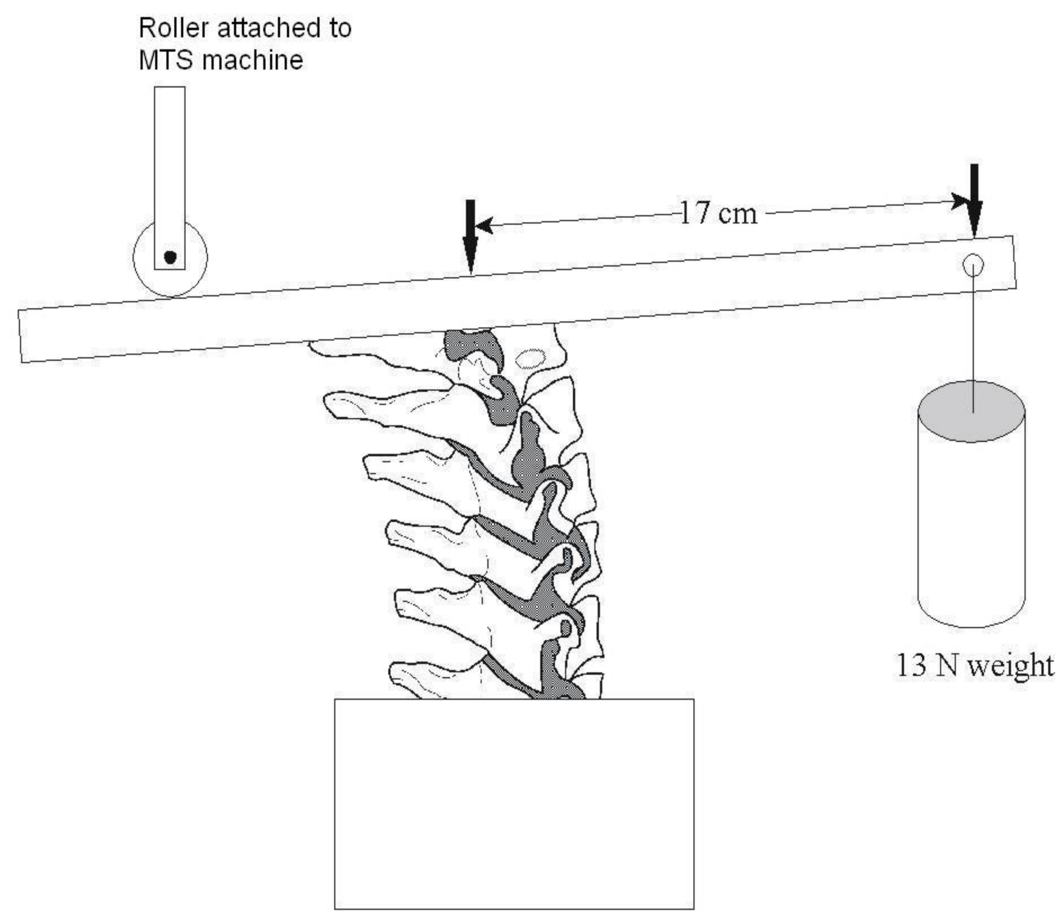

Figure 2: Schematic of test set up.

RESULTS:

An increase in sagittal range of motion of 31.30% (p-value=0.012) in the MSU above and 33.88% (p-value=0.067) in the MSU below the fused segment was found comparing a double level fusion to a single level, see Figure 3. The overall stiffness of the entire spinal construct increased 37.34% (p-value=0.0516) in extension and 30.59% (p-value=0.0130) in flexion as the second level was fused, see Figure 4. Also, as expected, the overall sagittal range of motion of the entire spinal construct decreased by 13.68% (p-value=0.0014) with a double compared to a single level fusion, see Figure 5.

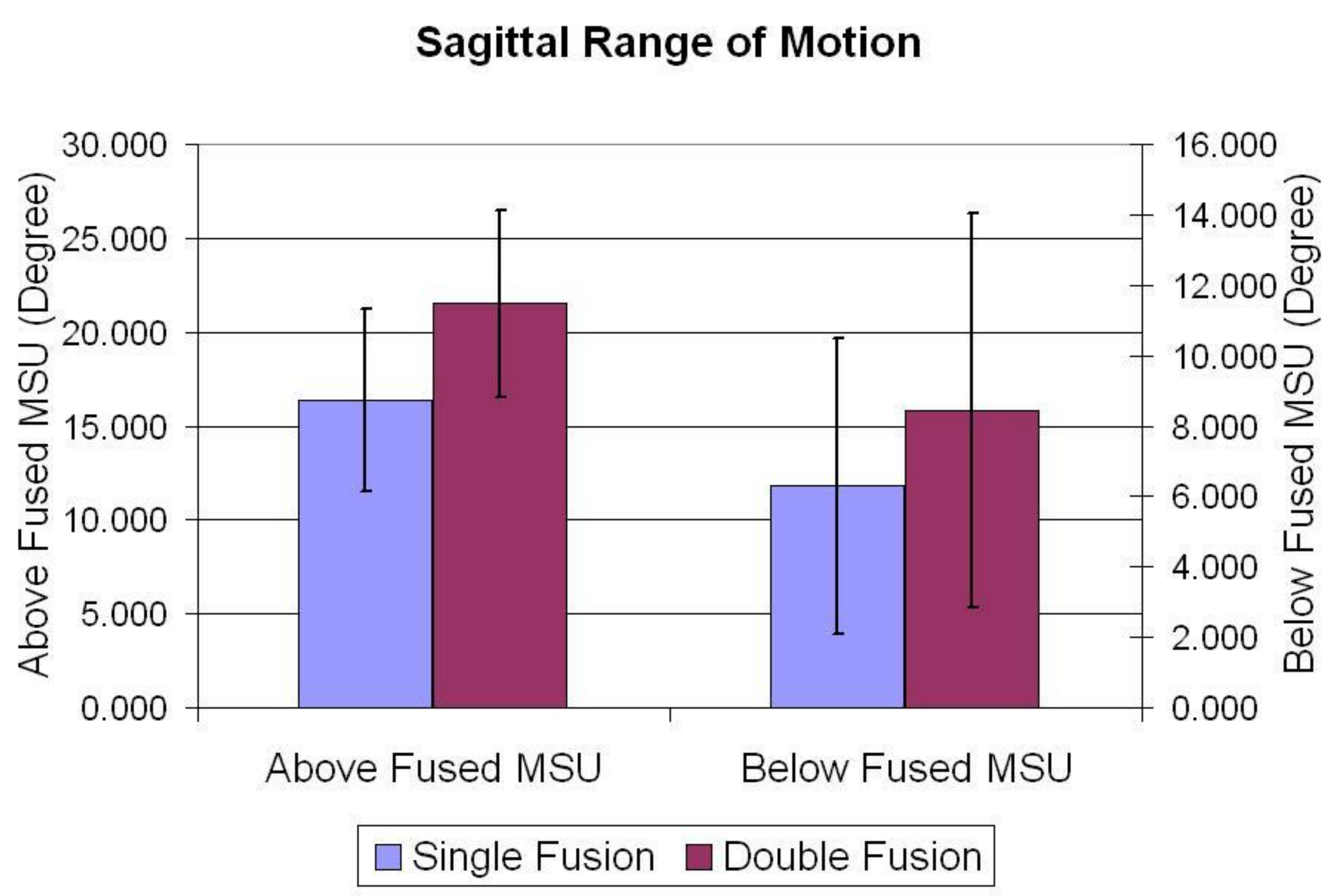

Figure 3: Sagittal range of motion above and below a MSU.

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1. Foley KT, DiAngelo DJ, et al. Anterior Cervical Plating Reverses Load Transfer Through Multilevel Strut-Grafts. Spine 2000;25:783-795.
2. White, A. A., III & Panjabi, M. M. *Clinical Biomechanics of the Spine*. Ed 2. Philadelphia, PA. J. B. Lippincott. 1990.

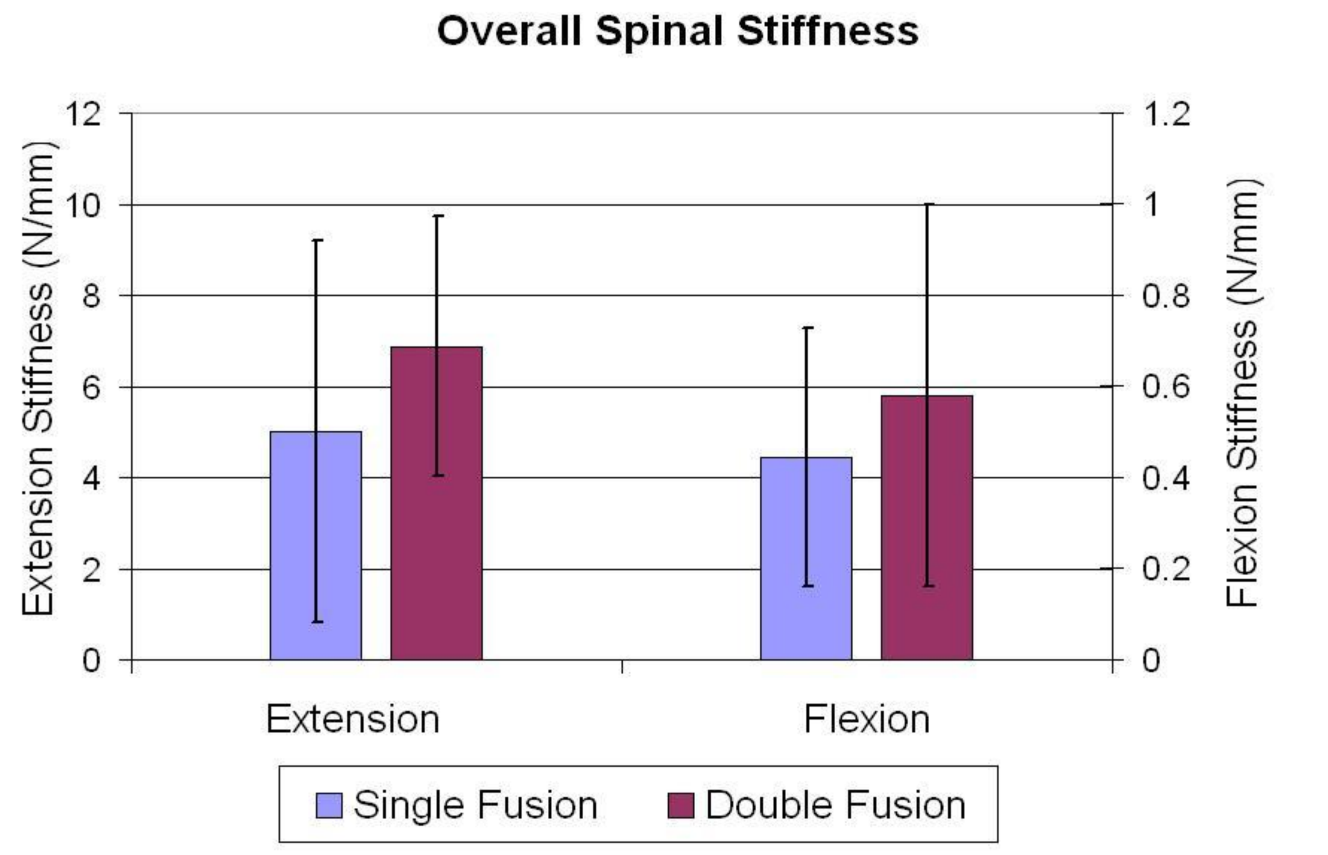

Figure 4: Overall spinal stiffness in flexion and extension.

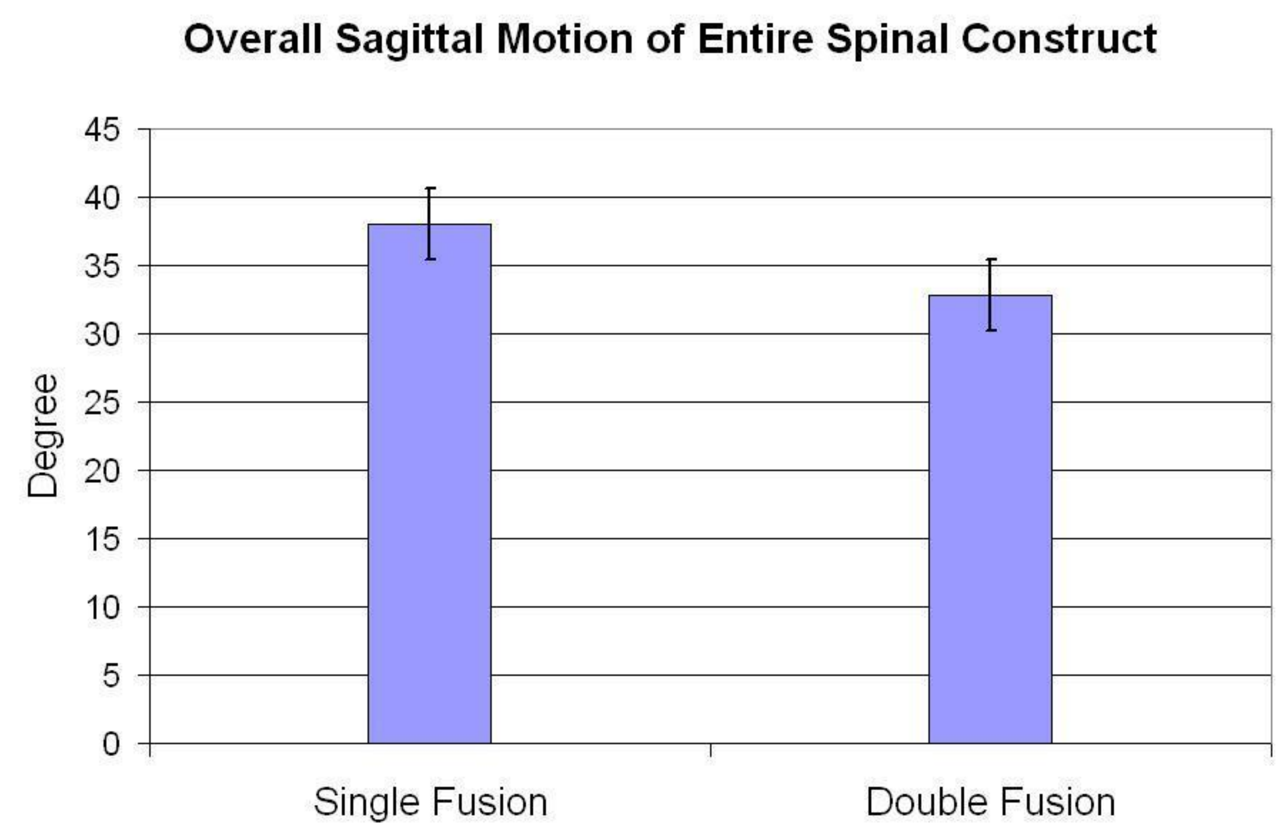

Figure 5: Overall sagittal range of motion.

CONCLUSION:

This study proves that the biomechanics affecting levels adjacent to arthrodesis do change from a single level to a double level fusion. The results indicate an increase in the overall stiffness and a decrease in the overall range of motion when two levels are fused compared to one. The change seen in the overall range of motion of the entire spinal construct seems intuitive; as a level is fused, motion is eliminated, causing the overall range of motion to decrease.

The most important change seen is the increase in sagittal range of motion, at MSU's above and below the fused segments. A close correlation exists between the risk of developing adjacent segment disease and the magnitude of motion at a given level.[2] Therefore, the data biomechanically shows there is potentially a higher risk for developing adjacent segment disease as the number of fusion levels increases.

ACKNOWLEDGEMENTS:

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