INTRODUCTION

Anterior cervical discectomy and fusion, a commonly performed surgical procedure, has a high rate of clinical success. However, there is a reported incidence of subsequently symptomatic degenerative disc disease of 3 percent per year at adjacent spinal levels. The motion lost through fusion is thought to be transferred to the adjacent motion segment units (MSUs). This increased motion may contribute to the development and advancement of disc degeneration, segmental instability, osteoarthritis, or stenosis. The objective of this study was to determine the influence of single-level cervical fusion on vertebral kinematics and biomechanical stability for different levels of cervical fusion.

MATERIALS AND METHODS

Seven fresh adult human cadaveric cervical spines (C2-T1) were harvested and radiographed to exclude those with degenerative diseases. The spines were mounted in a programmable testing apparatus and tested in flexion, extension, right and left lateral bending, and right and left axial rotation. The spines were tested in seven different conditions: the harvested condition and six independent single-level fused conditions (i.e., C2-C3, C3-C4, C4-C5, C5-C6, C6-C7, C7-T1). Fusion was simulated by attaching custom-designed clamps to pairs of adjacent spinal bodies (see Figure 1). The clamps could be removed and reattached to create the same alignment at each vertebral level. A previously developed in vitro testing protocol was adopted, i.e., incremental loading up to a target moment at T1 between 2 to 3Nm with limit checks of 35 degrees total spine rotation, maximum bending moment of 5Nm, and applied actuator load of 75N (DiAngelo and Foley, 2003). Motion of the individual spinal bodies was measured with an optical tracking system. Additional measurements included applied load and moment. Data for the motion segment unit (MSU) rotations and global stiffnesses were normalized to the harvested condition and compared using a one-way ANOVA and S-N-K test with significance set at P = 0.05.
RESULTS

The relative changes in the rotations of each MSU for the different fused conditions relative to their contribution in the harvested condition are shown in Figure 2 for flexion. A significant reduction in motion occurred at all fused MSU levels for flexion and extension (P<0.05). There were no significant differences in the rotational changes at the other levels compared to the harvested condition. The motion compensation occurred primarily at the adjacent segments. Similar results in the motion compensation occurred in lateral bending and axial rotation. When the relative rotations at the superior, fused, and inferior MSUs were analyzed with respect to the overall rotation of those three MSUs, the motion compensation at the adjacent levels was significant. Significant differences occurred at the level above the fusion site for the C3-C4 & C4-C5 fusion in both flexion and extension. The opposite occurred at C5-C6 and C6-C7; a significant increase in motion compensation occurred at the MSU below the C6-C7 fusion and the C5-C6 fusion in extension.

DISCUSSION

Questions still remain about what causes the degeneration and progression of disease at segments adjacent to a fused level. It was hypothesized that the adjacent segments carry an increased load due to the fusion that results in increased motion compensation at those segments. Such a hypothesis was supported by the results of this study. Vertebral rotations at the segments immediately adjacent to a fused level were larger than the rotations of the other levels of the spine and the compensation, when examining the fused level and the two adjacent segments, was significant. The results from this study further suggest that there is increased motion at the segment below a fusion in the lower cervical spine (C5-C6, C6-C7) or at the segment above an upper cervical fusion (C3-C4, C4-C5). This information may help to better understand the effects of single-level fusion on the advancement of degenerative disc disease and subsequent treatment plans.

Figure 2: MSU Rotations. Percent Change in MSU Rotation of Fused Levels Normalized to Harvested Contribution For Flexion Loading. Decrease rotation to the left and increased rotation to the right.

REFERENCES