THE EFFECT OF PLATE DESIGN, ENDPLATE PREPARATION AND BONE DENSITY ON IMMEDIATE STABILIZATION IN AN ANTERIOR CERVICAL PLATE FIXATION MODEL

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Introduction
There are two conceptual anterior plate designs in the cervical spine. A rigid screw-plate design is expected to provide reduction of postoperative flexibility and increase bone purchase. Such a device, however, would not allow the adjacent vertebral bodies to adapt to graft settling. The second plate design, a so-called dynamic device, allows sliding between the screw and plate and therefore changes its height with graft settling. The effect of these different plate designs on flexibility in the cervical spine has not been fully analyzed (1), particularly with reference to the effects of other important variables such as endplate preparation and vertebral bone density. The objective of this study was to evaluate the changes in spinal flexibility provided by anterior plates with these two different design concepts and contrast their load sharing characteristics. The effects of endplate preparation (i.e. removal or maintenance) and vertebral body bone density on the flexibility were also assessed.

Methods
Nine unembalmed human cadaveric cervical spines (C3-T1, some C5-T1) were dissected into twenty-four functional spinal units (FSU; C3-C4, C5-C6 and C7-T1). Bone mineral density (BMD) was determined using dual energy x-ray absorptiometry. The FSUs were separated into four groups with an equal distribution of vertebral levels (i.e. C3-C4, C5-C6, C7-T1) and BMD. The four groups represented a two by two experimental design with variables of plate design (rigid vs. dynamic) and endplate preparation (intact vs. removed). The rigid plate-screw system was the cervical spine locking plate (CSLP, Synthes Spine, Paoli PA), and the dynamic plate was the ABC plate (Aesculap, Tuttingen Germany). Each specimen was subjected to a three-dimensional flexibility test that consisted of loading using continuous pure moments of ±1.5 Nm in flexion-extension, axial rotation and lateral bending at a rate of 0.5 degrees/second in a custom-made apparatus. The three-dimensional flexibility test was performed for the intact specimen and after anterior plating and interbody grafting utilizing monocortical screws with all posterior ligaments and the facets removed. The positions of the vertebral bodies were monitored using an optoelectronic camera system (Optotrak 3020, Waterloo, Ontario, Canada) that recorded the positions of marker carriers with light-emitting diodes that were attached to the vertebrae. Segmental neutral zone (NZ) and range of motion (ROM) were determined as the joint laxity and the maximum rotation at the peak moment, respectively, and the ratios of these parameters between the fixation and intact states were used for analysis. To assess load sharing between the plate and the FSU, a strain gauge was glued onto the anterior inferior aspect of each plate and calibrated under an isolated pure bending moment. The three-dimensional flexibility test consisted of loading using continuous pure moments of ±1.5 Nm in flexion-extension, axial rotation and lateral bending at a rate of 0.5 degrees/second in a custom-made apparatus. The three-dimensional flexibility test was performed for the intact specimen and after anterior plating and interbody grafting utilizing monocortical screws with all posterior ligaments and the facets removed. The positions of the vertebral bodies were monitored using an optoelectronic camera system (Optotrak 3020, Waterloo, Ontario, Canada) that recorded the positions of marker carriers with light-emitting diodes that were attached to the vertebrae. Segmental neutral zone (NZ) and range of motion (ROM) were determined as the joint laxity and the maximum rotation at the peak moment, respectively, and the ratios of these parameters between the fixation and intact states were used for analysis. To assess load sharing between the plate and the FSU, a strain gauge was glued onto the anterior inferior aspect of each plate and calibrated under an isolated pure bending moment. This enabled the bending moment through the plate to be measured for all tests. Non-parametric statistical methods were used to determine the effect of plate design and endplate preparation on the flexibility changes after fixation since some assumptions of parametric analysis appeared not to be valid. Pearson moment correlation coefficients were calculated to determine the effect of BMD on these flexibility changes.

Results
There were no significant differences in the NZ or ROM ratios between the different plate designs in any loading direction. Furthermore, no differences were observed between the two endplate preparation techniques for any loading direction. The ROM ratios in all loading directions correlated significantly with BMD [Flexion: r²=0.54 (Figure 1); Extension: r²=0.39; Axial rotation: r²=0.41; Lateral bending: r²=0.44]. The NZ ratios in flexion-extension and axial rotation also correlated significantly with BMD. There was a significant difference in the bending moment through each plate, with the dynamic plate having significantly less load than the rigid plate (Figure 2). There were no significant differences in the NZ or ROM ratios between the fixation and intact states were used for analysis. To assess load sharing between the plate and the FSU, a strain gauge was glued onto the anterior inferior aspect of each plate and calibrated under an isolated pure bending moment. This enabled the bending moment through the plate to be measured for all tests. Non-parametric statistical methods were used to determine the effect of plate design and endplate preparation on the flexibility changes after fixation since some assumptions of parametric analysis appeared not to be valid. Pearson moment correlation coefficients were calculated to determine the effect of BMD on these flexibility changes.

Discussion
The two different designs of anterior plates in the cervical spine provided similar stabilization to the spine, although it was of interest that the load sharing pattern was different between the two. The endplate preparation method did not affect the stabilization. The bone mineral density was an important factor in the degree of stabilization achieved, regardless of the method of fixation.

Reference

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