DYNAMIC CERVICAL PLATES: DOES LOAD SHARING CAUSE INSTABILITY?

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Introduction

Single or multi-level corpectomy with anterior strut grafting is a common surgical technique for degenerative and traumatic conditions of the cervical spine. Many different styles of anterior plates have been designed to augment the initial stability and improve the fusion rate of corpectomy reconstructions. Recently, dynamic cervical plates have been introduced that allow for axial settling in order to increase load sharing with the graft and minimize device related osteopenia, however, there is some concern regarding the initial stability of these plates. This study evaluated load sharing and stiffness in flexion and extension, lateral bending, and axial torsion of the DePuy-Acromed DOC™ and Aesculap ABC™ dynamic cervical plates and compared them with the Synthes CSLP™ and Sofamor-Danek Orion™ locked cervical plates in a corpectomy reconstruction model. This model was intended to simulate initial surgical conditions, followed by graft subsidence or resorption with a 10% shorter graft, and complete graft failure or expulsion when the graft was removed.

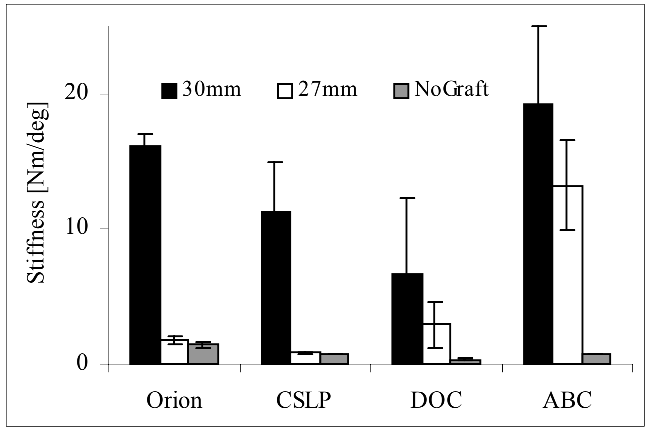
Methods

A simulated corpectomy reconstruction model using UHMWPE bodies was inserted into a custom 4-axis spine simulator, designed to apply compressive axial loading to the specimen, as well as pure flexion/extension, lateral bending, and axial torsion moments. Six constructs of each type were first precision drilled by a machinist in accordance with the plate manufacture's recommendations for screw geometry and spacing, the plates were implanted on the blocks, and the constructs were tested with a 30mm graft in place. The load sharing properties of the plates were calculated by measuring the load borne by the graft as a percentage of the applied axial load of 15 to 120N, using the TekScan™ system. The stiffness of each construct was then calculated in flexion/extension, lateral bending, and axial torsion by applying ± 2.5Nm moments in one plane, while maintaining the others at zero moment, and measuring displacement with the OptoTrak™ system. These measurements were then repeated using a 27mm graft to simulate 10% graft subsidence or resorption. The two dynamic plates were then compressed until they reached their limits for axial settling and the stiffness of all the plates in all three axes was then measured with no graft in place in order to simulate graft failure or expulsion. Statistical analysis was performed using an ANOVA with a predetermined p-value of 0.05.

Results

With a 30mm graft in place, there were no significant differences between the Orion, CSLP, and ABC plates with respect to flexion/extension stiffness, while the DOC was significantly less stiff. When the graft was shortened by 10% to 27mm, the ABC plate retained its initial stiffness significantly more than the other three plates, which became essentially equal. With removal of the graft the stiffness of all constructs was diminished (Figure). In lateral bending with a 30mm graft, the Orion, CSLP, and ABC plates were not significantly different, while the DOC plate was significantly less stiff. With a 27mm graft the Orion and CSLP retained the majority of their initial rigidity, while the ABC plate lost some initial rigidity due to the ability of the screw heads to slide in the elongated screw holes when lateral loads were applied. Again the DOC plate was significantly less stiff than the other three. This pattern was repeated when the graft was removed. In axial torsion, the four plates were significantly different, the Orion being the stiffest, followed by ABC, CSLP, and DOC plates. This pattern was essentially unchanged when testing was repeated with a 27mm graft and without a graft.

Preliminary data analysis indicates that all four plates shared applied axial loads with the 30mm graft with a range of 51-95%. In general, the stiffer plates carried a greater proportion of the applied axial loads and the dynamic plates load shared more effectively. When the graft was shortened by 10%, only the two dynamic cervical plates shared a significant proportion of the applied axial load to the 27mm graft over the entire 15 to 120N range. The locked cervical plates did not allow the graft to share any portion of the axial load until at least a 90N load was applied, and they allowed a maximum of approximately 20% of the applied load to be transmitted through the graft at 120N.



Discussion

There is a significant debate in the orthopaedic and neurosurgical literature about the use of instrumentation to augment anterior cervical discectomy and corpectomy reconstruction and fusions. Those who argue in favor of the use of anterior plates cite greater initial stability, increased fusion rates, lesser requirements for additional orthotic use, and an earlier return to work with decreased indirect costs to the patient. However, there are reports of hardware associated complications, increased operative times and direct costs with the use of instrumentation, and concerns about the stress shielding properties of locked cervical plates and the risk of device related osteopenia and pseudoarthrosis. There are scant published data on the comparative biomechanical properties of the various styles of plates that are currently available and the load sharing properties of dynamic plates as compared to locked plates has not been evaluated.

By using a simulated corpectomy reconstruction model made of UHMWPE, we were able to eliminate the inconsistencies associated with cadaveric spines and isolate the differences between four types of anterior plates. Notably, the two dynamic plates tested were able to effectively share applied physiologic axial loads with a graft under conditions simulating the initial reconstruction, and also with a subsequent 10% subsidence or resorption of the graft. In contrast, the locked cervical plates did not share any portion of the applied axial load with the shorter graft until at least 90N was applied to the model. With respect to rigidity, the locked cervical plates and the ABC dynamic plate were relatively similar in terms of their initial stiffness in flexion and extension, lateral bending and axial rotation. The DOC plate was consistently the least stiff of all the constructs in all modes of testing. Simulated graft subsidence or loss changed the flexion and extension and lateral bending properties of the all plates with little effect on axial torsion stiffness.

In summary, the ABC plate was able to dynamically settle along the vertical axis and load share with a graft more effectively than locked cervical plates and without a significant difference in initial stability. In contrast, the DOC dynamic plate was also able to effectively load share, but it did so at the expense of stability.

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