Biomechanical Investigation of the Stabilizing Effect of a Novel Device for Intra-articular Atlanto-axial Stabilization (DIAS)

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Introduction: The unique function and anatomy of the atlanto-axial joint (AAJ), combined with the vascular and neural anatomy, has made stabilization at this level highly challenging. Early fixation to the posterior laminae and spinous process of C2 was associated with poor rotational and translational stability. Newer techniques with oblique trans-articular screw fixation (TASF) across the lateral mass (LM) joints, or inserting segmental screw fixation at the LM complexes (SLMF), (Harms technique) give dramatically improved stability. Unfortunately, both techniques may be technically difficult or contraindicated by local vascular and vertebral artery (VA) anatomy. A novel device was designed and developed to obtain intra-articular stabilization via primary interference fixation within the C1/C2 lateral mass articulation (DIAS). This study characterized the extent of immediate stabilization of C1/C2 using the DIAS device in the setting of C1/C2 instability consistent with Type II odontoid fracture, with comparison to the Harms technique.

Methods: Biomechanical testing was performed using 6 human cadaveric cervical spines (C0-C5, age: 54.7±6.6 years) with load control in Flexion/Extension (FE), Lateral Bending (LB), and Axial Rotation (AR) under a moment of 1.5Nm. Comparison of C1-C2 Range of Motion (ROM) was performed using optoelectronic tracking. ROM was measured in intact state, following destabilization after creation of a Type II Odontoid Peg Fracture, after sequential stabilization using the Harms technique and the DIAS device.

Results: FE ROM of the intact specimens was a mean of 14.1±2.9 degrees. Destabilization increased the ROM to 31.6±4.6 degrees. Instrumentation with the Harms technique reduced the motion to a mean of 4.0±1.4 degrees (p=0.00) The DIAS reduced FE motion to 3.6±1.8 degrees (p=0.00). For evaluation of lateral bending the respective mean rotations were 1.8±1.1, 14.1±5.8, 1.4±0.7 and 0.3±0.5 degrees for the intact, destabilized, Harms technique and DIAS device. For axial rotation the respective mean values were 67.3±13.8, 74.2±16.1, 1.3±0.8 and 0.9±0.7 degrees. All comparisons between the destabilized state and both the Harms and DIAS were statistically significant (p< 0.05). Direct comparison of the Harms technique and the DIAS device revealed no significant difference (p>0.05).

Conclusions: The DIAS resulted in interference fixation at the AAJ LMJ with comparable stability to the Harms technique. Perceived advantages with the DIAS include avoidance of fixation below the C2 LM where the VA is susceptible to injury, access to the C1 screw entry point through the blade of the DIAS avoiding extended dissection superior to the C2 nerve root and its surrounding venous plexus, the possibility of intra-articular fusion through and around the DIAS, and the absence of imaging difficulties when looking at posterior interlaminar fusion. Biomechanical testing demonstrated improved construct stiffness with removal of articular cartilage from the LM, and bi-cortical fixation of the C1 LM screw in the DIAS.