Biomechanical analysis comparing three C1-C2 transarticular screw salvaging fixation techniques

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INTRODUCTION:
Atlanto-axial instability can be caused by trauma, malignancy, congenital malformation, or inflammatory diseases in which case surgical fixation is required to stabilize the segment. The current gold-standard for atlanto-axial fixation is C1-C2 Transarticular Screw (TS) fixation. In certain cases, the complicated nature of vertebral artery injury could make the application of bilateral transarticular screws impossible. Additionally, a surgeon would have to employ an alternative method for fixing the contralateral side. The current options are C1 Lateral Mass Screw (C1LMS) and short C2 pedicle screw (C2PS), or C1 Lateral Mass Screw and C2 InterLaminar Screw (C2ILS), or sublaminar wire [1]. This study biomechanically compares three atlantoaxial transarticular salvaging fixation techniques. Our hypothesis is that there is no statistical significant biomechanical difference between C1LMS+C2PS when compared to C1LMS+C2ILS and that sublaminar wire is not biomechanically stable as compared to the other two techniques.

MATERIALS AND METHODS:
Nine Fresh ligamentous human cervical spine specimens (C0-C4) were thawed, and the soft tissue surrounding the spine, except the ligaments and discs was carefully removed. The specimens were potted at C4 in a mixture of bono and resin with the C3-C4 disc space in the horizontal plane. Two orthogonal rods were inserted into the skull to apply pure moments. L-shaped plexiglass plates, each having three infrared light-emitting diodes were attached to C0, C1, C2 and C3 vertebrae. A special set of LEDs was placed on the immovable base to provide a reference axis system. Pure moments were applied to skull in increments of 0.5Nm from 0 Nm to 2.0 Nm. The specimens were tested in extension (EXT), flexion (FLEX), left lateral bending (LB), right lateral bending (RB), left axial rotation (LR) and right axial rotation (RR) for all the cases. The positions of the LEDs were recorded using an Optotrak™ Motion Measurement System (Northern Digital, Waterloo, Ontario, Canada) and converted into three rotations (flexion/extension, lateral bending and axial rotation) using rigid body kinematic principles in relation to the fixed base.

The specimens were sequentially tested intact, type II odontoid fracture, and stabilized with three fixation constructs: 1) C1-C2 TS on right side and C1LMS-C2PS on contralateral side 2) C1-C2 TS on right side and C1LMS-C2ILS on the contralateral side and 3) C1-C2 TS on right side with sublaminar wire (Fig.1).

RESULTS:
Table 1 illustrates the percentage change of motion at C1-C2 level in all the instrumented cases when compared to intact. The reduced motion was observed to be in the range of 54±3% of intact for EXT, 24±2% for FLEX, 15±5% for LB, 18±2% for RB. Similarly, in axial rotation modes of TS+C1LMS+C2PS and TS+C1LMS+C2ILS, the reduced motion was in the range of 7.5±2%. However, TS+Wire reduced the motion approximately by 23±0.4% of intact.

CONCLUSION:
Many posterior atlanto-axial stabilization techniques have been developed of which bilateral transarticular screw technique has been accepted as gold standard despite of the risk of vertebral artery injury. As expected, this study demonstrated no statistical significant difference between TS+C1LMS+C2PS and TS+C1LMS+C2ILS fixations in all the rotation modes and that TS+C1LMS+C2PS is superior to TS+Wire fixation in axial rotation. Also, TS+C1LMS+C2ILS fixation is superior to TS+Wire fixation in axial rotation. This concludes that either of C1LMS+C2PS or C1LMS+C2ILS stabilization techniques can be used to fix the contralateral side while using TS on one side of the atlanto-axial joint. Therefore, TS+C1LMS+C2ILS can be used as an alternative to stabilize the segment in case of serious complications followed by placement of C2 pedicle screws.

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REFERENCES: