The Effects of Lateral Eccentricity on Failure Loads and Injuries of the Cervical Spine in Head-First Impacts

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Abstract

Current neck injury criteria do not include limits for lateral bending combined with axial compression and this has been observed as a clinically relevant mechanism, particularly for rollover motor vehicle crashes. The primary objectives of this study were to evaluate the effects of lateral eccentricity (the perpendicular distance from the axial force to the centre of the spine) on peak loads, kinematics, spinal canal occlusions, and structural injury patterns of subaxial cervical spine specimens tested in dynamic axial compression (0.5 m/s).

Twelve 3-vertebra human cadaver cervical spine specimens (5 C3-5, 3 C4-6, 2 C5-7, 2 C6-T1) were tested in two groups: low and high eccentricity with initial eccentricities of 1% and 150% of the lateral diameter of the vertebral body. Six-axis loads inferior to the specimen, kinematics of the superior-most vertebra, and spinal canal occlusions were measured. The effects of eccentricity on peak loads, kinematics, and canal occlusions were evaluated using unpaired Student t-tests. Injuries were diagnosed by a spine surgeon and scored. Classification functions were developed using discriminant analysis.

The high eccentricity group had lower peak axial forces (1544 ±629 vs. 4296 ±1693 N), inferior displacements (0.2 ±1.0 vs. 6.6 ±2.0 mm), and canal occlusions (27 ±5 vs. 53 ±15%) and higher peak ipsilateral bending moments (53 ±17 vs. 3 ±18 Nm), ipsilateral bending rotations (22 ±3 vs. 1 ±2^{o}), and ipsilateral displacements (4.5 ±1.4 vs. -1.0 ±1.3 mm, $p<0.05$ for all comparisons). Low and high eccentric loading resulted in primarily bony fractures and soft tissue injuries, respectively. The developed classification functions had 92% classification accuracy.

Dynamic axial compression loading of the cervical spine with high lateral eccentricities produced lower canal occlusions and primarily soft tissue injuries while loading with low eccentricities produced greater canal occlusions and primarily bony fractures. These results provide new insights to develop prevention, recognition, and treatment strategies for compressive cervical spine injuries with lateral eccentricities.