Simulation of head-first impact using cervical spine specimens, simulated neck muscles, and a Hybrid III ATD head

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ABSTRACT

Neck muscles stiffen and stabilize the cervical spine; however, their influence during ex vivo axial impact experiments has previously only been examined for highly simplified musculature. The objective of this study was to create a model of head-first impact with simulation of several major neck muscles, using a Hybrid III ATD head and cadaver cervical spine, to create compressive cervical spine injuries.

Five osteoligamentous cervical spines (Occ-T2) were potted in dental stone at T1/2, mounted on a six-axis load cell and attached to a Hybrid III head at the occiput. Four bilateral muscles and three follower load cables were included.[2] Fishing line was tied to vertebrae or to the adapter plate at the occiput and connected to springs to simulate muscle forces.

Specimens were mounted to the carriage of a drop tower and dropped onto an impact platform overtop a uniaxial load cell while high speed video cameras and a high speed x-ray system captured the impacts. Injuries were diagnosed by a fellowship trained spine surgeon (JS). Specimens were aligned to minimize eccentricity (anteroposterior distance between the occipital condyles and T1 vertebral body).[3] Average segmental compression forces were 109 (SD 38) N at C0/1 and this increased inferiorly. Average peak head and lower neck axial loads were 6,893 (SD 791) N and 2,635 (SD 1096) N, respectively. Injuries included burst fractures, disc ruptures, and facet capsule ruptures.

This pilot study showed that compression injuries in head-first impacts can be reproduced with simulation of muscle forces that allow detailed control of spinal posture. As we tied muscle simulating cables to the vertebrae, this control was achieved without producing stress risers or damaging the structural integrity of the spinal column.