Lumbar Spine Kinematics and Injury Risk in Reclined Frontal Impacts

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Background and Objective:

The introduction of autonomous vehicles will result in a wide variety of seating postures not traditionally seen in today's vehicles. These autonomous vehicles will no longer require the control and attention of the driver; therefore, a traditional upright, forward-facing driving posture is not required. A reclined seating posture is proven to be a likely result of autonomous vehicle introduction. While this posture can be achieved by passengers in current vehicles, the kinematics of reclined occupants have not yet been thoroughly investigated.

Methodology:

Simulations of reclined occupants in a frontal impact were conducted using the GHBMC detailed and simplified 50th M different restraint and posture configurations. These simulations were performed using a 3-point seatback integrated belt with a lap belt pre-tensioner, retractor pre-tensioner and force limiter, and were run using the NCAP full frontal pulse (Δv 35 mph) at four different levels of seatback recline (0, 10, 20, 30 deg). In parallel, an in-depth literature search was conducted on available human lumbar spine injury risk factors in high-rate loading conditions.

Results:

Resulting kinematics from both the GHBMC simplified and detailed simulations show a high degree of combined compression and flexion in the lumbar spine as a result of i) forward excursion of the upper torso, ii) posterior rotation of the pelvis, and iii) loading of the lap belt on the abdomen. The literature search resulted in 25 studies that include lumbar spine injury risk factors resulting from a high rate single type of loading, either compression or flexion alone. Just three studies were found that included human lumbar data under a combined compression and bending loading, at a quasi-static rate. No data exists on lumbar spine injury risk prediction in combined loading at a high rate of impact, such as would be seen in a frontal crash scenario.

Conclusions:

The GHBMC simplified and detailed simulations in a reclined frontal impact show similar lumbar spine kinematics– namely, a combined compression and bending load. While automotive manufacturers use computational models to assess their restraint system performance, no computational models have been validated for reclined impacts. From the literature, no human lumbar spine data exists that includes a high rate of combined

compression and bending. There exists an urgent need for human lumbar spine data in high-impact combined compression and bending loading scenario for model validation in a reclined seating posture, as this posture is both achievable in current vehicles and will only be more frequent with the introduction of autonomous vehicles.