The Effect Of Occupant Posture On The Risk Of Fracture In The Human Tibia Under Dynamic Impact Loading

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Abstract

Vehicle floor intrusion is a common cause of injury to the lower leg in automotive collisions. For the most part, experimental investigations into the fracture tolerance of the lower leg in these collisions assume that a vehicle occupant will be seated in an idealized neutral posture, with compressive force directed along the long axis of the leg. This neglects the various postures an occupant may assume during a crash. Previous efforts have attempted to generate an injury criterion that calculates risk as a linear combination of compressive force and bending moment (Tibia Index). However, a consensus has not been reached on the critical values for cadaveric specimens undergoing dynamic impact, due to challenges in measuring transmitted loads and reproducing crash scenarios. A new injury criterion that accounts for the risk related to non-standard postures and the associated combined loading is needed in order to better assess risk and evaluate protective measures in collision scenarios.

A custom-built pneumatic apparatus was used to deliver impulses representative of automotive collisions to isolated human tibiae. Impacts were conducted at approximately 6 m/s, with a target duration of 40 ms, and the load was transmitted via an artificial talus that was rapid prototyped from a Computed Tomography scan of an average ankle. By varying the mass of the projectile used, impacts were applied in increasing energy levels until fracture (with the goal of attaining failure within 2-3 strikes, to minimize any accumulated damage). For this study, 12 isolated cadaveric tibiae (paired, female, aged 48-73) were potted at their proximal ends and instrumented with strain gauges and accelerometers. The specimens were suspended in the apparatus, with one tibia from each pair held at 20 degrees from the projectile's line of action and the contralateral held at an angle of 40 degrees, representing moderate and extreme knee extension in a seated occupant, respectively. A best subsets regression analysis will be used to identify the factors that influence injury risk (potentially including impact energy, force, bending moment, and accelerations), and used to develop a posture-specific injury criterion for dynamic impact loading of the tibia. The Hybrid III and MiL-Lx ATD lower legs were subjected to the same impacts to evaluate their biofidelity in these non-standard postures, and to translate the newly developed injury criterion into measures from these standard industry tools.

This work to quantify the effects of leg posture on injury risk will contribute to the development of more comprehensive design criteria for vehicle occupant protection measures, and ultimately reduce the incidence and severity of these injuries through better evaluation metrics.