Clavicle axial injury tolerance and the effect of age

Qi Zhang, Jason Kerrigan, Mathew Kindig, Jeff Crandall

University of Virginia

Abstract

It was reported that 66% of shoulder injuries during vehicle lateral impacts are clavicle fractures. Although several anthropometric testing devices (ATD), such as world-SID and THOR, have already incorporated clavicle load cells to measure clavicle loading response during side impact, no injury criterion is available yet to interpret this data in terms of the clavicle injury risk. Thus, the goal of this study is 1) expand the clavicle axial loading condition data set in the literature, 2) develop an injury risk function of the clavicle under axial loading condition, by using data from literature describing clavicle axial compression loading tolerances and the new test data from current study.

Four clavicle specimens extracted from 3 post-mortem human surrogates (PMHS) were tested in this study. The test fixture provided a pinned boundary condition at the medial end of the specimen (rotate about the superior-inferior axis only) and a fixed (cantilever) boundary condition at the lateral end. A 6-axis load cell and a rotational potentiometer were located on the medial end assembly to measure reaction force and rotation of the end. A uni-axial load cell was installed between the actuator and lateral potting block. The actuator was displaced at 1000 mm/sec to a maximum displacement of 30 mm to ensure gross failure of the specimen. A database was then compiled from the literature describing clavicle axial loading fracture tests with the data in current study. To be included in the database, the tests should be: 1) part of a peer-reviewed study available in the open literature, 2) specimen information such as size, age are included, 3) the tests are a component level test. Five studies that satisfied the above criterion were found, with a total of 58 specimens. This database includes specimens with age ranging from 14 to 86 years old, loading rate ranging from 0.16 mm/s to 1000 mm/s. Clavicle force-deflection response was not scaled in this study, as analysis indicates that there is no geometric similarity exists in the clavicle specimens. A Weibull distribution was assumed for the survival function. And the stepwise model selection method was used to develop the injury risk function with consideration of potential covariates such as age, gender, aspect (left vs right), loading rate and so on.

The clavicle injury risk function with age as the only covariate was developed for axial loading condition. The effect of age on clavicle injury risk shows a bi-phase trend, as the injury risk decreases as the age increase until 50 old, and then the clavicle injury risk increases as age increase.