US DEPARTMENT OF DEFENSE
BLAST INJURY RESEARCH PROGRAM
COORDINATING OFFICE

Facial, Hearing, and Visual Injuries

Biomechanical Modeling and Measurement of Blast Injury and Hearing Protection Mechanisms

Funded by the DHA RDA Directorate, researchers at the University of Oklahoma are studying exposure to high-intensity sound or blast that directly results in hearing loss. Development of effective personal hearing protection devices for military Service Members has been a major focus for research in protection of blast injury. However, there is a profound lack of knowledge about how blast waves are transmitted through the ear and what specific changes occur in the ear structures following blast exposure. This research project investigates the biomechanical response of the middle and inner ear to noise/blast, using a combined modeling and experimental approach. A comprehensive finite element model of the human ear, including the three-dimensional components of the ear canal, middle ear, and cochlea, is further developed to simulate acoustic injury during blast exposure. Using human cadaver ears, researchers are quantifying the middle ear damage in relation to overpressure level and wave direction by simultaneously monitoring the pressure at the entrance of the ear canal (P0), near the eardrum in the canal (P1), and behind the eardrum in the middle ear cavity (P2), as well as the eardrum rupture threshold. Changes of dynamic properties of middle ear tissues after blast exposure are also determined. All these findings are employed to validate the finite element model. The peak pressure ratio P1/P0 predicted by the model is in the same value as that measured in human cadaver ears. Supplementing this research, a chinchilla model is being used to identifying middle ear protective mechanisms during blast exposure that rely on middle ear muscle activity. Electromyography of the stapedius muscle is measured from chinchillas during exposure and the results will be used for developing the active model of the human ear. The mass block attached to the stapes footplate and fixed on the bony wall through dash ports represents the cochlear load.

The uniqueness of this research is that all ear components and hearing protection devices can be simulated in the finite element model for function analysis with anatomical, mechanical, and acoustic parameters. The project is directly relevant to provide a biomechanically validated three-dimensional model of the human ear so that a better understanding of prevention mechanisms of hearing loss in military operations can be obtained. The model will leverage the design and evaluation of both passive and active hearing protection devices for military applications.