D19 Biomedical Engineering Contributions in the Analysis of Head and Brain Impact With Legal Perspectives by Counsel for the Department of Transportation: Bicycle vs. Auto, Seatbelts, and Motorcycle Accidents

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After attending this presentation, attendees will have a better understanding of how biomedical engineering principles apply to the engineering analysis of head and brain impact injuries.

This presentation will impact the forensic science community by demonstrating the importance of biomedical engineering analysis of head and brain impacts.

In the forensic analysis of a head or brain impact incident, the biomedical engineer is uniquely situated to offer insights with respect to the quantification of forces and accelerations. Because of the multidisciplinary aspects of most head and brain injury incidents, the biomedical engineer is able to tie the engineering aspects together with the medical diagnoses by the health care providers and forensic pathologists. Various head impact scenarios are analyzed from an engineering perspective and supported with analysis of physical evidence and/or experimentally verified test data.

Experiments conducted follow Federal standards using data acquisition software at 10,000Hz with a 4th-order Butterworth filter with a 1,650Hz cutoff frequency, per the Society of Automotive Engineers (SAE) J211. These experiments used different impact surfaces, including asphalt, and vehicle sections. Impact speeds were determined and replicated using an inverted pendulum impact protocol. Anthropometric crash test dummy head-forms and necks were used to study the multi-axial direct contact to the respective impact surfaces in both helmeted and unhelmeted modes in which the anthropometric sections are instrumented with triaxial piezoelectric ICP® accelerometers.

The legal perspective is provided for three cases involving different mechanisms of injury: helmet, occupant restraint (seatbelts), and bicyclist head impact. Counter arguments are presented to provide a complete perspective of the litigation issues. Also presented will be how the issues changed prior to trial that, in one case, changed the course of the trial itself.

The case studies for this presentation involve various allegations over the use (or non-use) of various mechanisms to prevent injury or death: seatbelts, motorcycle helmets, and bicycle helmets. The biomedical engineer's analysis sheds light on both liability and damages issues, presents the factors that caused the accident and the resulting injuries, and discusses whether the injury would be reduced or eliminated with the proper use of a restraint device or helmet.

The case background, forensic questions, and brief results are summarized below for each of the three cases to be discussed. The presentation will include discussion of the engineering approach, fundamental principles employed, methods, results, and conclusions.

Seatbelt Analysis: a woman and her husband pulled out to make a left turn onto a rural two-lane highway, directly into the path of a truck, resulting in a relatively low-speed impact. The husband in the passenger seat died as a result of a head/brain injury. Plaintiff argued that her husband was wearing a seat belt, but nonetheless suffered a fatal injury. The defense argued that he was not wearing a seatbelt and would likely have survived the accident if he had been wearing one. A careful analysis of the trauma clearly revealed the mechanism of injury resulting in this man's death. This case went to trial.

Solo Motorcycle Accident: a young woman was a passenger on a motorcycle when the rider, who was going uphill on a curve, struck a guardrail, ejecting his passenger. She struck something with her face, which caused massive facial trauma. Plaintiff alleged she hit a nail sticking out of the stop sign post. But, could it have been a guardrail post, the ground, or something else? Biomedical engineering analysis determined the mechanism of injury. The matter settled.

Bicycle vs. Auto Accident: an un-helmeted bicyclist was struck by a car as he crossed a freeway on-ramp. He was thrown over the car and struck his head on the asphalt, suffering a severe traumatic brain injury. Plaintiff argued that he was not astride his bicycle, but was riding it as a scooter, with his right foot on the left pedal. Because he was not technically "riding," he did not legally have to wear a helmet. Defense argued that the injuries would have been prevented or significantly lessened if he had been wearing a helmet. Careful biomedical engineering assessments pieced together the physical evidence, some of it missed by both the accident reconstruction and bicycle experts, to determine how the injury occurred. An experiment then quantified the accelerations with and without a helmet. The matter settled.

Biomechanics, Brain, Impact

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