D37 Skull Fracture Risk: An Experimental Comparison Between Elastic (Drone) and Inelastic (Wood Block) Impacts Focused on Fracture Type and Tolerance Using Instrumented Postmortem Human Subjects (PMHS)

John H. Bolte, PhD, The Ohio State University, Columbus, OH 43210; David Stark, PhD, The Ohio State University, Columbus, OH 43210; Amanda M. Agnew, PhD, The Ohio State University, Columbus, OH 43210; Yun-Seok Kang, PhD, The Ohio State University, Columbus, OH 43210*

Learning Overview: After attending this presentation, attendees will have an appreciation for interdisciplinary research in skeletal trauma analysis, specifically focused on the cranial vault. Attendees will learn how to conduct experimentally driven biomechanical validation of skeletal trauma for forensic engineering purposes and will understand the importance of utilizing experimental data to better understand the differences in fracture type and threshold between elastic and rigid blunt force impacts.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by demonstrating the need for interdisciplinary biomechanical analyses of skeletal trauma in the cranial vault due to both elastic and rigid blunt impacts. Increased understanding of the differences in fracture tolerance and type due to elastic and rigid blunt force trauma will serve to improve skeletal trauma analyses in forensic engineering.

Currently, there are over one million recreational drones in the United States, with forecasts predicting increases to more than three million by 2021.[1] Originally, the Federal Aviation Administration (FAA) regulations limited drones to weights below 55lbs and top speeds below 100mph.[2] Recently, the FAA has begun allowing more widespread Unmanned Aircraft Systems (UAS) operations through a waiver program. As more drones populate the airspace and more lenient regulations are enacted, there is a need to understand and quantify the risk associated with drone impacts. To date, there have been several documented cases of concussion and whiplash injuries resulting from UAS impacts as well as one case of an Abbreviated Injury Scale (AIS) 3 level skull fracture.[3]

The focus of this study was to impact Postmortem Human Subjects (PMHS) over a range of drone head impact scenarios (including a wooden block) to: (1) investigate differences in fracture type between drone (elastic) and wooden block (inelastic) blunt impacts; and (2) assess current automotive-based injury criteria to predict the fracture thresholds of the cranial vault. The experimental variables included: drone impact orientation, drone vehicle type, and impact velocity.

The tests were conducted by using a catapult device to accelerate the drones and wooden block into five separate PMHS, with each PMHS receiving multiple impacts focused on separate bones of the cranial vault. A total of 41 blunt impacts were conducted using five different drones and a wooden block at speeds up to 22m/s. The PMHS were instrumented with strain gauges on the bones that comprise the cranial vault and two different arrays of accelerometers and Angular Rate Sensors (ARS) mounted to the skull to measure six-degree of freedom head kinematics. In-between each impact, X-rays of the head were taken to document if a fracture had occurred due to the preceding drone or block impact. Following the test series for each PMHS, an anatomical dissection was completed to document all fractures that occurred to the cranial vault due to the blunt impacts.

Of the 35 elastic drone impacts carried out, one AIS 2+ injury was observed: a 13cm linear skull fracture in the frontal bone resulting from a Phantom 3 impact. In addition, three rigid wood block tests all resulted in fractures to the cranial vault, one of which was an AIS 4 severity injury. Kinematics measured during PMHS tests indicated that automotive injury metrics may not be able to accurately predict skull fracture due to drone or elastic blunt impacts. To assess the risk of skull fracture, the Head Injury Criteria (HIC_{15}) and its associated risk curve were compared to PMHS head kinematics.[4] Based on the HIC_{15} criteria, five drone impacts had greater than an 85% probability of causing a skull fracture; yet only one skull fracture was observed. Additional investigation is needed to determine appropriate criteria or limits to be used for predicting the severity of head fractures due to elastic blunt impacts.

Reference(s):

1. FAA (2017). FAA Aerospace Forecast: Fiscal Years 2018-2038. *Federal Aviation Administration, Forecast.*
2. FAA (2016). Docket FAA-2015-0150, Amdt. 107-1, 81 FR 42209.
3. Abbreviated Injury Scale – 2015 Revision (2015). AAAM, Des Plaines IL, 2015.
4. Versace, J. (1971). *A review of the severity index* (No. 710881). SAE Technical Paper.

Skull Fracture, Injury Biomechanics, Blunt Force Trauma