D44 Investigation of Real-World Blunt Head Trauma Using a Commercial Skull/ Brain Surrogate

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The goal of this presentation is to educate the forensic community on a potential surrogate available for assessment of blunt force trauma, and how to critically evaluate such surrogates.

This presentation will impact the forensic science community by displaying data, laboratory procedural background, and morphological results related to human head blunt-force impacts that will provide insight into the applicability of blunt-force trauma surrogates as tools for human skull fracture pattern prediction.

Often, the circumstances leading to skull trauma as a result of blunt impacts may be unknown due to the lack of witnesses, the inability of the injured to recall the events leading to the trauma, or even the death of the injured party. In one real-life incident, a worker investigating the outlet area of a hydraulic pump that was removing fluid from a well sustained serious head and brain injuries as fluid pressure reached the critical value needed to blow the cam-lock cover off of the pump outlet, which then struck him in the head. For such cases, human head surrogates have been developed that allow laboratories to simulate such scenarios. Thali et al. (2002) introduced a novel headform, commonly known as the "skin-skull-brain model," which was developed with the intent of observing the subjective morphological results of blunt head traumas.[1] The focus of this study was to attempt to recreate the aforementioned real-life injury on a similar surrogate. In doing so, the goal was to attain a better understanding of the circumstances surrounding the injury by comparing experimental morphological results to injury evidence, and perhaps to gain insight into the validity of the surrogate for similar blunt trauma events.

For impact testing, the human head was represented using a surrogate similar to the Thali model, consisting of a polyurethane sphere to simulate the human skull (SYNBONE) and 20% ordnance gelatin as the brain simulant. The surrogate was hung in a thin net to simulate head movement as a reaction to impact force. In an attempt to simulate the head injury event, a 1.5 lb. cam-lock cover which matched the real-life blunt trauma projectile was launched from a 2.75" section of pipe on the end of an air cannon to produce a direct impact to the surrogate. Based on the available information pertaining to the impact event, three possible impact conditions were tested: the cam-lock cover was fired from 25" at 94.8 psi (gage) while loosely fitted to the cannon pipe, from 15.25" at 95 psi with the cover partially locked onto the pipe using the cam locking mechanisms, and from 15.25" at 102.5 psi (gage) without locking the cover. After each trial, the surrogate was closely examined, photographs were then taken to document the head model damage, measurements were made when applicable, and observations and data were documented.

For the test with a partially locked cover, air pressure was not sufficient to overcome the locking mechanism and no launch resulted. The long-range impact with the loosely-fitted cam-lock yielded only a small, hair-line fracture of the head form skull. The short-range and higher pressure test resulted in a significant fracture on the head form with a maximum crack length measuring about four inches from the impact site to the end of the crack, and three resulting skull surrogate fragments, with a combined size of about 1.18" x 1.57". When morphology of the cracks and broken pieces from this trial were subjectively compared with photographs of the accident evidence, similarities were observed, suggesting similar impact conditions. Evidence from the accident, however, consisted of only a single fragment measuring approximately 1.5" x 2". This difference in skull fracture pattern may imply different experimental impact conditions, but also may indicate the inability of the surrogate to accurately reproduce human skull failure modes due to different geometry or material properties. Because correlation of experimental results with the real-life event was largely subjective, further study on the subject should include additional research to simulate the accident more precisely, high speed videography to document the ballistic impacts, a complete "skin-skull-brain" model as a more biofidelic surrogate, and laboratory study to validate the "skin-skull-brain" model biofidelity as compared to controlled studies using postmortem human subjects.

Reference:

1. Thali, Michael J. , Beat P. Kneubuehl, Richard Dirnhofer "A "skin– skull–brain model" for the biomechanical reconstruction of blunt forces to the human head" Forensic Science International, Volume 125, Issues 2-3, 18 February 2002, Pages 195-200

Thali, Skull, Surrogate

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