Test Apparatus for Examining Brain Injury

Lead Investigator

Qianhong Wu, Ph.D., Professor, Department of Mechanical Engineering.

Background and Unmet Need

Chronic traumatic encephalopathy (CTE) is a progressive degenerative disease resulting from head trauma, particularly a history of repeated head trauma. Athletes who play contact sports and military personnel who incur repeated head traumas, including concussive or sub-concussive traumas, are at the greatest risk of developing CTE. Many athletes may experience frequent sub-concussive head trauma during participation in a contact sport and never have a symptomatic concussion. These athletes may still develop CTE.

The effects of CTE may include mood changes, personality and behavioral changes, memory loss, confusion, and problems with motor skills and function. Roughly 5 out of 10 (50%) concussions go unreported or undetected in student-athletes, where between 1.7 – 3 million sports and recreation-related concussions are reported annually in the United States.[1] The impact of brain injuries and the potential development of CTE is of growing concern.

Current tools available to study the brain non-invasively, such as magnetic resonance imaging (MRI), are expensive. Further, a patient is required to be already injured to study the effects on the brain. To realistically study brain function and injuries, there remains a need for a device that enables non-invasive methods of assessing the impact and characteristics of brain injury from acute brain trauma without the need for an injured patient.

The Invention

Dr. Wu has created a novel non-invasive test apparatus for the study of impact-induced brain trauma, including a see-through head model with a biomimetic skull and a brain. Within the interior of the skull chamber, a gel material and fluid are disposed to resemble an anatomical representation of the human skull and brain configuration. Further, the invention allows a patient-specific skull and brain model to be constructed to match an individual's anatomical specifications.

The biomimetic test model is accompanied by a plurality of sensors and high-speed cameras, which are used to detect impact-induced brain injuries. This enables an in-depth study of the brain, unlike any other testing device in its class. Such a model and approach allow the examination of the flow and pressurization of the cerebrospinal fluid flow (CSF) in the subarachnoid spaces (SAS) as the head is exposed to sudden external impacts. Further, deformations or stretching of the brain can also be observed because of the see-through model design.

An impact element is configured to simulate different types of impact surfaces and orientations. This includes both translational and rotational impacts, which may be tested individually or simultaneously. For example, an impact element may include or simulate concrete, the ground, metal, a bat, a ball, a vehicle, a person's head, or other impact elements. An actuator can precisely control the impact element to provide consistent impacts on the simulated head model, the consistent impacts having consistent physical parameters, including but not limited to impact velocity and acceleration.

Opportunity

The inventor believes this invention is highly valuable for studying patient-specific pathology. The apparatus and testing methods can be used to provide predictable results in locating the potential areas of the brain that sustain injury. Such capability better informs care providers in understanding the type of possible injuries their patients suffer and how best to treat them; at the same time reducing the number and amount of whole brain scans currently required.

[1] *Concussions Facts and Statistics.* University of Pittsburgh Medical Center, no date.

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The global non-invasive brain trauma monitoring device market is forecasted to grow at a compound annual growth rate (CAGR) of 7.27% and is expected to reach $18.17 billion USD by 2028.[2]

In addition to clinical and research applications, this novel technology will enable development of the next generation of protective headgear. A product prototype can be placed on the head model, and impact testing can be performed. The results may guide designers to create better products to minimize or eliminate brain injury across multiple industries. Because skull and brain models can be constructed from anatomical data, products may be specifically tailored to the needs of an individual, for example, a professional athlete with a history of brain injuries. The level of personal precision offered by Dr. Wu's invention can ensure that protective gear is adequate to provide the best possible protection for athletes, warfighters, and other professionals.

Global Market Insights forecasts the international industrial head protection market to grow at a CAGR of 5% and reach $4.9 billion by 2032.[3] The sports protective equipment market is projected to grow at a CAGR of 5.2% and to reach a total value of $13.35 billion USD by the end of 2031.[4]

Unique Attributes

- Biomimetic skull and brain model with cerebrospinal and intracranial fluid aspects.
- Customizable skull and brain test models based on individual anatomical data.
- Ability to test both rotational and translational impacts independently or simultaneously.
- Ability to help predict the location of injury based on the specific type of impact.

Applications

This invention is expected to enable researchers and product developers to further understand brain trauma and CTE due to its ability to analyze injury from repeated impacts at various sub-concussive and concussive levels. It provides valuable insight for scientific research, and can be a valuable tool to inform product designers seeking to develop better protective headgear in a wide variety of markets that include, but are not limited to, contact sports, construction and industrial applications, and military combat.

Stage of Development

Fully developed working prototype and Proof of Concept.

Intellectual Property

US Patent No. 11,559,245 issued January 24, 2023.

Licensing and Collaboration Opportunity

Villanova is seeking a licensee or collaborators to commercialize or further develop the invention.

INSTITUTIONAL CONTACT

Amanda M. Grannas, Ph.D.
Vice Provost & Chief Research Officer
+1 610.519.4881
amanda.grannas@villanova.edu

L2C PARTNERS CONTACT

Merle Gilmore, MBA
+1 610.662.0940
gilmore@l2cpartners.com

Alex Toglia, MS
+1 610.937.1067
toglia@l2cpartners.com

[2] *Non-Invasive brain trauma monitoring device market size…. Forecasts 2021 to 2028*. The Brainy Insights, 2020.
[3] *Industrial Head Protection Market…. Forecasts 2023 – 2032*. Global Market Insights, December 2022.
[4] *Sports Protective Equipment Market…. Forecasts 2022 – 2031*. Transparency Market Research, August 2022.