Development and Validation of a Detailed Finite Element Model of Human Eye for Predicting Ocular Trauma

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Opportunity and Significance

Approximately 2.5 million traumatic eye injuries occur each year in the United States. Eye injuries can be caused by blunt, penetrating and blast trauma to the eyeball, orbit or through the face. Eye trauma in sports is most frequently resulted from ball sport and contact sport. In car crashes, there were increased incident of eye injuries sustained by occupant due to an airbag deployment. The most ocular injuries sustained by causalities in the recent combat were related to explosive blast [1,2]. None of the published models incorporate eye within the orbit of an anatomically accurate head model

Technical Objectives

The current communication reports the development and validation of a detailed Finite Element eye model integrated with an anatomically inspired human head model that can be used to improve our understanding of the mechanism of ocular, orbital, maxillo-facial injuries in blunt trauma.

Related Work and State of Practice

In current practice, experiments are being performed on animal eyes like pig, monkey, rabbit to know the extent of injury occurred. This leads to unnecessary killing of animals. As an educated Human being , I thought of creating a computer software model which can reproduce the same results as of experimental tests.

Technical Approach and Results

FE Human Eye Model:

Geometry: the detailed FE model of human eye was developed using eye geometry data [3].

Mesh of anatomical structures:

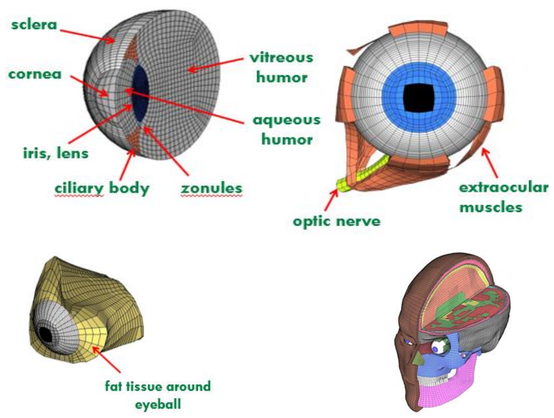
- Eyeball: Intraocular components
- Six extraocular muscles
- Optic nerve
- Fat tissue

Mesh resolution:

Over 28,000 elements, 95% hexahedral
Average element resolution: 0.6 mm

Material properties:

Five different material models to simulate mechanical behaviors of the intraocular structures, muscles, optic nerve and fat tissue with their material properties based on the literature.



eyes integrated to the head model

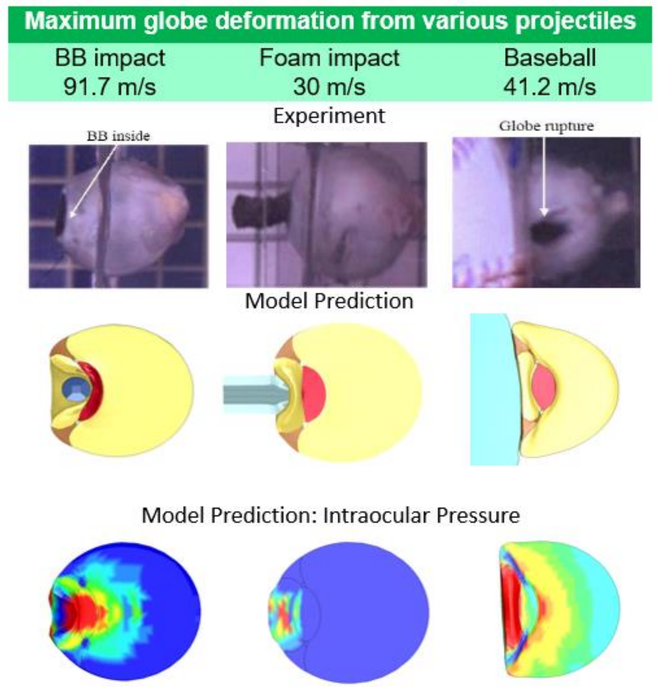
Mesh tools:

Hypermesh by Altair (Troy, MI), ANSA by BETA (Greece), Meshwork by DEP (Troy, MI)

Model Validation

Model Validation:

- Mechanical responses predicted by the model were validated against experimental measurements from cadaveric eye impact tests from different projectile types and impact velocities [2].



References

[1] Uchico et al., 1999, Br J Ophthalmol, 83(10):1106-11.
[2] Stitzel et al., 2002, Stapp Car Crash J, 46:81-102.
[3] Woo et al., 1972, Ann Biomed Eng, 1:87-98.

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