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MULTI-SCALE MECHANICS OF TRAUMATIC BRAIN INJURY

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ABSTRACT

Traumatic brain injury (TBI) is considered as a widespread problem. The incidence and mortality rate in Europe are estimated to be 235 and 15.4 per 100,000 of the population per year, respectively.[1] To solve this problem, much research has been conducted in the field of TBI. A wide range of length scales from several micrometers at the cellular level to several decimeters at the head level are concerned with the development of TBI. The global kinematics at the head level cause deformation of the tissue, which is responsible for mechanical and physiological damage at the cellular level. However, a relation between these levels has not been established yet. This relation is important for the use of tissue and cellular level injury criteria together with head level mechanical loads. Therefore, the aim of this research is to focus on the connection between the different length scales involved in TBI.

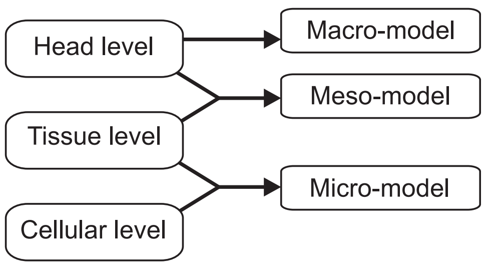

Figure 1: The length scales involved in TBI and the computational models for bridging these length scales.

The approach to bridge the length scales is schematically shown by Figure 1. Macro-models that predict the response of the head with geometrically homogeneous anatomical structures already exist.[2,3] However, these models lack the detailed anatomy of the heterogeneous structures within the head. Therefore, a meso-level model connecting the head level to the tissue level has been developed. The main objective of this model is to investigate the mechanical influences of the convolutions of the cerebral cortex during a mechanical load on the head. Stress concentrations of 1.3-1.9 with respect to the homogeneous reference situation have been found, indicating that tissue-based injury criteria cannot be applied directly to current numerical head models.

A microstructural model bridges the tissue level to the cellular level. At this level, mechanical loading of neurons can be coupled to physical injury mechanisms. Furthermore, by using a homogenization method, the material behavior at the tissue level can be related to microstructure of the tissue.

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