KTH SOLID MECHANICS SEMINAR; Tuesday, November 10th, 13.15; KTH Solid Mechanics Seminar room

# Svein Kleiven

# "Computational Modelling of Human Head Injuries"

In spite of several preventive strategies, there has not been an important impact on the burden of head injury world-wide. Consequences of head injuries are not limited to the victim alone but have impact on the society as a whole through the large costs involved, not to mention the tragedies and the suffering. It should be noted that very little is understood about the true mechanisms associated with head injury, but many theories exist. Implementation or modification of security systems (such as a new car model) is now a long and complex process. In recent years, biomechanical simulation models of head and human body acquired an increasingly larger place in the design of safety systems. One of the advantages with the finite element (FE) method is the possibility to model the anatomy with great detail, thus it is possible to study the kinematics of the head as well as the stresses and strains in the Central Nervous System (CNS) tissues. This presentation primarily focuses on summarizing current efforts, and to outline future strategies in human head injury modeling. Non-linear, anisotropic and viscoelastic models are derived for the CNS and meninges and their importance's for injury prediction is outlined. Multiple length scales are involved in the development of traumatic brain injury, where the global mechanics of the head level are responsible for local physiological impairment of brain cells (Fig.1). In a multi-scale approach, finite element models of the head and the axonal level are coupled, where it is observed that the maximum axonal strains do not always correlate directly with the brain tissue strain levels. The results indicate that cellular level heterogeneities have an important influence on the axonal strain, leading to an orientation and location-dependent sensitivity of the tissue to mechanical loads. It is concluded that constitutive modeling, skull-brain interface conditions, multi-scale modeling and authentic anatomical representation needs further investigation. However, using proper material characterization, correct boundary conditions and detailed geometric representation, a finite element model of the human head can provide us a powerful tool. Application of the FE head model to reconstructions of accidents and suspected child abuse (Fig.2) and homicide cases involving head traumas will also be discussed.

Svein Kleiven's research focuses on injury biomechanics and especially biomechanics resulting from external violence to the human head. Professor Svein Kleiven has more than 15 years of experience in dynamic, non-linear FEA, and head injury biomechanics. He has a PhD in Biomechanics, B.Sc. in Automotive Eng., M.Sc. in Mechanical Eng. and in 2013 he was appointed to Professor by KTH – Royal Institute of Technology, Stockholm, Sweden. He is Director of the Doctoral Programs in Technology and Health and Applied Medical Engineering at KTH, and the Director of a Joint Doctoral Program between Karolinska Institute and KTH in Medical Technology. He is currently Associate Editor of SAE International Journal of Transportation Safety and Frontiers in Bioengineering and Biotechnology, Editorial board member of Journal of Applied Mathematics and ISRN Biomedical Engineering, and Scientific Review Committee member for IRCOBI. Two book chapters and more than fifty peer-reviewed journal and proceedings articles on the topic of head injury modelling and head injury biomechanics have been published to date by Prof. Kleiven. The Neuronic engineering group at KTH is the result of an interdisciplinary collaboration with Karolinska University Hospital. The research primary focus on head and neck injury prevention and improving the clinical neuro-surgery treatment results with simulations and innovations.

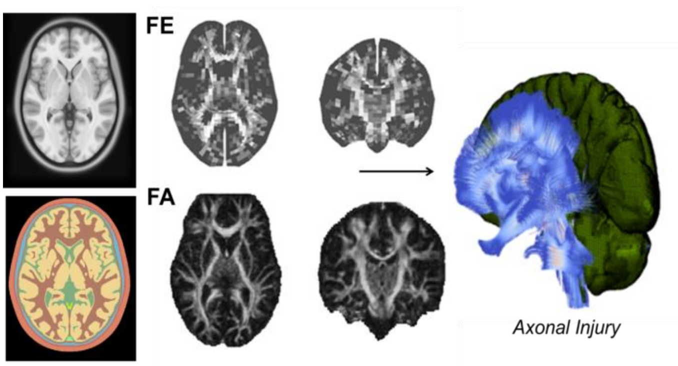


**Figure 1:** Connecting Fractional Anisotropy (FA) from medical images with mechanical anisotropy in a non-linear and anisotropic constitutive model using the Finite Element (FE) method.

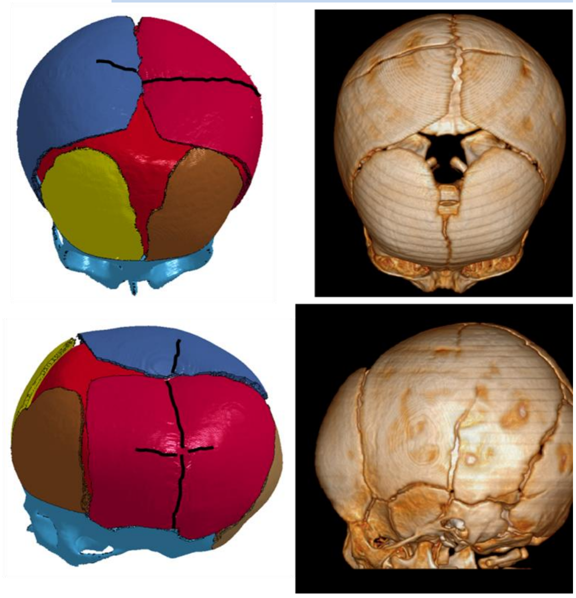

**Figure 2:** Comparison of predicted fracture patterns in FE analysis of infant skull fracture.