In-Vivo Soft Tissue Biomechanics: Experimental Investigation and Computational Modelling

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This presentation focusses on: 1) the state of the art of non-invasive techniques to study the mechanical properties of soft tissue in-vivo, and 2) the application of computational modelling of soft tissue in prosthetic device design.

MRI based indentation studies are discussed, which when combined with inverse finite element analysis (FEA) allow for the determination of global non-linear elastic behaviour. The most detailed modelling efforts incorporate MRI derived anatomical structure and skeletal muscle fibre architecture. In addition novel fibre density image data is incorporated offering spatially varying constitutive behaviour for FEA.

Furthermore MR Elastography (MRE) is treated which (through inversion of harmonic wave propagation data) offers a more direct method of soft tissue stiffness assessment. MRE allows for the assessment of high resolution and spatially varying stiffness data. This enables the detection of stiff masses and tissue damage in pathology. However the applications of MRE for large strain FEA are limited due to the current assumptions underlying inversion.

Finally a novel application of FEA of soft tissue biomechanics is discussed: a computational modelling framework for the automated design and biomechanical evaluation of patient specific prosthetic sockets.

Short bio:

Kevin M. Moerman is a biomechanical and design engineer. After completing a Bachelor in Mechanical Engineering he worked as a design engineer of robotic systems. He then decided to pursue a Master's degree in Bioengineering at Trinity College Dublin to learn how to apply his engineering skills in understanding and augmenting the human body. Being fascinated by the union of fundamental science, engineering, and advanced computational methods he stayed at Trinity College to obtain a PhD in Bioengineering. The topic of the PhD was the creation of an experimental, and computational modelling framework for the non-invasive analysis of the mechanical properties of human soft tissue. He is currently a post-doctoral research fellow at the Academic Medical Centre in Amsterdam, working on novel imaging and analysis techniques to understand soft tissue biomechanics related to pressure ulcer development. He holds a visiting research fellow position at Trinity College Dublin collaborating with Dr. Ciaran Simms on computational modelling of soft tissue mechanical behavior. He is also a research associate at MIT where together with Prof. Hugh Herr he works on finite element analysis based design and evaluation of comfortable prosthetic sockets which minimize soft tissue loading.