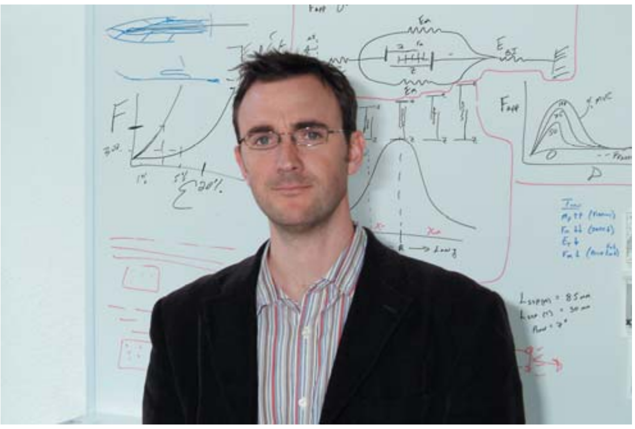
Institute of Biomechanics

Professor Jess Snedeker



Orthopedic Biomechanics – Today's Research, Tomorrow's Patient Therapies

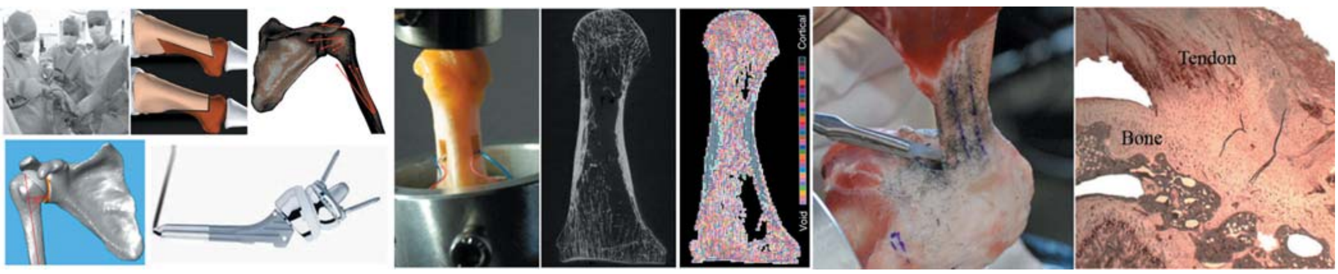
Jess Snedeker is a dual professor at the University of Zurich, Department of Orthopedics and ETH Zurich Department of Mechanical Engineering. His research group is located at the University Hospital, Balgrist, in close proximity to orthopedic patients and their surgeons. The projects undertaken and realized within Professor Snedeker's group are clinically motivated and seek to develop improved surgical and therapeutic approaches.

Professor Snedeker received his Bachelor of Science in Mechanical Engineering from Lehigh University in 1995. After several years in industrial research and development, he returned to academic research and earned his Masters of Science in Bioengineering from Penn State University in 2000, and his doctorate in Mechanical Engineering from the ETH Zurich in 2004. He was appointed as Assistant Professor at the University of Zurich in September 2006, and to the ETH Zurich in August 2008. The Snedeker group focuses on the development of numerical models of biological systems and the multi-scale (organ, tissue, cell) experiments validating them. The group is relatively young, but has received various international awards for their work.

Clinical Biomechanics: Systematically improving today's surgical treatments

Today's orthopedic surgery offers pain relief and a return to function from a wide range of degenerative skeletal disorders. However, surgical techniques and technologies are constantly evolving and certain joints (like the shoulder) are beset by some persistent problems that have no adequate therapeutic solution. We seek to fills these gaps through the development of fresh clinical concepts.

A considerable part of clinical innovation arises in the operating room itself, and our group actively collaborates with in-house surgeons to devise new treatments, test their potential efficacy, and develop them into practicable therapeutic approaches. We examine clinical problems and potential solutions in quantitative terms, applying high-precision measurement techniques and high-resolution computational models to identify and explore the important biological and technical factors at work. For example, we have performed parametric modeling studies of osteotomy design, quantifying the biomechanical consequences of bone cut geometry on the way that fragments are likely to bear load post-operatively and eventually heal. We have also investigated various commercial joint prostheses,



Clinical research at the Uniklinik Balgrist: Shoulder mechanics, surgical strategies for the foot, tendon to bone healing of the rotator cuff tendons critically evaluating implant systems with regard to robustness of primary fixation in bone, mechanisms for long-term implant loosening, and biomechanical consequences of implant design on joint function.

Tendon structure and function: Understanding the processes of disease, injury and healing

Tendon disorders continue to be among the most common medical conditions for which treatment is sought and they are associated with huge societal and economic costs. Injuries of certain tendons like those of the rotator cuff muscles can seriously compromise an individual's ability to perform daily activities and drastically reduce one's quality of life. Unfortunately, many cases of tendon injury cannot be adequately treated by even our best available therapies.

The Snedeker group is interested in developing advanced tendon therapies through a basic understanding of the relationship between tendon ultra-structure and function. Specifically, we investigate how tendon cells sense and interpret mechanical forces, and respond to those forces by the creation of the extra-cellular matrix that gives tendon its functional integrity. Our work centers on the belief that molecular cross-linking of collagen holds a large therapeutic potential that has yet to be sufficiently exploited. To explore the potential functional impact of collagen cross-linking, we implement large-scale numerical models of tendon at the protein level, and validate these models with appropriate experiments.

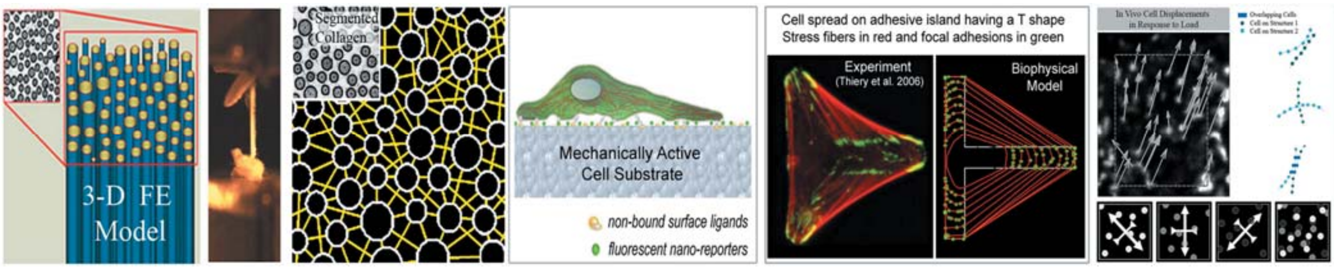
Through the help of small animal models, we are characterizing the biological sequences of tendon healing, hoping to identify critical cell-sensing mechanisms and cell-signaling pathways that may be augmented through therapeutic intervention. Our approach is to use micro-designed biomaterials that provide specific mechanical and/or biochemical cues to healing cells that stimulate tissue growth and formation of a robust and sustainable extra-cellular matrix. The Snedeker group is engaged in active collaborations with biomaterial scientists to attain these goals.

Cell mechanics in disease diagnosis and regenerative medicine

It is becoming increasingly clear that static and dynamic forces play key roles in the extremely complex biochemical and biophysical processes that underlie cell function. Cell mechanics can be involved in aberrant cell processes lying at the roots of disease, but also offer opportunities as focal points for therapeutic intervention.

The Snedeker group is creating novel experimental and computational platforms for quantifying cellular level forces (cell-matrix interactions) and how cells respond to those forces (cell differentiation, protein synthesis, and extra-cellular matrix production). This work is performed with the longer term aim of applying cell-mechanics within a tissue-engineering framework to intelligently guide cells to regenerate tissues of improved mechanical competency and long term viability.

We also focus on the use of cell mechanics as a diagnostic and research tool for characterizing diseases like osteosarcoma (bone cancer). Cancer metastasis depends on changes in functional cell behaviors such as adhesion and migration that are associated with changes in cell phenotypic cell elasticity and viscoelasticity. A large part of the group is dedicated to developing unique tools to characterize cell properties in 2D and 3D culture, as well as *in vivo.*



Basic research: Molecular models of tendon structure function; cell mechanics models and experiments