Title: **Multi-scale mechanics of the tendon-to-bone attachment**

Authors: Stavros Thomopoulos, Victor Birman, Markus J. Buehler, Ioannis Chasiotis, Mark Anastasio, Pedro Ponte-Castañeda, Asa Barber, Alix C. Deymier-Black, Yizhong Hu, Fatemeh Saadat, Guy M. Genin

Presenter: Stavros Thomopoulos

Successful repair of tears to the rotator cuff and anterior cruciate ligament requires re-attachment of tendon to bone. Outcomes after surgical repair, however, are generally poor, approaching 94% failure rate in the case of massive rotator cuff tears in the elderly population. The root of these failures is the challenge of attaching two materials, tendon and bone, with vastly different mechanical properties. The natural transitional tissue between tendon and bone meets this challenge through unique mechanisms that create a strong and tough attachment. Unfortunately, the healing attachment does not regenerate this transitional tissue. Our aim is therefore to develop multiscale models to better understand this natural material system, with the hope of guiding tissue engineering approaches for enhanced healing in the long term and to aid with treatment decisions in the short term. Experimentally, we are testing hypotheses that the interface at the tendon-to-bone insertion presents toughening mechanisms through: i) nanometer- to micrometer-scale spatial gradients in mineral content and collagen fiber organization, ii) a micrometer scale compliant region, iii) a micrometer scale interdigitation geometry, and iv) a millimeter scale footprint area with a splayed insertion morphology. Through multiscale models, we are testing hypotheses that: i) gradients in collagen orientation and patterns of mineral accumulation explain the compliant region, ii) percolation of mineral on collagen fibers determines the nature of stress transfer between tendon and bone, iii) a compliant region and interdigitation geometry minimizes stress concentrations and toughens the attachment between tendon and bone, and iv) a large attachment footprint and splayed insertion geometry improve load transfer by reducing stresses at the interface. Ongoing efforts are combining models of collagen-mineral interactions at the nanoscale with data for collagen orientation and mineral content at the microscale to produce a multiscale assessment of tendon-to-bone insertion mechanics. Early results suggest initial guidelines for tissue engineering efforts and for efforts to identify metrics of tendon-to-bone tissue health.