Mechanics, Imaging, and Biology: Towards a multi-faceted approach to understanding health and disease in orthopedic soft tissues

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Orthopedic disorders account for over a third of disabilities reported in American adults, resulting in significant direct medical costs as well as indirect socioeconomic losses. Most prevalent among these orthopedic disorders is osteoarthritis, which can be thought of as a whole joint disease, wherein the mechanics and metabolism of each component tissue interact in vivo.

Noninvasive techniques are important to assessing in situ biomechanical behavior. Utilizing magnetic resonance imaging to measure cartilage displacements under applied loading (dualMRI), internal tissue deformations can be visualized without the insertion of sensors. First applied to orthopedic tissues and with physiologically relevant loading conditions on high-field research MRI systems, dualMRI has since been implemented on a large-bore, clinical scanner, permitting the measurement of in vivo cartilage deformations in healthy human volunteers.

Although human subjects can provide a good “snapshot” of disease progression, a controlled scientific study in humans can be expensive and lengthy. Using inbred mice for disease models provides a highly consistent subject population and the means to target specific metabolic pathways of interest. To study the effect of a cartilage injury on the joint, defects in the cartilage were generated in the patellar groove. Traditional histological and biochemical approaches were used as “gold standards” in developing and evaluating this animal model. Ongoing work integrates noninvasive imaging and longitudinal functional assessments in examining the injury response in this model. The goals and techniques of these multi-disciplinary studies converge towards the development of a multi-faceted approach to assessing, predicting, and treating degenerative soft tissue diseases.