Ultrasoundimaging is commonly usedclinically to identify abnormalities in tendon geometry, fibrillarpattern andechogenicity. It can be challenging, however, to use these structural features todetect localized pathologies, such as partial tendon tears.Therefore, the measurement of tendon deformation could enhance the sensitivity of ultrasoundby allowing for the directevaluation of theintrinsic relationship between tendon structure and function.

We areinvestigating the use of ultrasound elastography to map tendontissue deformation duringfunctionalloading.To adapt traditional elastography techniques for this purpose, there are four specific challenges that must be addressed. First,it is necessary to perform two-dimensional motion tracking to account for the substantial tendonmotionand deformation that occurs with movement.Secondly,cumulative tissue deformations over time should be computed to characterize the nonlinear behavior of collagen tissue. Thirdly, it is imperative to use collection procedures that minimizemotion into and out of the imaging plane.Finally, the simultaneous measurement of external loading and motion data is important to relate tissue deformation to the overall biomechanical loading of the muscle-tendon unit.

We have addressed these challenges by: a) collectingcineRF (radiofrequency) data from tendons duringwell-controlled repeatable loading paradigms, and b) developing a mesh-based tracking algorithm for computingtwo-dimensional tissue deformation from the RF data.In our tracking algorithm, incrementalpixel displacements are first computedusing two-dimensional elastography techniques. A finite element mesh is then overlaid onto the visible tendon and nodal displacements are estimated by averaging nearby pixel displacements. Cumulative motion is obtained by integrating the incremental displacements in both forward and backward directions, with cyclic constraints imposed to offset errors that can occur with drift. The nodal displacement data are then spatially differentiated to estimate cumulative strain in the along-fiber and transverse directions.

To date, we haveperformed both *ex vivo* and *in vivo* experiments using these RF collection and analysis techniques. In the*ex vivo* tests,RF data were collectedat 63 Hz during 4%cyclic loading of porcine flexor tendon. The results were encouraging, with the computed tissue motion and strain patterns closelymimicking theoverall stretch andloading of the tendon. We have since constructed an inertial loading device that induces repeatable Achilles tendon loading in response to sagittal ankle motion. Our initial results suggest that systematic strain patterns exist across the tendon with greater tissue strain in the superficial regions. Interestingly, lower strain areas correspond to regions where partial tendon tears are often seen, raising interesting questions about the mechanisms of localized injuries.We conclude that the use of an elastographic technique to image tendon deformation may prove useful for both identifying tendon pathologies and investigating the underlying mechanisms of injury.

Learning Objectives:

1. Recognize the clinical relevance of assessing tendon mechanics

2. Understand the challengesand potential in using ultrasound elastography to measure tendon deformation