X-ray fiber diffraction to elucidate tissue transition and changes to molecular packing in relation damage

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The human body is a complex machine that relies upon controlled inter and intra cellular interactions that are often very difficult to understand and model. Although the body has the ability to repair disruptions to these processes, extensive damage caused by injury (chemical, physical and/or biological) often leads to pathological manifestations. Traumatic brain injury (TBI) alters myelin structure and packing and may result in mild to severe loss of function (based on extent of load) and a diminished quality of life as a result. Moderate to severe TBI is generally diagnosed using medical imaging (MRI and/or CT scans) which provide data at a millimeter level spatial resolution at best. However, in the case of mild or 'invisibile' TBI, physical damage leading to irreversible deformation of myelinated fibers may occur at significantly lower load levels and can go undetected by these imaging techniques.

Over the last several years, significant progress has been made in understanding the nature and extent of mechanical trauma required to bring about permanent damage to tissues and organs. With easier access to computing resources and abundance of patient medical data, trends in impact vs. tissue damage are becoming more evident. To capture a well-rounded picture of this process, it is important to understand the changes at a molecular level (nanometer or angstrom scale) as damage may occur at a significantly lower impact level that does not necessarily manifest at lower resolution (mm) scale.

Synchrotron X-ray diffraction has been proven to be able to capture these nm and Å level changes in situ. It also has the added benefit of requiring minimal sample preparation and can be used to scan larger sections of tissues unlike other molecular imaging techniques such as electron microscopy. Previous efforts in developing high resolution tissue transition models and annotating them to tissue level mechanical characteristics will be presented in this talk. The use of these methods to determine the material and mechanical characteristics of neurological tissues will also be presented with recent data from non-loaded and loaded myelinated fibers.