Effects of tissue hydration on nanoscale structural morphology and mechanics of individual Type I collagen fibrils in the Brtl mouse model of Osteogenesis Imperfecta

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Abstract:

Type I collagen is the most abundant protein in mammals, and is a vital part of the extracellular matrix for numerous tissues. Despite collagen's importance, little is known about its nanoscale morphology in tissues and how morphology relates to mechanical function. This study probes nanoscale structure and mechanical properties of collagen as a function of disease in native hydrated tendons. Wild type tendon and tendon from the Brtl/+ mouse model of Osteogenesis Imperfecta were investigated. An atomic force microscope (AFM) was used to image and indent minimally-processed collagen fibrils in hydrated and dehydrated conditions. AFM was used because of the ability to keep biological tissues as close to their native in situ conditions as possible. The study demonstrated phenotypic difference in Brtl/+ fibril morphology and mechanics in hydrated tendon which became more compelling upon dehydration. Dried tendons had a significant downward shift in fibril D- periodic spacing versus a shift up in wet tendons. Nanoscale changes in morphology in dry samples were accompanied by significant increases in modulus and adhesion force and decreased indentation depth. A minimal mechanical phenotype existed in hydrated samples, possibly due to water masking structural

defects within the diseased fibrils. This study demonstrates that collagen nanoscale morphology and mechanics are impacted in Brtl/+ tendons, and that the phenotype can be modulated by the presence or absence of water. Dehydration causes artifacts in biological samples which require water and this factor must be considered for studies at any length scale in collagen-based tissues, especially when characterizing disease- induced differences.

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