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Resilience through weakness: Tendon, bone, and nature's most severe tensile attachment

Joining of dissimilar materials is a fundamental challenge in engineering. Nature presents a highly effective solution at the attachment of tendon to bone in the rotator cuff of the humeral head. This is of interest in surgical practice because of challenges associated with rotator cuff repair, where failure rates as high as 94% are observed following surgical repair of massive tears in elderly patients. We believe that these high failure rates are related to the inability of the natural tissue to re-grow following injury, and consider the highly effective natural system to be a model for engineering attachment. To engineer a replacement tissue for the tendon-to-bone insertion or to develop treatments for tendon-to-bone healing, we first need to understand hierarchical structure-function relationships and how they develop at the natural interface between tendon and bone. Our current work suggests that at the center of these is a cross-scale toughening mechanism whereby competing phenomena at the nanometer and micrometer scales combine to produce a millimeter-scale band of tissue between tendon and bone that is more compliant than either.

The goal of this work, like the goal of this conference and of OMICS' new Journal of Material Sciences & Engineering, is to bring together knowledge across a broad range of disciplines to inform and direct both engineering and surgical practice. The talk will focus on recent efforts to characterize, understand, and regenerate the cross-scale toughening and stiffening mechanisms that exist at the natural tendon-to-bone insertion site.

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