Test Research Leads to a Better Understanding of Tissue Engineered Cartilage

The Challenge:

Quantify the Pre-failure and Failure Mechanical Properties of Articular Cartilage

Background

Cartilage is a remarkably complex biocomposite material that exhibits outstanding compressive stiffness, toughness, strength, resiliency, and shock absorption. Diseases such as osteoarthritis damage the tissue, leading to changes in mechanical properties.

Accurate characterization of these properties and relating them to changes in tissue microstructure is an appealing means to understand the importance of microstructure on the disease process. This may in turn guide diagnosis and treatment. This is especially true for failure properties, since cracks in cartilage do not heal. Cartilage fracture is an irreversible process. Understanding the connection between microstructure and mechanical properties can also be useful in the engineering of cartilage replacement tissue.

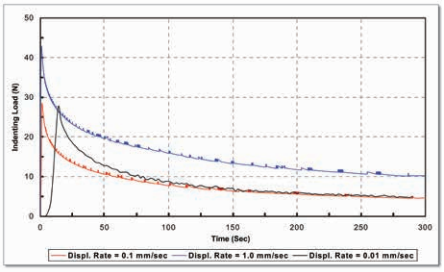
Meeting the Challenge

The goal of this work is to develop methods for characterizing failure properties of native cartilage and engineered cartilage constructs, including fracture and fatigue, and show how these properties vary with changes in tissue micro-structure.

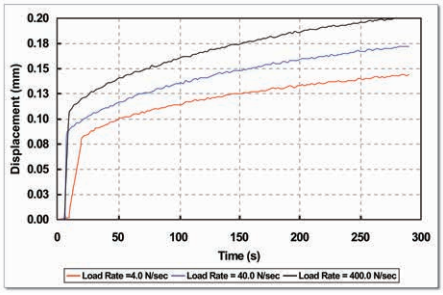
Researchers at the University of Minnesota, under the guidance of Dr. Jack Lewis, have been reviewing the issues of characterizing the mechanical properties of articular cartilage. In order to quantify the properties, cartilage must be tested in a unique dynamic loading system capable of providing precision creep capabilities while also providing a dynamic loading component during the same cycle. The ElectroForce® 3200 test instrument provides the capabilities required in a compact tabletop package.

Specimen preparation and preloading are important as articular cartilage has both a short time viscoelastic behavior and a long time constant for fluid retention. Cartilage tissue in vivo is under a constant compressive load with superimposed dynamic loads.

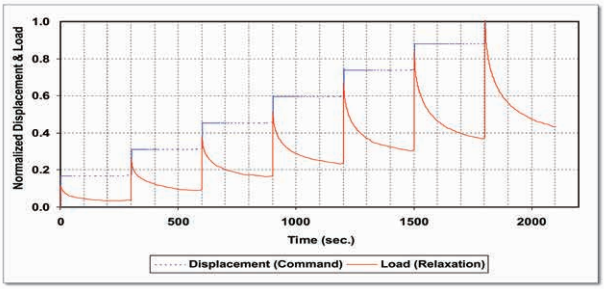
This complex loading profile needs to be duplicated in the in vitro test. Once the specimen has been stabilized and creep has been taken into account, dynamic loading is introduced to characterize the pre-failure properties. Focus will then be on failure properties. Methods to measure fracture toughness and fatigue strength are being developed. This requires large displacements during cyclic loading, a feature for which the ElectroForce 3200 instrument is especially suited.



Bovine Cartilage Indentation Relaxation Test with Different Loading Rates



Bovine Cartilage Indentation Creep Test with Different Loading Rates



Stress Relaxation in Indentation Test with Multi-step Loading

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