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Compressive Properties of Cartilage

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The main polymeric components of cartilage extracellular matrix, proteoglycans (PGs) and collagens, govern the biomechanical properties that vary with growth, aging, disease conditions, etc. Nearly 90% of PGs is the bottlebrush shaped aggrecan, which forms complexes with hyaluronic acid (HA) and link protein. The negatively charged PGs provide high osmotic swelling pressure. In contrast, the collagen network counterbalances the osmotic swelling pressure. The large aggrecan-HA complexes are entrapped within the collagen network. The aggrecan monomers contain many sulfated glycosaminoglycan chains (GAGs), such as chondroitin sulfate (CS) and keratan sulfate (KS). The electrostatic repulsion of negatively charged GAGs as well as the fix charge density due to the CS and KS chains also contributes to the compressive resistance of the tissue. It is known that the compressive properties of cartilage vary with depth from the articular surface to the bone.

A fundamental understanding of cartilage swelling and mechanical behavior is critically important for the engineering of replacement tissue. Our laboratory conducted exhaustive testing of cartilage samples (2.5 years old bovine cartilage) using complementary experimental techniques. The mechanical response was measured by the Atomic Force Microscope. Osmotic swelling pressure measurements were made by a novel Tissue Micro-Osmometer. Elastic and osmotic modulus maps of cartilage samples were constructed as a function of depth from the articular surface.