250th American Chemical Society National Meeting
August 16-20, 2015, Boston, MA

Division of Biological Chemistry, Abstracts

Supramolecular organization of cartilage extracellular matrix

Ferenc Horkay[1], Iren Horkayne-Szakaly[1], Emilios K. Dimitriadis[2], Peter J. Basser[1]

[1]Section on Tissue Biophysics and Biomimetics, Program in Pediatric Imaging and Tissue Sciences, Eunice Kennedy Shriver National Institute of Child Health and Human Development, National Institutes of Health
13 South Drive, Bethesda, MD 20892, USA

[2]Laboratory of Bioengineering and Physical Science, National Institute of Biomedical Imaging and Bioengineering, National Institutes of Health
13 South Drive, Bethesda, MD 20892, USA

Cartilage has multiple biological functions. It helps to distribute the loads between bones and provides a contact surface with low friction and wear. Cartilage exhibits elastic (gel-like) behavior and acts as a shock absorber. Approximately 80% of the weight of cartilage is water. The solid material is composed mainly of proteoglycans and collagen. The main cartilage proteoglycan is aggrecan. The proteoglycans bind to hyaluronic acid and form very large aggregates. Cartilage composition varies through the depth of the tissue. Collagen forms a network that makes up 60 to 70% of the dry weight of the tissue. It provides both tensile strength and toughness in cartilage. Proteoglycan aggregates govern the weight-bearing properties. Proteoglycan concentration is the lowest near the articular surface. In the deeper zones, near subchondral bone, the proteoglycan concentration is greater.

Unlike many other tissues, cartilage has a very low self-repairing capacity. A number of age-related changes in cartilage have been documented. For example the capability of proteoglycans to form large aggregates is reduced and denaturation of the collagen is increased. Decrease of proteoglycan content leads to mechanical weakening of cartilage and the reduction of fixed charge density. The latter is required to maintain tissue hydration. A better knowledge of the physical-chemical interactions among the components of cartilage extracellular matrix is fundamental to our understanding of both normal joint function and its malfunction. We apply different experimental techniques to quantify the interactions. We use nanoindentation by the atomic force microscope (AFM) to determine how cartilage as a complex structure responds to load. We have constructed a tissue micro-osmometer that allows us to determine the osmotic swelling pressure of very small (< 1 microgram) tissue specimens. We developed a method to map the osmotic modulus of cartilage by combining AFM nanoindentation with tissue micro-osmometry.