Joint cartilage dissipates load and enables almost frictionless movements. It is organized as a composite tissue to withstand the compressive forces and shear stresses of daily living. Its reinforced fibril-network consists primarily of type II collagen and aggrecan. Aggrecan consists of a core protein to which negatively charged glycosaminoglycans (GAG) are attached. Due to the high fixed charged density of the GAG, water is drawn into the tissue generating a swelling pressure that is counteracted by the tensile properties of the collagen network.

A prerequisite for healthy cartilage with functional resilience and mechanical properties is molecular integrity maintained by the chondrocyte. It seems biologically reasonable that cartilage adapts to fulfill mechanical demands. Morphologically intact cartilage may have different molecular content (quality) and thereby constitute different functional properties. Consequently, joint cartilage may have different capacity to resist loading demands and have different susceptibility to develop joint disease.

Our group has clinically developed a special magnetic resonance imaging (MRI) method called delayed Gadolinium Enhanced MRI of cartilage (dGEMRIC). It is based on the principle that a negatively charged paramagnetic contrast agent distributes in the cartilage in an inverse relationship to the likewise negatively charged cartilage GAG. Since the MRI signal is related to cartilage contrast concentration, joint cartilage GAG content can be estimated.

Recent research progress in molecular imaging by dGEMRIC show that in healthy volunteers, there is a significant relationship between level of physical exercise and cartilage T1Gd (GAG content) indicating human knee cartilage has an adaptive capacity. That is, in order to resist increasing joint loads the cartilage increases its GAG content to improve the biomechanical properties. In a randomized trial in middle-aged subjects previously meniscectomized due to a degenerative meniscus tear, dGEMRIC indicated that exercise intervention for four months increased knee cartilage GAG content. This further confirms that adult human articular cartilage can adapt to loading change and that exercise treatment may improve knee cartilage quality middle-aged subjects. dGEMRIC also suggests a relationship between weight, muscle strength, and cartilage GAG content.

In patients with anterior cruciate ligament injuries, common in sports, dGEMRIC shows that although such an injury causes a contusion in the lateral femoral condyle, there is a general GAG loss from the joint cartilage. This suggests that a broad metabolic change is initialized by the injury that may have significance regarding rehabilitation and the time point for return in sports. A new dGEMRIC examination of these subjects two years after the injury reveals that the cartilage in the medial compartment has still not recovered from the GAG loss that occurred at the injury. It is in the medial compartment that ACL injured subjects are at risk to develop osteoarthritis (OA). This suggests a possible molecular correlate to the OA risk and that subjects with low cartilage GAG content need further rehabilitation before they attend physical demanding sports in order to minimize the risk of joint cartilage disease.

Keywords: Cartilage, Adaptation, Exercise