Low-field NMR profiling and relaxation dispersion as new biomarkers for osteoarthritis in articular cartilage

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The dependence of the proton NMR relaxation times on field strength and on location within the tissue has been determined for a number of bovine and human articular cartilage samples. While the strong variation of T2 across the triple-layered cartilage structure as well as its orientation dependence are well known from clinical and laboratory high-field studies, T1 shows similar behavior only in low magnetic fields. At 0.27 T, the ratio of longest to shortest T1 has been found to cover a ratio of about 3-5 in healthy tissue, less in osteoarthritic tissue (see Figure 1). At the same time, the average T1 was found to be strongly field dependent in the range down to 0.25 mT, but no spatially resolved data are available under these conditions.

Parameters obtained from a low-field and variable-field study are correlated with the severity of osteoarthritis and interpreted based on models of biomolecular mobility. Furthermore, by correlating the spatially resolved T1 distribution obtained at field strengths of 0.27 T with mathematical decompositions of the signal recovery function into multiexponential components, an attempt is made to quantify the width of P(T1) for variable field strengths, and to identify the field value where this distribution is widest. This field is optimally situated for obtaining P(T1) as a biomarker for laboratory studies or preclinical low-field investigations where spatial resolution is absent or insufficient to resolve the cartilage layer structure.