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 T_2 across the triple-layered cartilage structure as well as its orientation dependence are well known from clinical and laboratory high-field studies, T_1 shows similar behavior only in low magnetic fields. At 0.27 T, the ratio of longest to shortest T_1 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 T_1 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 T_1 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 $P(T_1)$ for variable field strengths, and to identify the field value where this distribution is widest. This field is optimally situated for obtaining $P(T_1)$ as a biomarker for laboratory studies or preclinical low-field investigations where spatial resolution is absent or insufficient to resolve the cartilage layer structure.