INTRODUCTION:

The degradation of articular cartilage can be monitored in MRI by two quantitative parameters T2 and T1ρ [1-2], each having its unique characteristics related to the mobility and concentrations of the macromolecules in the tissue. This project concerns the depth and orientational dependencies of both T2 and T1ρ sensitivities in cartilage, in the absence and presence of the contrast agent Gd-DTPA2- in the tissue. Both native and trypsin-degraded articular cartilages were imaged at microscopic resolution (13 µm transverse resolution). The influence of the specimen orientation in the magnet and the dependency of T1ρ on the strength of the spin-lock field were both being considered.

METHODS:

Three pairs of canine humeral tissue blocks were prepared from three mature and healthy dogs. The specimens were first imaged by the same µMRI protocols as their own controls. After the initial MRI, one specimen from each pair was immersed in 1mM Gd-DTPA2- (Magnevist, Berlex, NJ) solution in saline with 1% protease inhibitor (Sigma, Missouri) for more than 8 hours before the second MRI experiment. The other specimen in the pair was first soaked in 0.1mg/ml trypsin (Sigma, Missouri) solution for more than 8 hours to deplete proteoglycans and then soaked in fresh saline with 1% protease inhibitor to remove excess trypsin before repeating the MRI. After repeating the MRI, this PG-depleted specimen was immersed in the Gd-DTPA2- saline and subsequently imaged using the same protocol for the third time.

The µMRI experiments were carried out on a Bruker AVANCE II 7T/9 cm system, with an acquisition matrix of 256×128 (13×26 µm pixel resolution) and a slice thickness of 1 mm. The repetition time TR was 2 s for the specimens without Gd-DTPA2- immersion and 0.8 s for the specimens soaked in Gd-DTPA2- solution. The echo spacing in the CPMG T2-weighting segment was 1 ms and the number of echoes were 2, 4, 10, 30, 60 when the cartilage surface was perpendicular to the static magnetic field and 2, 14, 36, 60, 120 at the magic angle, respectively. The lengths of the spin-locking pulse were 2, 6, 12, 40, 80 ms when the cartilage surface was perpendicular to the static magnetic field and 2, 18, 40, 80, 140 ms at the magic angle, respectively.

RESULTS:

When the cartilage surface was perpendicular to B0, a typical laminar appearance was visible in T2 weighted images but not in T1ρ weighted images, especially when the spin-lock field was high (2 kHz). At the magic angle (55°) orientation, neither T2 nor T1ρ weighted image had a laminar appearance. The following images are from the native tissue.

The effects of trypsin digestion and Gd immersion are shown in Fig 2. Two interesting features can be identified when the tissue is digested in trypsin or immersed in the Gd-DTPA2- solution. First, the trypsin digestion causes the increase of T2 and T1ρ over the entire tissue depth, regardless of whether the specimen is at 0° (Fig 2a vs Fig 2e) or 55° (Fig 2b vs Fig 2f). Second, for the native tissue, the soaking of specimen in the Gd solution does not change T2 or T1ρ significantly (Fig 2a vs Fig 2c, and Fig 2b vs Fig 2d). However, the soaking of the degraded specimen in the Gd solution significantly reduces both T2 and T1ρ (Fig 2e vs Fig 2g, and Fig 2f vs Fig 2h).

DISCUSSION AND CONCLUSIONS:

T1ρ values were very sensitive to PG loss regardless of the specimen orientation in the magnet. The T2 sensitivity to PG loss, by comparison, depended on the fibril orientation (more sensitive at the magic angle than at 0°) and the depth of cartilage (at 0°, more sensitive at TZ than SZ and RZ; at 55°, nearly uniform sensitivity). Compared to a slight decrement between native tissue with and without Gd solution, there was a more significant change between degraded tissue before/after soaked in Gd solution. The presence of 1 mM Gd-DTPA2- reduced the sensitivity of both T2 and T1ρ to cartilage degradation.

SIGNIFICANCE:

The profiles of T2 and T1ρ were mapped out quantitatively in native and trypsin-degraded articular cartilage specimens, without and with the presence of 1mM Gd-DTPA2- and at both 0° and the magic angle.

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