T1rho MRI of Menisci and Cartilage in Osteoarthritic Patients at 3T

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Introduction The loss of glycosaminoglycans (GAGs) and breakdown of collagen are typical characteristics of early osteoarthritis (OA) (1). T1rho mapping has been shown to be sensitive to changes in cartilage proteoglycan loss (2). Previous studies have demonstrated that cartilage T1rho values are elevated in OA patients compared to corresponding healthy subjects (3, 4). Recent work has reported (5, 6) that T1rho values of the meniscus and the adjacent cartilage varies in healthy subjects and OA patients. The aim of this study was to assess and compare the compartment-wise T1rho values of menisci and cartilage with doubtful (Kellgren-Lawrence (KL) grade 1) to severe (KL4) OA at 3T.

Methods 30 subjects with varying degrees of OA (KL1-4, 13 females, 17 males, mean age $\pm$ SD = 63.9 $\pm$ 13.1 years) were recruited (7, 8). Approval for this study was obtained from the local institutional review board (IRB), and informed consent was obtained from all the subjects. All the MRI experiments were performed on a 3.0T clinical scanner utilizing an 8-channel phased array knee coil (transmit-receive). 3D T1rho-weighted images with parallel imaging (AF = 2) were acquired with TR/TE = 175/2.04 ms, spin-lock frequency = 300Hz, number of slices = 30, time of spin-lock (TSL) = 2/10/20/30 ms, slice thickness = 3 mm, matrix = 256X128, FOV = 15 cm, bandwidth = 260 Hz using the GRE sequence based on the spin-lock techniques (9). Mean cartilage T1rho values were evaluated in twelve compartments (LFa, LFc, LFp, LTa, LTc, LTp, MFa, MFc, MFp, MTa, MTc, MTp). Mean meniscus T1rho values were evaluated in six regions (lateral anterior, lateral central, lateral posterior, medial anterior, medial central, medial posterior). The Student's t-test was used to determine whether there were any statistically significant differences in T1rho relaxation times between the femoral-tibial cartilage and the corresponding adjacent meniscus (anterior, central, and posterior) in the lateral and medial compartments.

Results and Discussion Fig.1 showed representative T1rho maps of cartilage in the lateral (a) and medial (b) compartments, and T1rho maps of menisci in the lateral (c, d) and medial (e, f) compartments, respectively, obtained from a doubtful-minimal OA patient. The color bars on the right show the T1rho values ranges, respectively. Table 1 listed the T1rho values (ms) of cartilage (mean $\pm$ SD) based on KL and WORMS grading. Likewise, Table 2 listed the T1rho values (ms) of meniscus (mean $\pm$ SD) based on KL and WORMS grading. Statistically significant differences (P < 0.05) were identified between cartilage T1rho values of moderate-severe OA subjects in the lateral femoral anterior sub-compartment and doubtful-minimal OA subjects in the lateral and medial compartments. There were statistically significant differences in meniscus T1rho values of the medial posterior sub-region of subjects with moderate-severe OA and all sub-regions in the lateral and medial compartments of subjects with doubtful-minimal OA. When evaluated based on WORMS, statistically significant differences were identified in cartilage T1rho values between cartilage with WORMS0-1 in the lateral tibial central and medial femoral central sub-compartments and cartilage with WORMS5-6 in the lateral and medial compartments.

Fig.1

Table 1

T1rho values (ms) of cartilage (mean $\pm$ SD) based on KL and WORMS grading

	LFa	LFc	LFp	LTa	LTc	LTp	MFa	MFc	MFp	MTa	MTc	MTp
KL1-2	64±7	50±9	52±6	56±9	49±7	50±4	62±13	51±9	54±6	46±11	54±7	48±6
KL3-4	70±7	51±6	54±4	61±8	53±10	54±7	66±8	59±13	53±5	51±8	60±13	51±10
WORMS0-1	62±7	53±3	48±1	58±7	47±1	50±5	58±6	47±2	48±5	45±8	48±10	41±7
WORMS2-4	66±6	48±13	50±7	56±13	51±8	50±3	61±14	48±12	53±6	46±14	58±6	48±4
WORMS5-6	67±8	51±7	54±5	59±8	51±9	52±6	65±11	56±11	54±5	49±10	57±11	51±7

Table 2

T1rho values (ms) of meniscus (mean $\pm$ SD) based on KL and WORMS grading

	La	Lp	Lc	Ma	Mp	Mc
KL1-2	31±7	34±7	32±6	29±8	35±9	34±7
KL3-4	32±6	34±10	28±2	36±16	41±7	34±8
WORMS0-1	31±6	33±6	32±5	32±11	36±7	32±6
WORMS2-4	29±5	33±7	33±8	25±3	34±11	33±5
WORMS5-6	33±7	36±10	28±2	36±14	40±7	38±10

Conclusion The preliminary results suggest that there are significant differences in T1rho relaxation times of the lateral femoral anterior cartilage in subjects with moderate-severe OA (KL3-4) versus all the other cartilage sub-compartments in subjects with doubtful-minimal OA (KL1-2) (P < 0.05). There is also a statistically significant increase in the T1rho relaxation time in the medial posterior meniscus in subjects with moderate-severe OA (KL3-4) compared to all the other sub-regions except the medial posterior meniscus in subjects with doubtful-minimal OA (KL1-2). These preliminary data could serve as reference standards for future studies and suggest that T1rho might detect meniscal abnormalities in subjects with osteoarthritis.

References 1) Menezes NM et al, Magn Reson Med. 2004; 51: 503-509. 2) Akella SV et al, Magn Reson Med. 2001; 46: 419-423. 3) Li X et al, Osteoarthritis Cartilage 2007; 15: 789-797. 4) Blumenkrantz G et al, Eur Cell Mater. 2007; 13: 76-86. 5) Bolbos RI et al, Osteoarthritis Cartilage 2009; 17: 12-18. 6) Rauscher I et al, Radiology. 2008; 249: 591-600. 7) Kellgren J et al, Ann Rheum Dis 1957; 16: 494-501. 8) Kijowski R et al, AJR 2006; 187:794-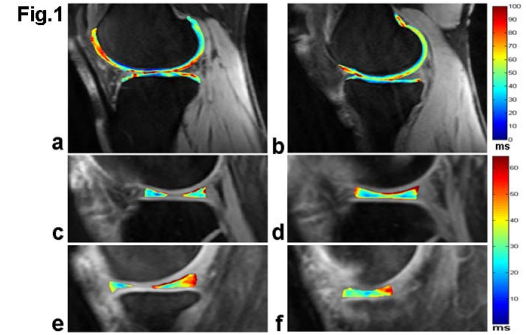799. 9) Pakin SK et al, Magn Reson Med. 2006; 56: 563-571.