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COMPARISON OF T1RHO RELAXATION TIMES BETWEEN ACL-RECONSTRUCTED KNEES AND UNINJURED, CONTRALATERAL KNEES ONE YEAR FOLLOWING SURGICAL REPAIR

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Purpose: Compare cartilage MR T1rho values of defined subcompartments in ACL-reconstructed knees with and without meniscal tears to the patient's own contralateral, uninjured knee at 12 to 16 months after ACL-reconstructions.

Methods: Nineteen patients' knees with ACL injuries [10 females, mean age 37.4; 9 males, mean age 39.6) and their contralateral knees were studied. All patients had ACL reconstruction, 12 to 16 months after which patients were scanned. Meniscal tears of injured and uninjured knees were identified by chart review of each post-operative note and MRI.

The imaging protocol included sagittal 3D fat-suppressed high-resolution spoiled gradient-echo (HR-SPGR) images and 3D quantitative T1ρ mapping. The acquisition parameters for the sagittal 3D T1ρ-weighted imaging sequence were TSL (time of spin-lock) = 0, 10, 40, 80 ms, FSL = 500 Hz. The T1ρ map was reconstructed by fitting the T1ρ-weighted images pixel-by-pixel to the equation: $S(TSL) \propto \exp(-TSL/T1\rho)$, and the reconstructed maps were subsequently registered to the previously acquired HR-SPGR images. Using an in-house developed program, the SPGR images were used to semi-automatically segment five compartments, the lateral/medial femoral condyles (LFC/MFC), the lateral/medial tibias (LT/MT) and the patella (Fig. 1A). The femoral condyles and tibias were divided into subcompartments with regard to the meniscus (Fig. 1B).

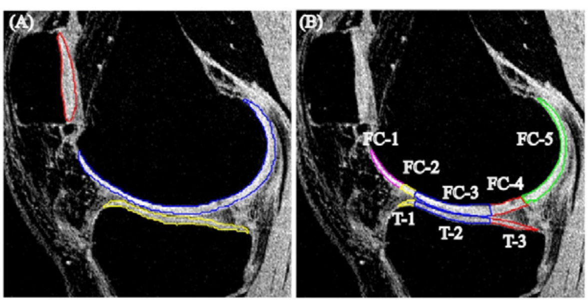

Fig. 1.

The average T1ρ values of the injured knees' five knee (sub)compartments were compared to respective regions in the uninjured knees. The average T1ρ values of the MFC and MT and defined subcompartments of patients with medial meniscal tears were compared between injured and uninjured knees. A similar comparison was done for the LFC and LT in patients with lateral meniscal tears. A Student t-test was used for statistical analysis. A P-value <0.05 was considered significant.

Results: Compared to the contralateral knee, the injured knee had significantly greater T1ρ values in the MFC and MT, and significantly higher T1ρ values in the MT's weight-bearing contact region (MT-2), the MFC's most anterior cartilage compartment (MFC-1), and weight-bearing regions (MFC-2,3,4) (Fig. 2).

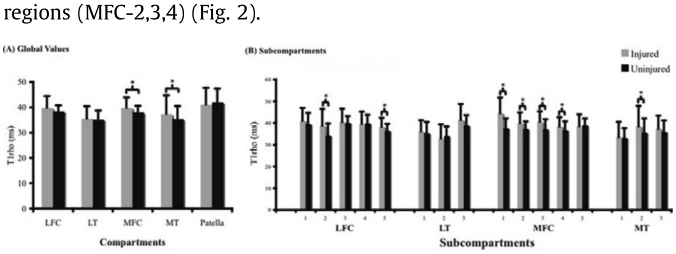

Fig. 2.

The uninjured knees had no meniscal tears.

Injured knees without a meniscal tear (n = 9) had no significant differences in T1ρ values in all five cartilage compartments and subcompartments compared to uninjured knees (Fig. 3).

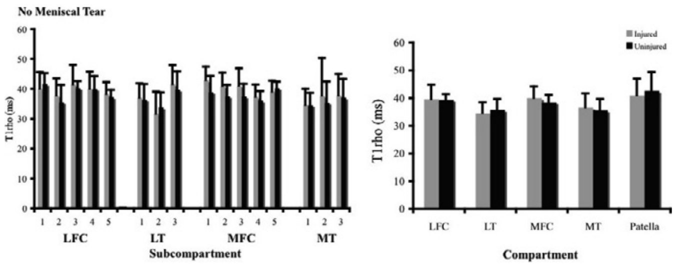

Fig. 3.

The injured knees with a medial meniscal tear (n = 7), compared to contralateral knees, had significantly higher T1ρ values in the MFC (overall and MFC-1,3,4) and MT (overall and MT-3) had greater T1ρ values in the MFC-2,5 and MT-2, with the differences approaching significance (Fig. 4).

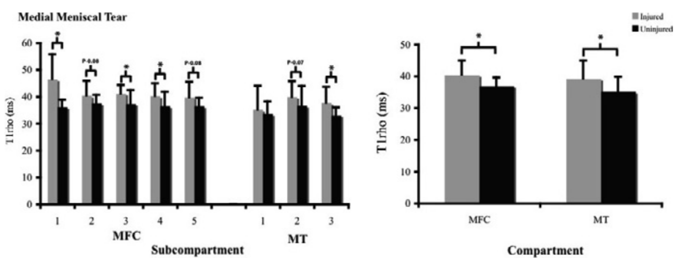

Fig. 4.

The injured knees with a lateral meniscal tear (n = 8), compared to contralateral knees, had elevated T1ρ values in the LFC and LT, with the differences approaching significance. Additionally, the injured knees had significantly greater T1ρ values in the LFC-1 and LFC-2, and had greater T1ρ values in LFC-5 and LT-3, with the differences approaching significance (Fig. 5).

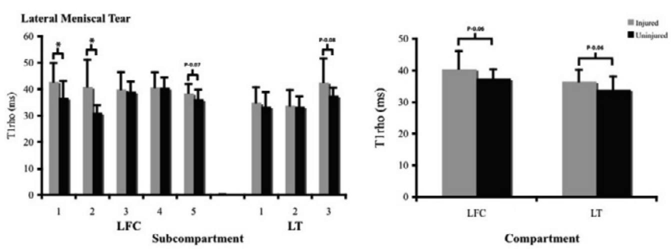

Fig. 5.

Conclusions: The observed T1ρ elevations in the knees' compartments indicate cartilage matrix damage, as T1ρ is sensitive to proteoglycan loss. Altered biomechanics that subsequently cause shifted joint loads are likely the cause of this early cartilage damage. Our data suggest that the presence of a meniscal tear at ACL injury is a significant risk factor for cartilage damage in the femorotibial compartments on the side of the injured meniscus. We believe that T1ρ MRI holds great potential as a modality for detection of early cartilage damage in ACL-reconstructed knees.

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T1ρ AND T2 MAPPING OF THE PROXIMAL TIBIOFIBULAR JOINT WITH REGARD TO AGING AND CARTILAGE DEGENERATION

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Purpose: Proximal tibiofibular joint (PTFJ) cartilage remains in good condition, even with advanced age, and the T_2 values of the PTFJ have been reported not to change with age or cartilage degeneration of the femorotibial joint (FTJ). However, the $T_1\rho$ values of the PTFJ have not been studied. The purpose of this study was to evaluate the cartilage of the PTFJ by $T_1\rho$ mapping with regard to aging and cartilage degeneration of the PTFJ and FTJ.

Methods: This study received the Institutional Review Board approval of our institution and conformed to the Declaration of Helsinki. Fifty-five subjects (17 males and 38 females with an average age of 46.7 years and a range of 13 to 92 years) with knee disorders, including anterior cruciate ligament injury, meniscus injury or knee osteoarthritis (OA), were studied with magnatic resonance imaging and knee radiography. Sagittal $T_1\rho$ and T_2 maps of the PTFJ and FTJ were obtained, and three regions of interest (ROIs) were positioned in the cartilage within the PTFJ, medial femoral condyle (MFC) and medial tibial (MT). Correlation analyses were performed among the following parameters: the $T_1\rho$ and T_2 values of each ROI, patient's age, and the OA grades of the PTFJ and FTJ measured with a whole-organ magnetic resonance imaging score (WORMS) and the Kellgren-Lawrence (KL) system, respectively.

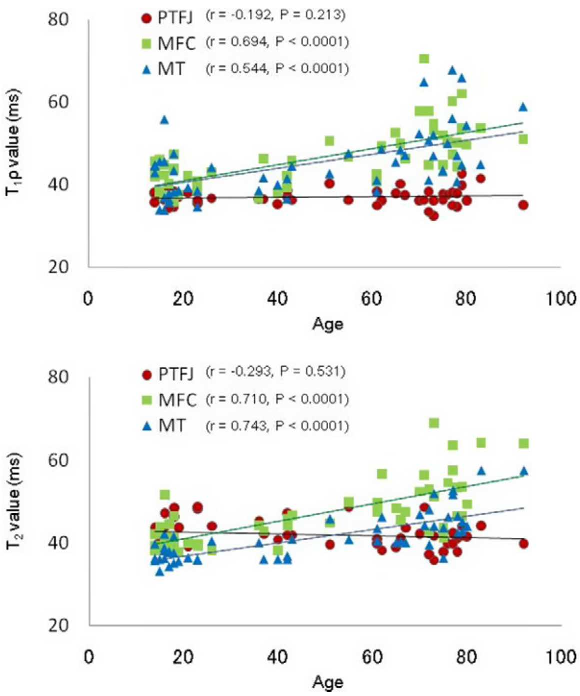

Fig. 1. Scatterplot of $T_1\rho$ and T_2 values of the PTFJ, MFC and MT.

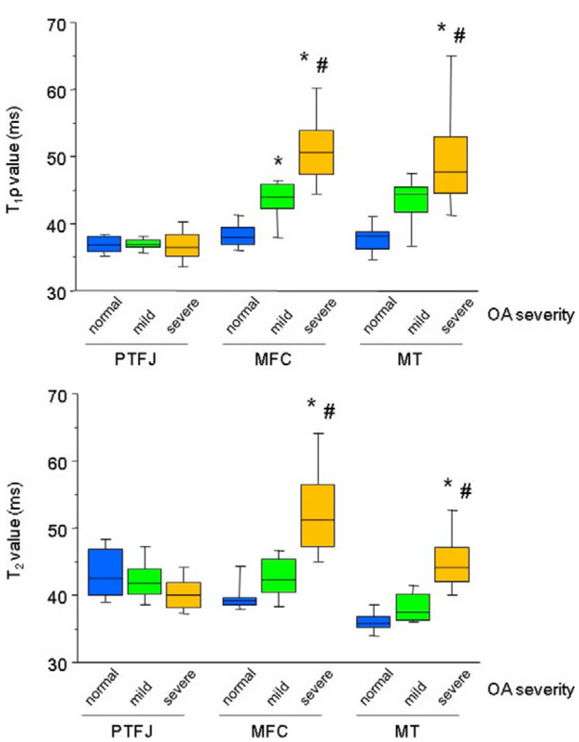

Fig. 2. Box plot for T1ρ and T2 values of the FTJ according to OA severity by KL grade. *P < 0.05 versus normal, #P < 0.05 versus mild by ANOVA with the Tukey HSD.

Results: The $T_1\rho$ and T_2 values of the PTFJ were not affected by aging (Figure 1) and the OA grade of the FTJ (Figure 2). T1ρ values of the PTFJ were correlated with the WORMS score; in contrast, the T2 values of the PTFJ were not (Table 1). The $T_1\rho$ and T_2 values of the MFC and MT were correlated with aging (Figure 1) and the OA grade of the FTJ (Figure 2). The $\%T_1\rho$ (the $T_1\rho$ of the FTJ/PTFJ $\times 100$) and $\%T_2$ (the T_2 of the FTJ/PTFJ $\times 100$) were correlated with the OA grade of the FTJ in the MFC ($r = 0.851$ and 0.635, respectively) and in the MT ($r = 0.779$ and 0.762, respectively). There were significant differences in the $T_1\rho$ values and $\%T_1\rho$ of the MFC between normal (KL score of 0) and mild OA cartilage (KL score of 1 or 2), but not in the T_2 values (Figure 2).

Conclusions: The present study demonstrated that the $T_1\rho$ and T_2 values of PTFJ cartilage were unchanged, regardless of aging and cartilage degeneration in the FTJ. The T1ρ values of the PTFJ could be useful as an internal standard reference for evaluating early degeneration of the FTJ.

Table 1. The relationship between the WORMS grade and the T1ρ and T2 values of the PTFJ

WORMS grade	0	1	2	2.5	P value	ρ
N	44	3	3	2		
Age	42.5±25.9	72.0±6.2	75.3±4.0	74.5±12.0	0.003	0.417
$T_1\rho$ value (ms)	36.7±1.5	38.9±3.5	38.0±1.8	40.9±1.0	0.021	0.324
T_2 value (ms)	41.8±3.4	43.3±1.0	43.4±4.6	42.8±2.1	0.132	0.211

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RADIOGRAPHIC MEASUREMENT OF TIBIOFEMORAL JOINT SPACE WIDTH FOLLOWING ACL INJURY AND RECONSTRUCTION

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Purpose: Progression of established knee OA is often quantified by measuring change in tibiofemoral joint space width (JSW) over time; however, limited information is available regarding the JSW changes that occur during the initial onset and subsequent progression of post-traumatic OA (PTOA) that is often associated with injury to the anterior cruciate ligament (ACL) of the knee. Furthermore, there is a paucity of information regarding JSW changes that occur naturally in healthy individuals over time, making the interpretation of JSW changes following the onset and early progression of PTOA (when the subject is asymptomatic) challenging. The purpose of this investigation was to evaluate changes in tibiofemoral JSW following ACL injury and reconstruction (ACL-R), compared to those observed in healthy, matched controls.

Methods: This investigation was designed as a prospective cohort study with a nested case-control analysis. Thirty-six ACL-injured and 32 matched control subjects participated. Entry criteria included: Age 14–55yrs; BMI = 18.5–30, Tegner score >4; no relevant knee pathologies other than the index ACL injury; normal anatomic alignment; <2/3 menisectomy; <Gr IIIb articular cartilage lesions, and surgical ACL-R within six months of injury. Controls reported no pain or dysfunction; normal knee evaluation; and normal MRIs. Injured subjects were assessed at baseline (within 3 weeks of surgery) and 1, 2, and 4 years post ACL-R. Controls underwent baseline, 1, 2, and 3-year follow-ups, and baseline MRI to rule-out underlying pathologies. Bilateral A-P view x-rays were obtained using a semi-flexed, metatarsal phalangeal view technique. X-ray films were digitized and JSW calculated using previously validated techniques. To ascertain if the injured knee JSW was "normal" at baseline, between knee JSW comparisons were performed and compared to the side-to-side differences obtained from the controls. To determine if JSW changes in normal knees over time, within knee comparisons were performed for control subject knees as well as the uninjured knee of ACL-R subjects. For injured subjects, JSW difference (JSW-D) was determined by subtracting injured knee JSW's from their "normal" knee JSW's. Control JSW's were determined by subtracting JSW values between knees. To establish a JSW range in which normal knees change over time, control values were averaged and 95% confidence intervals (CI) determined (+/−(bias+1.96*measurement error)). Multilevel regression was used to estimate bias, measurement error, and change over time using "normal" knee data (controls & uninjured knee).

Results: Analysis of the baseline data demonstrated the between knee comparisons in the ACL-R group resulted in a greater proportion of