

# **The Preoperative T1 $\rho$ value of the Posterior Lateral Tibial Cartilage Predicted the Progression of Knee Osteoarthritis 10 Years after Anatomical Double-bundle ACL Reconstruction: Follow-up of a Previous Prospective Study**

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## **INTRODUCTION:**

Post-traumatic osteoarthritis can develop after an anterior cruciate ligament (ACL) injury and after reconstruction; the factors contributing to osteoarthritis progression are not fully understood. The initial collision between bones during subluxation at the time of ACL injury may be implicated postoperatively. Quantitative MRI offers a noninvasive way to evaluate cartilage biochemical composition, detecting of early cartilage degeneration. The relationship between preoperative factors and ACL reconstruction (ACLR) outcomes has been reported; however, the specific impact of preoperative quantitative MRI on long-term outcomes remains underreported. This study hypothesized that baseline individual differences in cartilage condition may influence degenerative progression 10 years after ACLR. It aimed to report on 10-year postoperative outcomes and investigate the effects of various factors, including preoperative cartilage T1 $\rho$  values, on these outcomes.

## **METHODS:**

This case series involved 13 patients with primary ACL injuries who underwent preoperative quantitative MRI and anatomical double-bundle ACLR using hamstring autografts between April 2012 and August 2013. 9 patients were available for a 10-year follow-up; manual examinations, such as the Lachman test and pivot shift test, a single leg sit-to-stand (SL-STS), patient-reported outcomes (PROs), Tegner Activity Scale (TAS) score, and radiography were conducted. PROs included the Knee injury and Osteoarthritis Outcome Score (KOOS), Lysholm Score (LS), Forgotten Joint Score-12 (FJS), and ACL-Return to Sport after Injury scale (ACL-RSI). The posterior tibial slope, medial proximal tibial angle (MPTA), femoral tibial angle, and Kellgren–Lawrence (KL) grades were determined by two orthopedic surgeons and used to divide patients into two groups: progression and no-progression groups. All MR examinations were conducted on a 3.0T MR scanner using an 8-channel knee coil. 3D MERGE, 3D SPGR, and 3D CUBE were acquired to create precise cartilage mask images. For compositional evaluation, 18 areas were manually registered as the region of interest using in-house software developed with MATLAB, version R2020a (Fig.1). The average T1 $\rho$  values in each compartment were calculated.

We compared the postoperative PROs between the two KL grade groups and also compared the PROs with or without a decrease in TAS score, meniscectomy, and SL-STS good status (possible to stand up from a height of 30 cm). The PROs were investigated for correlations with preoperative T1 $\rho$  values for each cartilage compartment with Spearman's correlation coefficient. The T1 $\rho$  values were compared between the KL grade progression and no-progression groups using a two-sided Welch's t-test. Statistical significance was set at  $p < 0.05$ . All statistical analyses were performed using STATA.

## **RESULTS:**

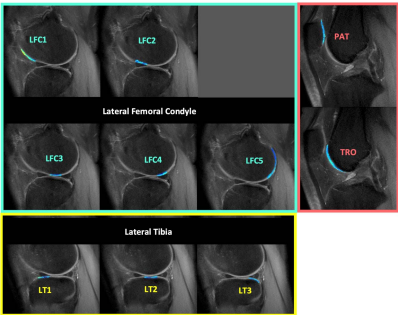
The patients (6 female, 3 male) had an average age of 26.4 years and body mass index of 23.3 kg/m<sup>2</sup> at surgery. They exhibited favorable PROs at the 10-year follow-up. However, five showed progressions in the KL grade. Compared with no progression, the patients with progression scored lower on the FJS ( $p = 0.027$ ) and the KOOS Quality of Life score ( $p = 0.042$ ; Table 1). No significant differences were observed in any postoperative PROs between the patient groups with or without a decrease in the TAS score, good SL-STS status, and meniscectomy. Regarding radiograph evaluation, however, all three patients without good SL-STS status were consistent with the five cases with KL progression. All three cases with decreased TAS scores were also in the KL grade progression group (Table 2). Among the three patients who underwent meniscectomy, one showed KL progression. The T1 $\rho$  values for each compartment did not correlate with the PROs at 10 years postoperatively for any compartment. In the comparison of KL grade between the progression and no progression groups, the posterior lateral tibial cartilage showed higher T1 $\rho$  values in the progression group ( $55.9 \pm 6.4$  vs  $45.9 \pm 6.0$ ;  $p = 0.040$ ). However, no significant differences were observed in any of the other compartments.

## **DISCUSSION AND CONCLUSION:**

Ten years after anatomical double-bundle ACLR, the PROs were favorable. No factors that significantly affected PROs at 10 years postoperatively were identified, including preoperative T1 $\rho$  relaxation times. The patients with KL grade progression showed higher T1 $\rho$  values in the posterior lateral tibial cartilage preoperatively compared to the patients without progression.

This finding may be indirectly related to the degree of knee subluxation at the time of the ACL injury. This is the first study to investigate the relationship between preoperative T1p and long-term postoperative outcomes of ACL reconstruction. Thus, this study contributes to our understanding of the impact of ACL injury on cartilage status and aids in the development of effective treatment strategies.

Figure 1. Cartilage Segmentation with T1p Color Map



The lateral femoral condyle (LFC) and lateral tibia (LT) were divided into five and three segments, respectively. The medial femoral condyle and tibial plateau were similarly divided. PAT, patella; TRO, trochlea.

Table 1. Patient-reported outcomes 10 years after anterior cruciate ligament reconstruction

	KOOS Symptom	KOOS Pain	KOOS ADL	KOOS Sports/Rec	KOOS QOL	LS	FJS	ACL-RSI
All patients mean (SD)	87.7 (9.1)	94.1 (6.4)	98 (5.9)	88.3 (19)	86.8 (16)	93.1 (7.9)	71.8 (23.5)	53.9 (21.1)
KL progression group (n=5)	84.3 (8.2)	91.9 (9.4)	96.5 (7.9)	81 (23.8)	77.5 (16.3)	91.4 (9.2)	57.9 (22.0)	50.3 (13.7)
KL no progression group (n=4)	91.9 (9.4)	97.9 (2.7)	100 (0)	97.5 (2.9)	98.4 (3.1)	95.3 (6.6)	89.1 (10.7)	58.3 (30)

KOOS, Knee injury and Osteoarthritis Outcome Score; ADL, activities of daily living; Rec, recreation; QOL, quality of life; LS, Lysholm Score; FJS, Forgotten Joint Score-12; ACL-RSI, anterior cruciate ligament-Return to Sport after Injury scale; SD, standard deviation; KL, Kellgren-Lawrence grade. \* p < 0.05.

Table 2. Individual data 10 years after surgery

Patient number	TAS	10y decrease	KL progression	10y SL-STS	SL-STS	FTA	MPTA	PTS	Lachman test	Post adult
		Yes=1, No=0	Yes=1, No=0	cm	mm	degrees	degrees	degrees		test
1	3	1	3	1	40	0	178	87	10	0
2	6	0	0	0	10	1	177	86	3	1
3	7	0	0	0	50	1	179	86	13	0
4	5	0	1	0	30	1	180	86	9	0
5	6	1	2	1	10	1	177	85	14	0
6	4	1	2	1	40	0	181	82	9	0
7	6	0	2	1	50	0	174	85	8	0
8	2	0	0	0	20	1	175	82	10.5	0
9	8	0	2	1	0	1	181	84	11	1

10y, 10 years after surgery; TAS, Tegner Activity Scale; KL, Kellgren-Lawrence; SL-STS, single leg sit to stand; FTA, femoral tibial angle; MPTA, medial proximal tibial angle; PTS, posterior tibial slope. In the SL-STS 30 cm column, 1 means the patient could stand up from a height of 30 cm, and 0 means the patient could not.