Higher Posterior Tibial Slope and Varus Alignment of the Knee Are Associated with Delayed Graft Maturation after ACL Reconstruction Surgery

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INTRODUCTION: Graft re-tear after anterior cruciate ligament (ACL) reconstruction occurs in greater than 15% in certain high-risk patient populations and is highest within the first two years after returning to full sports activity. An increased posterior tibial slope (PTS) is an independent risk factor associated with graft re-tear and may place excessive load across both the native ACL and the ACL graft. The coronal alignment of the knee may also influence forces across the ACL graft. The excessive load across the ACL graft due knee alignment may influence graft healing. Recently, some studies reported that T1ρ and T2 sequences could offer a noninvasive method for monitoring ACL graft maturation. T1ρ is inversely correlated with proteoglycan content and that T2 is related to collagen structure. Lower relaxation times of each are associated, respectively, with higher proteoglycan content and more longitudinal organization of the collagen. The objective of this study is to investigate the relationship between sagittal and coronal alignment and ACL graft maturation following ACL reconstruction. Our hypothesis is that a higher PTS and varus alignment are associated with inferior graft maturation following ACL reconstruction.

METHODS: We evaluated 28 patients who underwent ACL reconstruction with a hamstring auto graft at our institution from 2018 to 2020. Surgical reconstruction was performed by one of four fellowship-trained sports medicine orthopedic surgeons and with independent drilling of the femoral and tibial tunnels. The femoral fixation was achieved with suspensory fixation (RIGIDLOOP, Depuy Syhthes, Raynham, MA or Ultrabutton Adjustable Fixation Device, Smith & Nephew, Watford, England, UK), and nonmetallic interference fixation with a sheath and screw device was used on the tibial side (Intra-Fix, Depuy Synthes, Raynham, MA). Postoperatively, patients were partial weight-bearing with crutches for 3 weeks and used a hinged knee brace for 6 weeks after surgery. To assess patients reported outcome (PRO) score, International Knee Documentation Committee (IKDC) score, Marx activity scale, ACL Return to Sport after Injury (ACL-RSI) scale and Knee Osteoarthritis and Injury Outcome Score (KOOS) were completed at 2 years follow up. To assess coronal alignment, the medial proximal tibial angle (MPTA), femoral-tibial angle (FTA) and joint line convergence angle (JLCA) were measured on preoperative antero-posterior radiographs of the knee. To assess sagittal alignment The lateral posterior tibial slope (PTS) was measured on preoperative lateral radiograph of the knee. Postoperative 3T magnetic resonance imaging (MRI) was acquired at 2 years after surgery (General Electric, Milwaukee, WI). A 3D combined T1ρ/T2 MAPSS sequence (FOV=14X14cm2; 256X256 matrix size; 22 slices;TR/TE=8.49/2.1ms; Trec=1.2s; BW=±31.25 kHz; TSL=0/10/40/80ms; FSL=500 HZ; TE for T2-preparation=0/12.8/25.7/51.4ms;ARC Ky AF=2) were obtained in a sagittal-oblique plane to maximize imaging of the ACL graft.[1] After acquiring images, a manual segmentation for ACL graft was performed to obtain the T1ρ and T2 relaxation time.[2] Statistical analysis was made using Spearman correlation analysis to obtain the association between PRO scores and radiographic parameters and T1ρ and T2 relaxation time. Significance level was set at $p = 0.05$.

RESULTS SECTION: There were 28 patients (Male: 12, Female: 16) who were enrolled in this study. The average of age and BMI were 34.3 years (SD=8.5 years) and 24.4 kg/m2 (SD=4.5 kg/m2), respectively. The PRO scores were shown Table 1. The mean T1ρ and T2 relaxation time at 2 years after surgery were 33.2 ms (SD=3.7 ms) and 22.9 ms (SD=2.7 ms), respectively. The preoperative PTS was significantly correlated with T1 ρ and T2 relaxation time at 2 years after surgery (r=0.43; p=0.019 and r =0.49; p=0.0074), respectively (Table 2, Figure 1A and B). The preoperative MPTA was significantly negative correlated with T1 ρ and T2 relaxation time at 2 years after surgery (r=-0.42; p=0.024 and r =-0.46; p=0.012), respectively (Table 2, Figure 1C and D). There was not significantly correlation between PRO scores at 2 years after surgery and T1ρ and T2 relaxation time at 2 years after surgery.

DISCUSSION: Increasing posterior tibial slope and increasing varus alignment at the knee are associated with inferior graft maturation as assessed by quantitative imaging at 2 years after ACL reconstruction with hamstring autograft. These findings demonstrate that patients with certain bony shape and alignment features may be at risk for inferior mechanical properties of the ACL graft after surgical reconstruction. Future studies should focus on larger sample sizes and long-term follow-up in order to further investigate this relationship.

SIGNIFICANCE/CLINICAL RELEVANCE: The study findings suggest that an increased PTS and varus knee alignment are associated with inferior graft maturation as per T1ρ and T2 imaging at 2 years post-ACL reconstruction. This suggests that patients with certain bony shape and alignment may risk inferior mechanical properties of the ACL graft after surgical reconstruction.

REFERENCES: 1. Li X, et al, Magn Reson Med. 2008;59(2):298-307., 2. Lansdown DA, et al. J Orthop Res. 2020;38(6):1289-1295.

IMAGES AND TABLES:

Table 1. Patients reported outcome scores at 2 years post-operatively

	2 years postoperative
Marx activity scale	7.1 (3.9)
ACL-RSI	63.7 (23.3)
IKDC	86.3 (11.1)
KOOS total	91.1 (7.8)
KOOS Pain	93.9 (8.1)
KOOS Symptom	86.8 (10.2)
KOOS ADL	97.1 (5.6)
KOOS Sports/rec	84.8 (14.1)
KOOS QOL	73.3 (22.5)

Data are reported as mean ± SD unless otherwise indicated. IKDC; International Knee Documentation Committee, ACL-RSI; ACL Return to Sport after Injury, KOOS; Knee Osteoarthritis and Injury Outcome Score

Table 2. Correlation analyses between Pre-op X-P parameter and Post-op MRI parameters

	T1 ρ relaxation time		T2 relaxation time	
	r	p	r	p
PTS	0.43	0.019	0.49	0.0074
FTA	0.11	0.55	-0.073	0.70
MPTA	-0.42	0.024	-0.46	0.012
JLCA	-0.053	0.78	0.11	0.55

Data are reported as mean ± SD unless otherwise indicated. UTE; Ultrashort echo time, MPTA; Medial proximal tibial angle, JLCA; Joint line convergency angle, FTA; Femoral-tibial angle, PTS; Posterior tibial slope

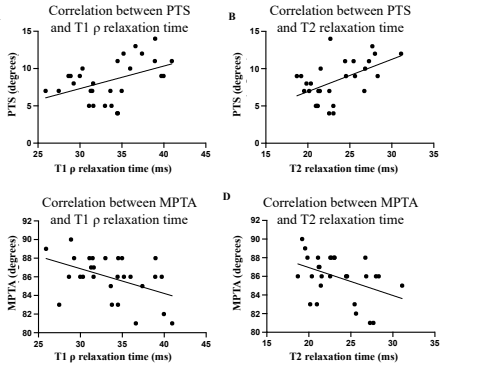

Figure 1. Correlation between radiographic parameters and T1ρ and T2 relaxation time at 2 years postoperatively MPTA; Medial proximal tibial angle, PTS; Posterior tibial slope