

# Higher Posterior Tibial Slope and Varus Alignment of the Knee are Associated with Delayed Graft Maturation after Anterior Cruciate Ligament Reconstruction Surgery

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## INTRODUCTION:

Negative outcomes after anterior cruciate ligament reconstruction (ACLR) are common and include graft re-tear in greater than 15% in some 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 to knee alignment may influence graft healing. T1 $\rho$  and T2 sequences can offer a noninvasive method for monitoring ACL graft maturation. T1 $\rho$  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 after ACLR. Our hypothesis is that a higher PTS and varus alignment are associated with inferior graft maturation following ACLR.

## METHODS:

We evaluated 28 patients who underwent ACL reconstruction at our institution from 2018 to 2020. Surgical reconstruction was performed by one of four fellowship-trained sports medicine orthopaedic surgeons and with independent drilling of the femoral and tibial tunnels. The femoral fixation was achieved with suspensory fixation and nonmetallic interference fixation with a sheath and screw device was used on the tibial side. Postoperatively, patients were partial weight-bearing with crutches for 3 weeks and used a hinged knee brace for 6 weeks after surgery.

To assess patient-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. A 3D combined T1 $\rho$ /T2 MAPSS sequence were obtained in a sagittal-oblique plane to maximize imaging of the ACL graft. After acquiring images, a manual segmentation for ACL graft was performed to obtain the T1 $\rho$  and T2 relaxation time. Statistical analysis was made using Pearson correlation analysis to obtain the association between PRO scores and radiographic parameters and T1 $\rho$  and T2 relaxation time. Significance level was set at  $p = 0.05$ .

## RESULTS:

There were 28 patients (Male: 12, Female: 16) who were enrolled in this study. All patients underwent arthroscopic ACL-R with a hamstring auto graft. The average of age and BMI were 34.3 years (SD=8.5 years) and 24.4 kg/m<sup>2</sup> (SD=4.5 kg/m<sup>2</sup>), respectively. The PRO scores were shown Table 1. The mean T1 $\rho$  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 $\rho$  and T2 relaxation time at 2 years after surgery ( $r=0.4126$ ;  $p=0.0291$  and  $r =0.5169$ ;  $p=0.0049$ ), respectively (Table 2, Figure 1A and B). The preoperative MPTA was significantly negative correlated with T1 $\rho$  and T2 relaxation time at 2 years after surgery ( $r=-0.4541$ ;  $p=0.0152$  and  $r =-0.4042$ ;  $p=0.0308$ ), respectively (Table 2, Figure 1C and D). There was not significant correlation between PRO scores at 2 years after surgery and T1 $\rho$  and T2 relaxation time at 2 years after surgery (Table 3).

## DISCUSSION AND CONCLUSION:

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.

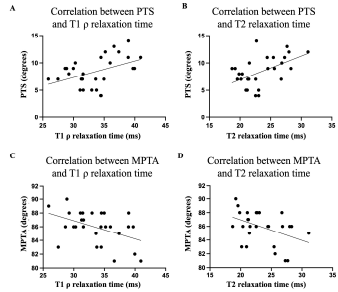


Figure 1. Correlation analyses between pre-op X-P parameters and post-op MRI parameters

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

	T1 $\rho$ relaxation time		T2 relaxation time	
	r	p	r	p
PTS	0.4438	0.0180	0.4954	0.0074
FTA	0.1495	0.4477	0.00593	0.9761
MPFA	-0.4541	0.0152	-0.4024	0.0338
JLCA	-0.1144	0.5621	0.1177	0.5509

Pearson correlation analyses, significance level was set at  $p = 0.05$

Table 1. PRO 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)
	Mean (SD)