# Posterior Tibial Slope is Associated with Pediatric Anterior and Posterior Cruciate Ligament Injury

Rajiv Siddhartha Vasudevan[1], Tyler Wilps, Garrett Rupp, Andrew Zogby, Andrew Tennant Pennock
[1]University of California, San Diego School of Medi

INTRODUCTION:

Recent adult studies have demonstrated that decreased posterior tibial slope angle (PTSA) may be a risk factor for posterior cruciate ligament (PCL) injury while increased PTSA is a known risk factor for anterior cruciate ligament (ACL) injury and ACL reconstruction failure. However, there is no study investigating these phenomena in a pediatric population. Understanding modifiable risk factors for cruciate ligament injuries among a pediatric population is important given the recent rise in athletic competition/specialization and sports related injuries. The purpose of this study was to determine differences in PTSA between pediatric patients suffering a primary PCL tear, primary ACL tear, and ACL graft failure after reconstruction compared to age and sex matched healthy controls.

METHODS:

We included patients ≤18 years with MRI-confirmed PCL tear or ACL graft failure between 2006 and 2021 at a level 1 pediatric trauma center. A primary ACL (non-failure) group was created via age and sex-match to the ACL graft failure group. In the PCL tear group, patients were excluded with concomitant ACL tears, prior PCL reconstruction, or prior coronal plane realignment. In the ACL primary injury and graft failure groups, patients were excluded with multiligamentous injuries and if they did not have injury films. A control group with MRI-confirmed ligament-intact knees were matched based on age and sex. PTSA was measured on injury lateral radiographs and then compared between PCL groups and ACL groups (Figure 1). In the PCL and ACL groups, odds ratios were calculated based on low (<7˚), normal (7˚-12˚), and high (>12˚) PTSA. Inter- and intra-rater reliability was determined through calculation of an intraclass correlation coefficient (ICC).

RESULTS:

Fifty-nine patients with primary PCL tear, 53 patients with non-failure ACL reconstructed knees, and 53 patients with ACL graft failure met inclusion criteria for the study. In total, 50-60 healthy-knee controls were age and sex matched for each of the groups. There were no differences between the groups for age (p=0.90) or sex (p=1.0). The PCL group had a lower mean ± SD PTSA than control (5.9˚ ± 2.7˚ vs. 7.3˚ ± 4.3˚; p=0.029). Low PTSA (<7˚) was associated with a 2.8 (CI 95% (1.3, 6.0); p=0.006) odds ratio of PCL tear. The ACL tear group had a higher mean ± SD PTSA than the control group (9.3˚ ± 3.3˚ vs. 7.2˚ ± 4.4 ˚; p<0.001). Further, high PTSA (>12˚) was associated with a 3.6 (CI 95% (1.1, 12); p=.038) times higher risk of primary ACL tear (Table 1). The ACL graft failure group had a non-significant (p>0.05) higher mean ± SD PTSA than the ACL tear group (9.8˚ ± 2.9˚ vs. 9.3˚ ± 3.3˚). Additionally, the ACL graft failure group had a higher mean ± SD PTSA than the matched control normal knee (9.8˚ ± 2.9˚ vs. 7.2˚ ± 4.4˚, p<0.001). Our PTSA measurements demonstrated acceptable intra-rater and inter-rater reliability (p<0.05).

DISCUSSION AND CONCLUSION: A PTSA (<7˚) was associated with a 2.8 times greater odds of PCL injury, and PTSA (>12˚) was associated with a 3.6 times greater odds of ACL injury in a pediatric population. There was no significant difference in PTSA between the ACL graft failure and ACL reconstruction groups, but both these groups had a significantly greater PTSA than the age matched control. These findings corroborate similar findings in adult studies; however, further studies are needed to further elucidate PTSA as a modifiable risk factor for PCL injury and ACL graft failure in the pediatric population and to determine if there is a possible role for growth modulation.
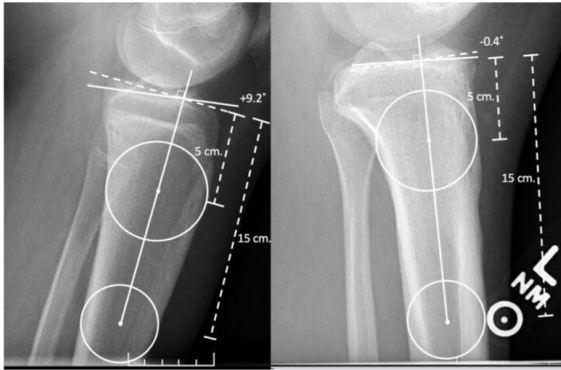
Figure 1: **Posterior tibial slope angle measurements (PTSA) for a posterior cruciate ligament (PCL) deficient knee and a matched control.** Panel A depicts a lateral radiograph for a healthy knee control patient, utilizing the circle method for measuring PTSA and demonstrating a relatively posterior tibial slope denoted with a positive angle. Panel B depicts the circle method on a lateral knee radiograph on a patient who suffered a PCL tear, demonstrating relatively anterior slope denoted with a negative angle.

**Table 1.** Risk of ACL and PCL Injury vs. Healthy Patients Stratified by PTSA Categories

|  | High (>12˚) | Normal (7-12˚) | Low (<7˚) |
|---|---|---|---|
| ACL |  |  |  |
| OR (95% CI) | **3.6 (1.1, 12)** | 1.4 (.63, 2.9) | 1.4 (.62, 3.2) |
| p-value | .038 | .44 | .41 |
| ACL tear, n | 12 | 26 | 15 |
| Control, n | 4 | 30 | 19 |
| PCL |  |  |  |
| OR (95% CI) | **2.8 (1.3, 6.0)** | **.47 (.23, .98)** | -- |
| p-value | .006 | .044 | -- |
| PCL tear, n | 36 | 23 | 0 |
| Control, n | 21 | 34 | 4 |