

There is a Difference in Preoperative Mechanical Axis Alignment in Pediatric and Adolescent Patients with Anterior Cruciate Ligament Rupture and Patellofemoral Instability

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INTRODUCTION: Anterior cruciate ligament (ACL) rupture and patellofemoral instability (PFI) are common injuries in pediatric and adolescent patients. Previous literature has identified non-modifiable risk factors of ACL rupture and PFI such as sex, joint laxity, tibial slope, variations in the intercondylar notch, patella alta, trochlear dysplasia, and distance from the tibial tuberosity to the trochlear groove (TT-TG). The primary aim of this study was to examine mechanical axis alignment as a risk factor for ACL rupture and PFI in pediatric and adolescent patients. The authors hypothesized that there will be differences in mechanical axis alignment between patients with ACL rupture, PFI, and a comparison cohort.

METHODS: Patients aged 8 to 21 years at a single institution that sustained an ACL rupture or PFI injury and underwent surgical treatment between January 2015 and August 2022 were identified. Participants were included if they had a preoperative EOS lower limb x-ray. Participants with a history of previous knee surgery to either knee, more than one diagnosis of either ACL rupture or PFI, and/or no biplane hip-to-ankle radiograph before surgical intervention were excluded. Participants were compared to a cohort of scoliosis patients with a Cobb angle less than 20° who had biplane EOS radiographs (Controls). All preoperative radiographs were sent for EOS 3D reconstructions and data acquisitions were received with a specific focus on mechanical axis measurements. Demographics for all patients were gathered. Measurements had positive and negative values, valgus and varus, respectively. A Shapiro-Wilk Test for Normality was performed, therefore, normally distributed continuous variables are represented as mean and standard deviation, and non-normally distributed continuous variables are represented as median and interquartile range (IQR). A one-way ANOVA was run to compare mechanical axis alignment between the three groups (ACL, PFI, Controls), and t-tests were also analyzed to compare the individual differences between the groups. Statistical significance was set to $p \leq 0.05$. The same software was used for all statistical analysis.

RESULTS: Of the patients identified, 197 met final inclusion and exclusion criteria (60 ACL, 92 PFI, 45 Controls). For the entire cohort, the mean age at time of imaging for all patients was 14.4 ± 2.2 years (ACL: 14.3 ± 1.8 years; PFI: 14.3 ± 2.4 years; Controls: 14.9 ± 2.4 years) and 50.8% were female (ACL: 43.3% female; PFI: 58.7% female; Controls: 44.4% female). The mean mechanical axis for the ACL group was $0.067 \pm 2.5^\circ$ of valgus. The mean mechanical axis for the PFI group was $0.937 \pm 2.4^\circ$ of valgus. The mean mechanical axis for the Control group was $-0.073 \pm 2.6^\circ$ of varus. Mechanical axis alignment was significantly different between cohorts ($p=0.032$), with the PFI patients in significantly more valgus. The PFI group was in significantly more valgus than the ACL group ($p=0.032$) and the Control group ($p=0.026$). There was not a significant difference in the mechanical axis alignment between the ACL group and the Control group ($p=0.781$).

DISCUSSION AND CONCLUSION: Mechanical axis alignment was found to be statistically significantly different in preoperative weight-bearing radiographs between patients with ACL rupture, PFI, and a comparison cohort, demonstrating that femorotibial rotation and varus/valgus alignment may be a nonmodifiable anatomical risk factor for ACL rupture and PFI in pediatric and adolescent patients.

Figure 1. Total number of patients in each cohort in neutral alignment (-15° mechanical axis), valgus (mechanical axis $>1^\circ$), and varus (mechanical axis $<-1^\circ$).

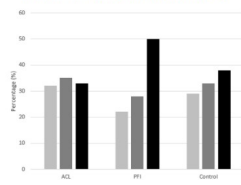


Figure 2. Distribution of mechanical axis alignment between cohorts.

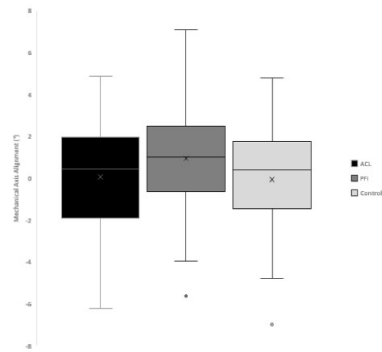


Table 1. Mechanical axis alignment between groups.

	Mechanical Axis Alignment (°)	P-value
ACL	0.067 ± 2.5	0.032*
PFI	0.937 ± 2.4	
Control	-0.073 ± 2.6	

*Positive values indicate valgus. Negative values indicate varus.