Posterior Tibial Subchondral Bone and Meniscal Slope Correlate with In-Vivo Internal Tibial Rotation

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Introduction

Background
- Increased posterior tibial slope (PTS) and posterior meniscal slope (PMS) are potential risk factors for anterior cruciate ligament (ACL) injuries and high-grade pivot shift. [1-4]
- The role of the medial and lateral PTS and PMS on *in-vivo* knee kinematics has not been investigated.

Aim
- To investigate relationships between the lateral and medial PTS and PMS on *in-vivo* knee kinematics.

Hypotheses
- Lateral PTS and PMS are associated with increased anterior tibial translation (ATT) and internal tibial rotation (IR).
- Greater differences between the medial and lateral PTS and PMS are associated with increased IR.

Methods

Subjects
- Forty-two subjects (26 male, 16 female; 21.2±6.9 years old)
- 6 months after unilateral ACL reconstruction.

Slope Measurements
- 3T magnetic resonance imaging (MRI) on ACL reconstructed and contralateral healthy knee.
- Medial and lateral PTS and PMS measured according to the method described by Hudek et al. [5] (Figure 1)
- Calculation of the difference between the lateral and medial slopes

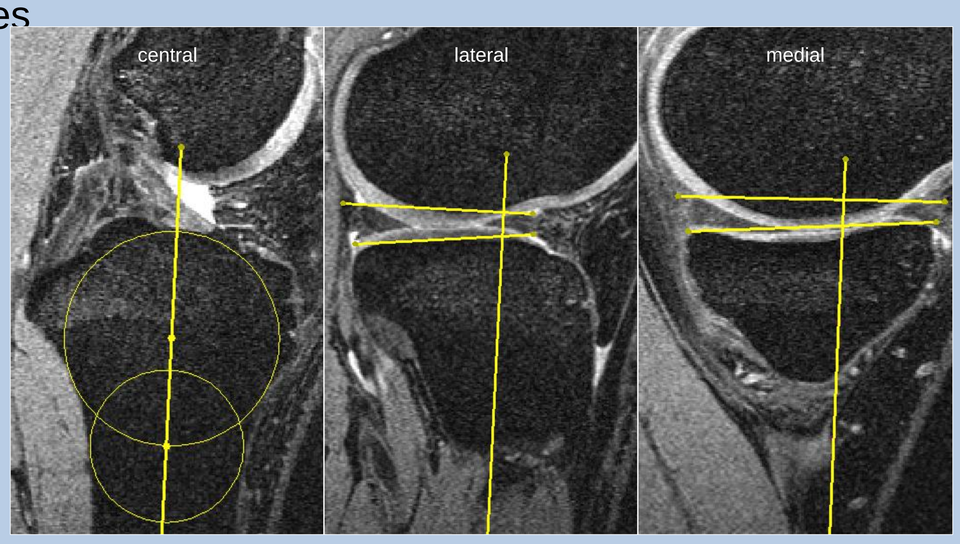

Figure 1: *Posterior tibial and meniscal slope measurements on sagittal MRI. First, the tibial shaft axis is established by connecting two centroids of two circles in the central slice. The PTS and PMS are determined by the angle between the tibial shaft axis and the line connecting the two most proximal anterior and posterior subchondral bone and meniscal points in the center of each joint compartment.*

***In-vivo* Kinematics**
- Three-dimensional *in-vivo* kinematics data were acquired 6 months postoperatively using dynamic stereo x-ray [6, 7] during
  - Level walking (1.3 m/s) at 100 Hz,
  - Downhill running (3.0 m/s) at 150 Hz
- Average tibiofemoral motion from heel strike to mid-stance

Correlations between bone morphology and dynamic knee kinematics were evaluated using Spearman´s Rho ($p<0.05$)

Results

Healthy Contralateral Knees
- Steeper lateral PTS and PMS were correlated with increased IR.
- Higher difference between medial and lateral PTS and PMS was associated with increased IR (Table 1, Figure 2).

ACL Reconstructed Knees
- Lateral PMS was correlated with increased ATT during level walking.
- Steeper lateral PTS and PMS were correlated with increased IR during level walking.
- Higher differences between the medial and lateral PTS and PMS was associated with increased IR (Table 1, Figure 2).

Table 1: *Spearman´s Rho (ρ) and p-values for morphological parameters with significant correlations with in-vivo knee kinematics. Medial posterior tibial slope (PTS) and meniscal slope (PMS) were not associated with internal tibial rotation and anterior tibial translation.*

	Contralateral Knee		ACL – Reconstructed Knee	
	Level Walking	Downhill Running	Level Walking	Downhill Running
Internal Tibial Rotation				
Lateral PTS	ρ = .264 (*NS*)	ρ = .443 (p = .010)	ρ = .597 (p = .003)	ρ = .156 (*NS*)
PTS*diff (lateral-medial)*	ρ = .312 (*NS*)	ρ = .441 (p = .010)	ρ = .561 (p = .005)	ρ = .271 (*NS*)
Lateral PMS	ρ = .595 (p = .002)	ρ = .440 (p = .010)	ρ = .441 (p = .035)	ρ = .278 (*NS*)
PMS*diff (lateral-medial)*	ρ = .730 (p < .001)	ρ = .548 (p = .001)	ρ = .575 (p = .004)	ρ = .543 (p = .003)
Anterior Tibial Translation				
Lateral PMS	ρ = .168 (*NS*)	ρ = .022 (*NS*)	ρ = .393 (p = .016)	ρ = .234 (*NS*)

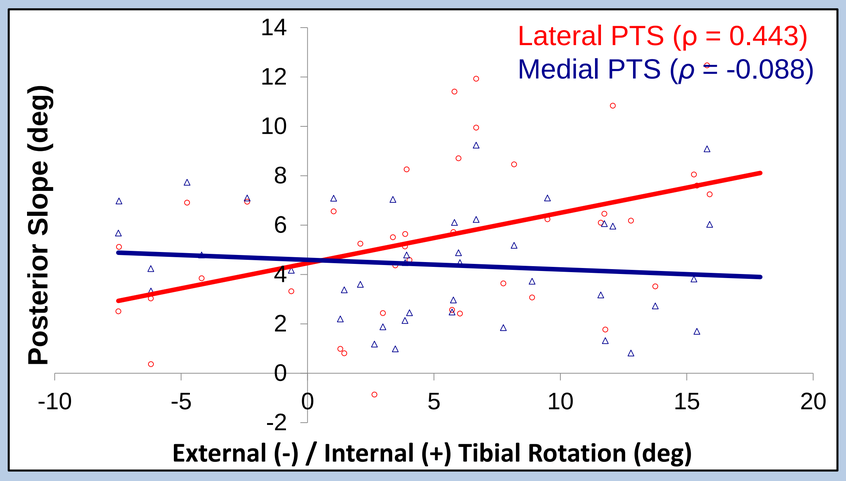

Figure 2: *Correlation between lateral and medial posterior tibial slope (PTS) and in-vivo tibial rotation during downhill running. Lateral PTS is positively correlated with internal tibial rotation, while medial PMS is not significantly correlated.*

Discussion

- PTS and PMS as well as the difference between medial and lateral compartment slopes are related to dynamic *in-vivo* knee kinematics, especially internal tibial rotation.
- **Steep lateral PTS and PMS may contribute to IR when an ACL injury occurs.**
- **Not only soft tissues but also bone morphology may contribute to rotatory knee laxity.**

Clinical significance
- Both soft tissues and bone morphology should be taken into account when evaluating rotatory knee laxity.
- Steep PTS and PMS may contribute to abnormal knee kinematics, which might explain the increased ACL injury risk [4].

References and Acknowledgement

1. Amis AA, Knee Surg Sports Traumatol Arthrosc, 2013; **2.** Rahnemai-Azar AA et al., Knee Surg Sports Traumatol Arthrosc, 2016; **3.** Hashemi J et al., Am J Sports Med, 2010; **4.** Sturnick DR et al., J Orthop Res, 2014; **5.** Hudek et al., Clin Orthop Relat Res, 2009; **6.** Anderst WJ et al., Med Eng Phys, 2009; **7.** Tashman S et al., Am J Sports Med, 2004.

This project was funded by NIH/NIAMS, grant # R01 AR 056630.

U.S. Department of Health and Human Services
Supported by the
NIH National Institute of Arthritis and Musculoskeletal and Skin Diseases