# Commentary & Perspective

## Steeper Tibial Slopes, Like Steeper Ski Slopes, Might Lead to More ACL Stress and Tears

*Commentary on an article by Dean Wang, MD, et al.: "Tibiofemoral Kinematics During Compressive Loading of the ACL-Intact and ACL-Sectioned Knee. Roles of Tibial Slope, Medial Eminence Volume, and Anterior Laxity"*

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Examining the associations between differing knee osseous geometries and knee kinematics during loading provides an important step toward the broader understanding of what causes anterior cruciate ligament (ACL) tears. In this study involving compressive loading of cadaveric knees, Wang et al. found that differences in osseous geometries were predictive of changes in anterior tibial translation and internal tibial rotation. In addition, different portions of the osseous geometry affected the ACL-intact and ACL-sectioned conditions differently. For the ACL-intact condition, increased anterior tibial translation correlated with the sagittal-plane tibial slope of both compartments as well as the difference in slope (slope differential) between each compartment. Internal tibial rotation, which would be important during the pivot-shift mechanism, correlated with increased lateral-compartment sagittal slope and the slope differential. For the ACL-sectioned condition, the volume of the anteromedial portion of the medial tibial eminence and the amount of anterior translation during a simulated Lachman test were more related to knee kinematics.

The roles of increased sagittal-plane tibial slope and increased lateral-to-medial slope asymmetry are just being understood in the settings of primary ACL tears and the risk of ACL reconstruction graft failure[1]. In this study, Wang et al. found that increased sagittal-plane tibial slope, particularly for each compartment in the ACL-intact state, was predictive of the amount of anterior tibial translation. What this means is that increasing slopes cause the tibia to translate more anteriorly. Recent studies have shown that patients who sustain noncontact ACL tears have significantly increased sagittal-plane tibial slope[2]. This study helps us to understand why knees with increased slope are at an increased risk of a noncontact ACL tear. In addition, Wang and colleagues found that, for the ACL-intact condition, lateral-compartment tibial slope and the difference in increased tibial slope between the lateral and medial compartments were predictive of internal tibial rotation. Thus, patients with a greater slope differential may have more of a native physiologic basis to translate more on a pivoting maneuver, which also could place them at a higher risk for a noncontact ACL tear. In addition, this study demonstrated that knees with a larger medial tibial eminence may not translate as much during a Lachman test as those with a smaller medial tibial eminence.

This study looked at both an ACL-intact and sectioned state. What the investigators did not analyze was the effects of changes in osseous geometry on an ACL reconstruction graft. One can assume that the state of an ACL reconstruction graft would be close to that of the native ACL state that was studied here. In a recent study, Bernhardson et al. investigated the effects of changes in sagittal-plane tibial slope on forces in ACL reconstruction grafts[3]. They reported that forces in ACL grafts significantly increased in a linear fashion as tibial slope increased. They also found that flatter slopes had lower ACL graft forces and were more protective of an ACL reconstruction graft. Clinically, this was brought to light in even more detail in a recent study by Salmon et al., who reported on 20-year outcomes of patients with hamstring grafts used in ACL reconstruction. They found that the success rate of ACL reconstruction grafts in adolescents with a tibial slope of >12° was 22%[4].

Suboptimal clinical outcomes with residual rotatory knee laxity still occur after many ACL reconstructions. More recently, there has been a revival in the use of lateral-sided extra-articular augmentation procedures to supplement an ACL reconstruction graft in order to minimize the risk of both a graft retear and any recurrent rotatory laxity. While these procedures fell out of favor decades ago because they were thought to over-constrain the knee, we may find that there is a subset of patients who could benefit from a lateral extra-articular augmentation procedure because their osseous geometry may put them at risk for a higher rate of graft tear or laxity over time. Thus, it implores us to perform further biomechanical and clinical studies to better identify and objectively quantify these differences in osseous geometry, such as the effect of medial tibial eminence volume on anterior tibial translation as found in this study, to help us identify patients who are at a higher risk of ACL graft failure. Better identification of these risk factors would allow us to focus on patients who could benefit from possible supplemental augmentation procedures concurrent with ACL reconstruction, which would lead to the holy grail of ACL reconstructions: providing the vast majority of our patients with a stable knee while returning them to higher levels of activity.

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