Determination of the Roles of the Anterior Cruciate Ligament, Posterolateral Corner, and Medial Collateral Ligament in Knee Hyperextension Using the Heel Height Test

Allison Karen Perry, Derrick Knapik, Safa Gursoy, Thomas Daniel Alter, Ian Clapp, Nikhil N Verma, Robert F LaPrade[1], Jorge A Chahla
[1]Twin Cities Orthopedics

INTRODUCTION: Anterior cruciate ligament (ACL) tears are often associated with other ligament injuries. Accurate diagnosis of combined injuries can be challenging to diagnose as subtle differences in physical examination might be present, meaning a high level of clinical suspicion is necessary. Side-to-side differences in heel height can represent a valuable tool as a diagnostic clinical test in the setting of multiligamentous injuries. The purpose of this investigation was to assess how sequential sectioning of the static stabilizing structures of the knee (ACL, fibular collateral ligament (FCL), popliteus tendon (PLT), popliteofibular ligament (PFL), and medial collateral ligament (MCL)) influence heel height measurements in a cadaveric model when comparing groups undergoing initial transection of the ACL versus FCL, along with assessment of posterior tibial slope following sequential sectioning.

METHODS: Sixteen fresh cadaveric knees were carefully dissected to expose the ACL, FCL, PLT, PFL, and MCL. Each knee was randomized to one of two groups based on the initial structure sectioned: ACL versus FCL. In the ACL first group, the sectioning order was: (1) ACL, (2) FCL, (3) PLT, (4) PFL, (5) MCL. The FCL first group followed the same sectioning order except for the FCL being sectioned first, followed by the ACL. Each knee was attached to a custom jig to allow for application of a superiorly directed 12 Newton-meter (Nm) force while stabilizing the femur to replicate a clinical scenario. In the intact state and following each sectioning, heel height was also measured with a clinician-applied force (Figure 1). Heel height measurements were compared between and within groups at each section state. The correlation between tibial slope and heel height measurements was analyzed.

RESULTS:

No significant differences in heel height measurements were appreciated between groups with initial sectioning of ACL versus FCL (P=0.863) (Figure 2). Combined ACL-FCL sectioning led to an average 2.85 ± 0.83 cm increase in heel height compared to the intact state (Table 1). Significant increases in heel height occurred following all sequential sectioning states except between PLT and PFL sectioning values (Table 1). Combined ACL-posterolateral corner (PLC) sectioning resulted in a 3.72 ± 1.02 cm increase in heel height, and additional sectioning of the MCL resulted in a 4.73 ± 1.35 cm increase compared to the intact state (Table 1). Tibial slope was not correlated with increases in heel height following each sectioning (P=0.154).

DISCUSSION AND CONCLUSION:

Combined ACL/FCL, ACL/PLC, and ACL/PLC/MCL injuries resulted in increasing heel height measurements compared to the intact state (mean of 2.85, 3.72, and 4.73 cm, respectively) regardless of sectioning order of the ACL and FCL. Tibial slope was not found to significantly influence increases in heel height with sequential sectioning. Our results suggest that heel height changes may be a clinically relevant examination tool to aid in the diagnosis of multiligament knee injuries.

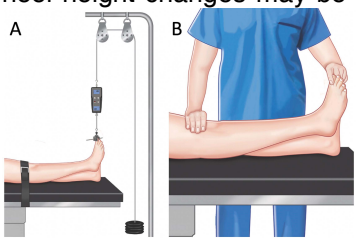

Figure 1. Application of standardized (A) and clinician-applied extension forces (B). Application of a standardized 12 Newton-meter force was accomplished by securing the distal femur of each cadaver to a standard dissection table, attaching the distal aspect of the hallux to a custom jig with a K-wire, and applying an extension force through a pulley system.

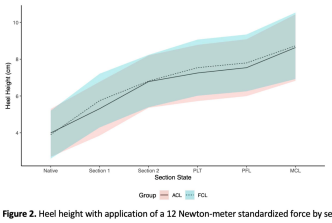

Figure 2. Heel height with application of a 12 Newton-meter standardized force by section state compared by sectioning group (ACL first vs FCL first) with a 95% confidence interval.
Abbreviations: ACL, Anterior cruciate ligament; FCL, Fibular collateral ligament; PLT, Popliteus tendon; PFL, Popliteofibular ligament; MCL: Medial collateral ligament.

Table I. Change in heel height between intact state and subsequent section states with application of a 12 Newton-meter standardized force

	Section 1	Section 2	PLT	PFL	MCL
All Specimens					
Section Change (cm)	1.58 ± 0.73	1.27 ± 0.65	0.60 ± 0.35	0.27 ± 0.32	1.01 ± 0.54
Section *P* value	**< 0.001**	**< 0.001**	**< 0.001**	0.086	**< 0.001**
Total Change (cm)	1.58 ± 0.73	2.85 ± 0.83	3.45 ± 0.90	3.72 ± 1.02	4.73 ± 1.35
ACL First					
Section Change (cm)	1.32 ± 0.59	1.47 ± 0.61	0.47 ± 0.17	0.29 ± 0.26	1.09 ± 0.64
Section *P* value	**< 0.001**	**< 0.001**	**< 0.001**	0.020	**0.003**
Total Change (cm)	1.32 ± 0.59	2.79 ± 0.70	3.26 ± 0.77	3.54 ± 0.95	4.64 ± 1.38
FCL First					
Section Change (cm)	1.85 ± 0.71	1.06 ± 0.58	0.73 ± 0.40	0.26 ± 0.36	0.93 ± 0.35
Section *P* value	**< 0.001**	**0.002**	**0.002**	0.101	**< 0.001**
Total Change (cm)	1.85 ± 0.71	2.91 ± 0.89	3.64 ± 0.92	3.90 ± 1.00	4.83 ± 1.23

Note: Table depicts sectioning performed in a sequential manner. Section change is the change in heel height relative to the intact state (section 1) or prior sectioned state, with the corresponding standard deviation and *P* value reported. Total change is the change in heel height relative to the intact state. Bolded values indicate statistical significance of < 0.01.
Abbreviations: ACL, Anterior cruciate ligament; FCL, Fibular collateral ligament; PLT, Popliteus tendon; PFL, Popliteofibular ligament; MCL: Medial collateral ligament.