THE ANTERIOR CRUCIATE LIGAMENT DOES NOT STABILIZE INTERNAL TIBIAL ROTATIONS

An in vitro study of tibiofemoral kinematics under physiological loading conditions

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INTRODUCTION

Anterior cruciate ligament (ACL) injury can cause immediate functional instability, which would consequently increase the risk to subsequent meniscal tears and degenerative osteoarthritis [1-4]. To restore the ACL-deficient knee back to its normal stability, the knowledge of the role of ACL in determining tibiofemoral kinematics is clearly warranted.

It has been shown that ACL primarily restrains the anterior tibial translation. However, the role of ACL in restraining internal tibial rotation remains controversial [5,6]. Although knee kinematics have been studied previously, most studies ignored the effects of muscle loading [7] or simply applied constant muscle forces [8], creating unrealistic knee kinematics simulation.

Therefore, in the current study, weight-bearing knee flexion was simulated, and tibiofemoral kinematics in response to external loading (50 N anterior tibial force, ATF, and 5 Nm internal tibial torque, ITT) was investigated with and without the presence of ACL. We hypothesized that in a simulated weight-bearing knee flexion with and without external tibial load: the absence of ACL does not affect the internal tibial rotation.

METHODS

Nine human knee specimens were mounted on a dynamic knee simulator which simulated weight bearing knee flexions similar to the “Oxford Rig” [9]. A robotic/UFS system was used to provide external tibial loads during the movement. Three loading conditions were prescribed to the movement, including body weight only (BW), a 50 N ATF, or a 5 Nm ITT. Tibiofemoral kinematics of each specimen was measured using a ultrasonic motion capture system (ZEBRIS), when ACL was intact and after the ACL was arthroscopically dissected.

A two-way repeated-measure analysis of variance was conducted (SAS, SAS Institute Inc., Cary, NC) to investigate the effect of external loading and ACL status on knee kinematics. A post hoc test using Tukey-Krammer method was also performed.

RESULTS AND DISCUSSION

We failed to refute our null hypothesis that internal tibial rotation is not affected by the absence of the ACL. Our results showed that even under a 5 Nm internal tibial torque, the dissection of ACL did not increase the internal tibial rotation significantly (by approximately 2 deg, p>0.2, see Figure 1).

On the other hand, ACL dissection significantly increased anterior tibial translation under the ATF loading condition (p<0.003). Even without the application of anterior tibial force (BW loading condition), we observed a significant increase in anterior tibial translation by approximately 4 mm at 20 to 40 degree flexion angles (p<0.02, see Figure 2).

Our findings suggest that ACL has limited ability to stabilize internal tibial rotation during muscle-loaded knee flexion, which corroborate previous in-vivo investigations [10]. This implies other structures, such as collateral ligaments, quadriceps, and hamstrings, may play a more important role in maintaining internal rotational stability.

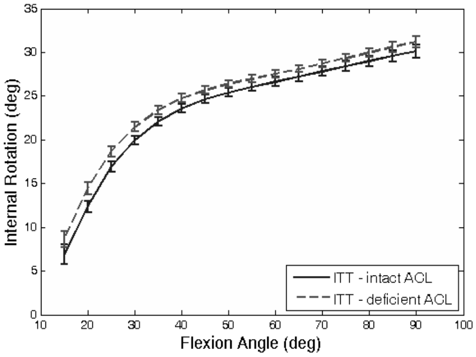

Figure 1: Internal tibial rotation during internal torque (ITT) with and without ACL. Error bars represent one standard error.

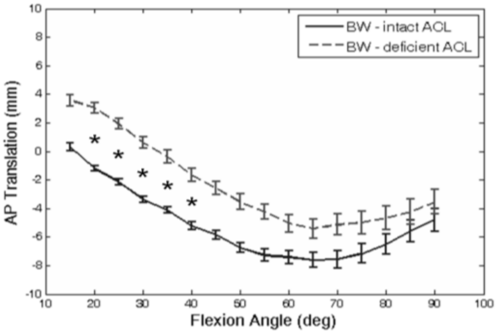

Figure 2: AP tibial translation during body weight only (BW) loading with and without ACL. Error bars represent one standard error. * denotes statistical significant difference in the displacement between the two conditions (p<0.05).

CONCLUSION

Our findings indicate (a) anterior tibial translation is stabilized by ACL while (b) internal tibial rotation is not.

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