LARGE PATELLAR LIGAMENT INSERTION ANGLE FOLLOWING ACL INJURY CAUSES LARGE QUADRICEPS REDUCTION DURING WALKING

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INTRODUCTION

Functional adaptations in gait patterns have been observed following anterior cruciate ligament (ACL) injury. In particular, a reduction in the peak quadriceps moment has been reported following ACL injury (Berchuck, 1990). It has been suggested that reduced quadriceps contraction may be an adaptation to prevent anterior tibial translation in ACL-Deficient (ACL-D) knees. However, the level of quadriceps reduction varies between individuals (Noyes, 1992; Robert, 1999). One potential factor causing these differences may be the anatomical variations in the knee extensor mechanism, because the patellar ligament insertion angle (PLIA) determines how quadriceps force is decomposed into anterior and superior components.

This study tested the hypothesis that the reduction in peak external knee flexion moment (balanced by net quadriceps moment) of ACL-D knees compared to their contralateral knees during walking is negatively correlated to the PLIA in individuals with large PLIA, while no relationship would be observed in individuals with small PLIA.

METHODS

Nineteen unilateral ACL-Deficient subjects (40.3±12.5 yrs, 12 male, 2~432 months past injury) were tested after IRB consent. Sagittal-plane MRIs (3D-SPGR) were taken in a supine, non-weight-bearing, fully extended position. PLIA of the ACL-D knee was measured as the angle between the patellar ligament and the tibial shaft, as described previously (Fig. 1) (Shin, 2004). Individuals were divided into a large-PLIA group and small-PLIA group based on the median PLIA observed for all ACL-D knees.

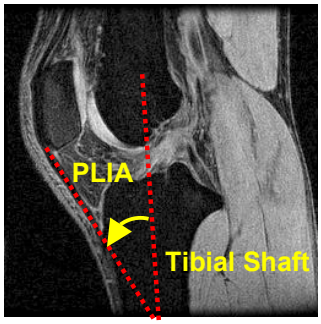

Figure 1: Measurement of patellar ligament insertion angle (PLIA) relative to tibial shaft.

Kinetics was measured using an opto-electronic motion capture system (Qualisys, Gothenburg, Sweden) with a force plate (Bertec, Columbus, OH) using a previously-described 6-marker link protocol (Berchuck, 1990). All subjects walked at three self-selected speeds (fast, normal, slow), three trials each. Peak external knee flexion moments (% body weight * height) corresponding to the average walking speed (1.35m/s) were estimated from each individual's speed vs. peak knee flexion moment regression equation, since peak knee flexion moment is known to be strongly correlated with walking speed (R^2=0.73) (Lelas, 2003). The reduction in peak knee flexion moment of ACL-D sides compared to subjects' uninjured contralateral sides was calculated. Linear

regression analysis was performed to study the relationship between PLIA (°) and the reduction in peak knee flexion moment for each of the two groups.

RESULTS AND DISCUSSION

The reduction in the peak knee flexion moment was associated with an increased PLIA for subjects in the large PLIA Group (Fig. 2). In the large-PLIA group of ACL-D knees, a significant negative correlation was observed between PLIA and reduction of peak external knee flexion moment (R^2=0.81, P<0.001). However, in the small-PLIA group of ACL-D knees, no significant correlation was observed (R^2=0.03, P=0.65). The median value of PLIA was 20.1°.

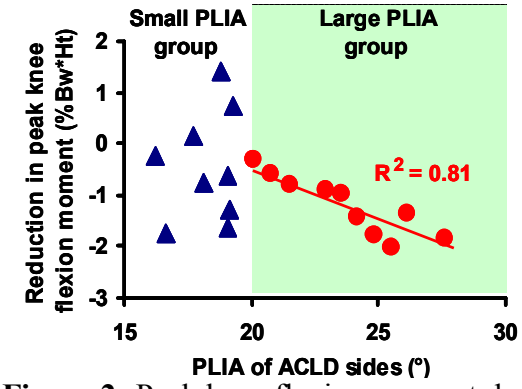

Figure 2: Peak knee flexion moment during walking vs. patellar ligament insertion angle (PLIA). Only the large-PLIA group (•) showed a significant correlation (p<0.001).

The strong negative correlation in the large-PLIA group suggests that these subjects adapt their walking actively following ACL injury. As previously hypothesized (Berchuck, 1990), these patients may perceive instability due to the anterior drawer effect of quadriceps contraction. The quadriceps reduction in this group appears to be a proportional adaptation in response to needs.

In the small-PLIA group, the lack of a correlation suggests that the anterior drawer effect of quadriceps contraction is small enough not to be perceptible to all individuals. Some may perceive instability and reduce quadriceps usage, whereas others do not. Other factors may also influence a quadriceps adaptation in this group, leading to the large variability observed.

Adapting gait by reduced flexion moment has been shown to result in a more normal tibiofemoral position (Andriacchi, 2005). Thus, this adaptation in the large PLIA group may be beneficial for reducing secondary changes in the meniscus or articular cartilage, thereby slowing down the rate of osteoarthritis following ACL injury.

SUMMARY/CONCLUSIONS

This study has shown that the anatomy of the knee extensor mechanism provides a possible explanation for the variability previously observed in the adaptation of a quadriceps reduction strategy following ACL injury. In the future, individually-tailored treatment and rehabilitation protocols that include information about the individual's own knee extensor anatomy may improve patient outcomes.

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ACKNOWLEDGEMENTS

Funding from NIH R01-AR39212.