THE INFLUENCE OF PATELLAR LIGAMENT INSERTION ANGLE ON QUADRICEPS USAGE DURING WALKING IN ACL RECONSTRUCTED SUBJECTS

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INTRODUCTION

It has been theorized that reduced quadriceps contraction is an adaptation to prevent anterior tibial translation in ACL-deficient (ACL-D) knees (Berchuck, 1990) and consequently the quadriceps reduction during walking is proportional to the patellar ligament insertion angle (PLIA) (Figure 1). This theory has been supported by a recent study that reported the peak net quadriceps moment was correlated with the PLIA for ACL-D knees, but not in contralateral knees (Shin, 2007). In addition, the PLIA of ACL-D knees is significantly smaller than the PLIA of their uninjured contralateral knees (Shin, 2007), most likely as a consequence of the loss of tension in the ACL. At present it has not been shown whether ACL reconstruction (ACL-R) restores the PLIA and if the PLIA is restored if the quadriceps reduction previously observed in ACL-D knees disappears.

This study tested the following hypotheses: (1) The PLIA of ACL-R knees is not different from the PLIA of uninjured contralateral knees; (2) Peak external knee flexion moment during walking (balanced by net quadriceps moment) is not correlated with PLIA in ACL-R knees.

METHODS

24 unilateral ACL-R subjects (33.6 ±9.2 years, 9 males, 1.69±0.08 m, 69.1±10.2 kg, BMI 24.2±3.1kg/m^2, 3.6±3.2 years post injury, 2.8±2.8 years post surgery) were tested after IRB consent. Sagittal-plane MRIs (3D-SPGR) were taken in a supine, non-weight-bearing, fully extended position. PLIA of the both knees were measured as the angle between the patellar ligament and the tibial shaft, as described previously (Figure 1) (Shin, 2007). Hypothesis 1 was tested using a paired two-tailed paired Student's t-test ($\alpha = 0.05$, power=0.9). Kinetics was measured using an opto-electronic motion capture system (Qualisys, Gothenburg, Sweden) using a previously-described 6-marker link protocol (Andriacchi, 1980). 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 difference in peak knee flexion moment between ACL-R and contralateral knees was examined using a paired two-tailed Student's t-test (α=0.05). Linear regression analysis was performed to study the relationship between PLIA and the peak knee flexion moment (Hypothesis 2).

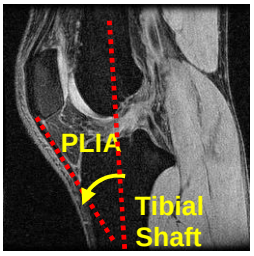

Figure 1: Measurement of patellar ligament insertion angle (PLIA) relative to tibial shaft

RESULTS AND DISCUSSION

ACL reconstruction restored the PLIA to normal values. The PLIA of the ACL-R knee was not different from the contralateral knee (p=0.18, power=0.985). In addition, peak knee flexion moment (balanced by net quadriceps moment) was not correlated with the PLIA following ACL reconstruction (R^2=0.012, power=0.99) (Figure 2).

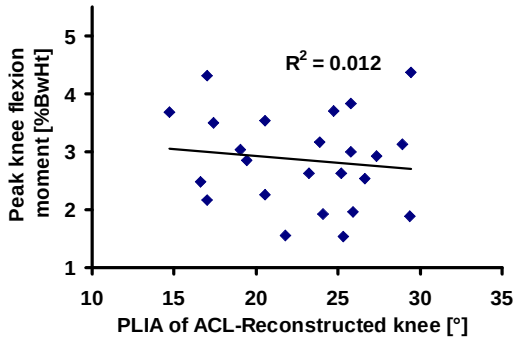

Figure 2: In ACL–R knee, no correlation was observed between peak external knee flexion moment and PLIA

These results on ACL-R knees show an important difference to a previous study (Shin, 2007), which reported ACL-deficient subjects with a large PLIA reduced their quadriceps usage proportionately to the PLIA. The combined results of these studies further support the theory that a reduced quadriceps moment in an ACL deficient population is an adaptation to reduce the anterior tibial translation associated with quadriceps contraction when the knee is near full extension.

It should be noted that while the peak knee flexion moment was not correlated with PLIA in ACL-R knees, the magnitude of the knee flexion moment in patients following ACL reconstruction was significantly lower than the peak knee flexion moment in the contralateral knees for almost every subject. This reduced quadriceps moment (Figure 3) is similar to previous studies for ACL-D knees and is consistent with previous findings that quadriceps reduction remains several years post surgery and rehabilitation (Devita, 1998). It remains unknown why quadriceps reduction adaptations persist in ACL-R knees, but this persistent adaptation may result in altered tibiofemoral contact kinematics that may lead to early onset of osteoarthritis.

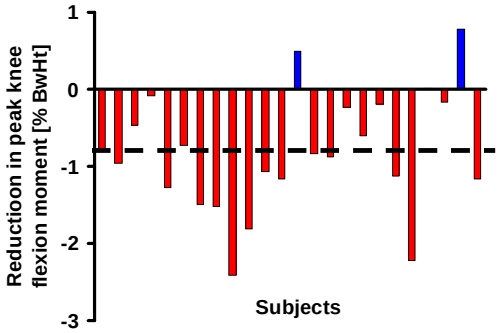

Figure 3: Most subjects show reduced peak knee flexion moment (red bars). Mean reduction was 0.83% BwHt (black dashed line).

In summary, this study has shown that the PLIA of ACL-R knees returned to normal after surgery and that patients no longer adapt their gait in response to the PLIA. However, quadriceps function did not return to normal levels during walking following ACL reconstruction, which may partially explain the increased incidence of osteoarthritis in this population.

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