Muscle activation as a function of graft type in ACL reconstruction

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Introduction

ACL reconstruction (ACLR) is typically done with either an autograft or allograft. Although many studies have investigated the in vitro and in vivo biomechanical properties of the different types of grafts, few have examined the implications of graft choice on the activity levels of the surrounding musculature in the leg. Specifically, no previous work has looked at the effect of a weakened donor-site tendon on the muscle activity of the leg muscles.

The purpose of this study was to understand the effect of graft type in ACLr on muscle activity of the affected leg. It was hypothesized that patients who received an autograft would have resulting altered muscle activity, specifically in the muscle directly affected by the donor-site tendon.

Methods

25 ACLr patients and 25 healthy subjects participated in this IRB-approved study at 5 months post-op. 10 (2F, 8M, age 34.10±2.69) subjects had received a hamstring tendon autograft, 6 (2F, 4M, age 31.50±3.84) received a BPTB autograft, and 9 (3F, 6M, age 34.00±2.76) received a contralateral BPTB autograft. Although the contralateral graft is rarely done in today’s practice, this graft type mimics an allograft in that there is no donor site tendon in the reconstructed limb. Surface EMG electrodes were attached to the affected leg of the subjects and measured the activity levels of the vastus medialis and lateralis, medial and lateral hamstrings, rectus femoris, and the gastrocnemius. Subjects ran on a 10° decline treadmill at 2.5 m/s, and EMG data was collected during three running trials. Additionally, subjects wore an accelerometer in order to extract heelstrike times during each trial.

Results

Each muscle’s activation start time and duration of activity was extracted from the processed EMG data, and the results are plotted in Figure 2. We found previously that there are significant differences in muscle activation between reconstructed and non-reconstructed knees (Figure 3), particularly in the vastus medialis and lateralis, rectus femoris, and the gastrocnemius. The muscle activity of healthy knees serves as a reference in Figure 2, though comparisons were only made between the different grafts. Statistical significance is only observed in the duration of activation of the gastrocnemius between the hamstring and contralateral grafts (Mann-Whitney, p=0.050). Graphically, however, there do appear to be trends toward significance between the hamstring and contralateral grafts in the lateral hamstring, and between the BPTB and contralateral grafts in the rectus femoris.

Discussion

Although there are significant differences in muscle activation between a healthy and reconstructed limb, there appear to be minimally significant differences in muscle activation based on graft choice. The significance in duration of gastrocnemius activation between hamstring and contralateral grafts can be attributed to the loss of full flexion in gait, which has been observed in patients with hamstring autografts in ACLr. This loss of full flexion may also be responsible for the decrease in activation in the lateral hamstring when comparing the hamstring and contralateral grafts. Clinically, however, these differences mean little for the rehabilitating patient, and the overall lack of significance indicates that there is little effect of graft choice on the surrounding leg musculature in ACLr. Therefore surgeons do not need to consider altered muscle activity when choosing the graft type in reconstruction.

It is important to note, however, that there were relatively small, unequal sample sizes in the graft groups. As a result, there was a large amount of variance in the data. In the future, larger sample sizes may make it possible to decrease the variance seen in the muscle activation data and to ascertain whether the trends toward significance are meaningful. Additionally, future analysis could include the use of the dynamic stereo X-ray (DSX) system with EMG collection, which would allow for a link between kinematic and muscle activation data.

Significance

An estimated 200,000 ACL reconstructions are performed each year, with the vast majority being reconstructed with an autograft or allograft. By understanding the implications of graft choice on the muscle activity of the reconstructed leg, surgeons will be better able to choose an appropriate graft for each patient, potentially resulting in fewer failures and quicker return to function.

References


Figure 1: Subject running on declined treadmill [1]

Figure 2: Muscle activation times and duration during downhill running as a function of graft type in ACLr

Figure 3: Muscle activation times and duration during downhill running in healthy and reconstructed subjects [2]