MUSCLE MORPHOLOGY AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION WITH AUTOLOGOUS SEMITENDINOSUS-GRACILIS GRAFT

Glenn N. Williams, Peter J. Barrance, Lynn Snyder-Mackler, Thomas S. Buchanan

Center for Biomedical Engineering Research, University of Delaware, Newark, DE. USA
E-mail: glennwms@udel.edu

INTRODUCTION

It is estimated that 250,000 anterior cruciate ligament (ACL) injuries occur in the United States each year (Boden, 2000). More than half of those who sustain ACL injuries are treated surgically. Autologous semitendinosus-gracilis (ST-GRA) grafts have increased in popularity over the last decade and are rapidly becoming the graft of choice for many surgeons. Although there is a growing body evidence demonstrating that the short-term functional outcomes for this procedure are comparable to that which is observed with other grafts, the effect(s) that it has on the muscles of the injured person’s limb remains unclear. The purpose of this study was to evaluate the effect that ACL reconstruction with autologous ST-GRA graft has on muscle volume and peak cross-sectional area (CSA) by digitally reconstructing participants’ muscles from magnetic resonance images.

METHODS

Six subjects who sustained isolated ACL ruptures volunteered to participate in this study. Magnetic resonance imaging (MRI) of both limbs of each subject was performed shortly before surgery and after the subjects had returned to playing their sport of choice (6 to 9 months later). All subjects had been regular participants in activities that required quick changes of directions and/or jumping prior to their injuries and had been injured within 6 months of the date of enrollment in this study. Axial spine-echo T1-weighted scans were acquired with a 1.5-T GE SignaLX scanner from the level of the ankle mortise to the iliac crest while subjects lay supine in the scanner. The images were acquired in four sequences: lower leg, knee, thigh, and pelvis. Both limbs were imaged simultaneously using the scanner’s body coil. The imaging protocol was as follows: repetition time (TR) = 350 ms, echo time (TE) = 9 ms, slick thickness = 10 mm except over the knee joint where it was 5 mm, gap between slices = 1.5 mm except over the knee joint where it was 1.0 mm, 256x160 matrix, and the field of view varied with the subjects size.

Each subject’s semitendinosus (ST), semimembranosus (SM), biceps femoris longus (BF), sartorius (SAR), rectus femoris (RF), tensor fascia lata (TFL), gracilis (GRA), vastus medialis (VM), and vastus lateralis (VL) muscles were digitally reconstructed by tracing the contour of each muscle in each axial slice.

Figure 1: A) Tracing muscles with a digital palette. B) Axial image of the thigh with the ST (green), SM (blue), & GRA (red) traced.
The contours from all imaging sequences containing each muscle were grouped and used to build patient-specific polygonal models of each muscle with custom software. The volume and peak CSA of each muscle were calculated from these models.

RESULTS AND DISCUSSION

The ST and GRA muscles of the reconstructed knees exhibited markedly reduced muscle volume and peak CSA when pre-surgery and post-surgery data were compared (Figures 2 & 3). Conversely, the BF, SM, and TFL hypertrophied. The other muscles of the reconstructed knee displayed slight atrophy. Little change was observed in the muscles of the uninjured limbs.

Figure 3: MRI image (mid-thigh) showing marked atrophy of the ST & GRA muscles.

The BF and SM hypertrophy observed in our subjects suggests that they used these muscles to compensate for their ST and GRA deficits. Using the BF to account for decreased medial flexor function may result in increased loading of the lateral compartment of the knee. This could be detrimental to articular cartilage health over the long term. The reasons for TFL hypertrophy are unclear. It is plausible that subjects compensated for decreased medial knee rotation with increased medial rotation of the hip (an action of the TFL).

SUMMARY

Semitendinosus and GRA muscle volume and peak CSA were markedly reduced. Our results suggest that people may compensate for autologous ST-GRA graft harvest with increased BF and SM use. Although subjects who undergo ACL reconstruction with autologous ST-GRA grafts appear to do well over the short-term, this procedure may not be as benign as is currently thought. More research is needed on this topic.

REFERENCES


ACKNOWLEDGEMENTS

NIH Grant RO1-AR46386 and the Foundation for Physical Therapy.