CONTRACTION OF THE GASTROCNEMIUS MUSCLE PRODUCES STRAINS ON THE ACL

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INTRODUCTION:
The primary muscles that span the knee are the quadriceps, hamstrings and gastrocnemius. The effects that the quadriceps and hamstrings have on the ACL have been well documented. However, the influence of the gastrocnemius remains unclear. Since the proximal tendon of the gastrocnemius wraps around the posterior aspect of the tibial plateau, it’s contraction could potentially strain the ACL by pushing the tibia anterior when the knee is near extension. The objective of this study was to determine if the gastrocnemius muscle is an antagonist of the ACL.

METHODS:
Six subjects who were candidates for arthroscopic meniscectomy participated in the study. The surgical procedure was performed under spinal anesthesia to ensure that the leg musculature was relaxed. The study was approved by the Institutional Review Board and all subjects granted their informed consent prior to participating.

Following the routine surgical procedure, a Differential Variable Reluctance Transducer (DVRT; MicroStrain, Inc. Burlington VT) was implanted in the anteromedial bundle of the ACL to measure the ACL displacement response. The displacement measurements were converted to ACL strain values using the engineering strain formulation. The transducer length that corresponded to the slack-taut transition length of the ACL was used as the reference length (1).

Transcutaneous electrical muscle stimulation (CPS 400 Stim; Chattanooga Group, Hixson TN) was used to induce contractions in the gastrocnemius muscle of the anesthetized subject using two 2” x 4” oval electrodes (PALSFLex 42081; Chattanooga Group) placed over the belly of the muscle. During testing, the thigh was constrained in the horizontal plane and the foot was positioned in a fixture that controlled knee and ankle position (Figure 1). The fixture also utilized a 6 DOF load cell (SRMC3A; AMTI, Watertown MA) to measure the plantar-flexion moments produced at the ankle due to the gastrocnemius contractions. The gastrocnemius was electrically stimulated with the knee at 5°, 15°, 30° and 45° of flexion (randomized) while the foot was constrained with the ankle in the neutral position (0° plantar-flexion). Electrical muscle stimulation was applied to produce ankle moments of 15 Nm (a 2-second ramp) while the ACL strain values and ankle moment were recorded. Assuming a gastrocnemius moment arm of 5 cm, a 15 Nm ankle moment corresponded to a gastrocnemius force of approximately 300 N.

The effects of knee flexion angle and gastrocnemius force magnitude on ACL strain values were statistically analyzed using ANOVA (a factorial randomized complete block experimental design). Each subject served as his/her own control.

RESULTS:
Both knee flexion angle (p<0.01) and gastrocnemius force activity (p<0.01) affected ACL strain values (Figure 2). With the knee at 5° and 15° of flexion, contraction of the gastrocnemius increased ACL strain values relative to the relaxed state. At the higher knee flexion angles (30° and 45°), the ACL was not strained.

DISCUSSION:
In this study, the gastrocnemius muscle was proven to be an antagonist of the ACL when the knee was near extension. O’Connor (1) previously demonstrated this phenomenon using a geometrical model of the knee. He predicted that the gastrocnemius could potentially load the ACL when the knee was near extension due to tibial impingement. These results are in contrast to those of Durselen (2) who concluded from a cadaver study that the gastrocnemius muscle did not strain the ACL at any knee flexion angle. However, they simulated muscle function in the cadaver by replacing the muscle with a thin cable without preserving the bulk of the muscle. Our results may have important clinical ramifications in ACL rehabilitation since flexor moments are generally thought to be protective of the ACL. Flexor moments are generally associated with the hamstrings muscles that are known to strain the ACL (4). However, the gastrocnemius is a flexor of the knee and may also contribute to the flexor moment. Thus, it is important to consider all of the muscles that may contribute to knee function when evaluating the protective mechanisms of different rehabilitation exercises.

REFERENCES:

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