KNEE KINEMATICS IN ACL RECONSTRUCTED BILATERAL SQUAT

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INTRODUCTION
Knee motions are determined by the interaction between active and passive constraints of the joint and forces acting on the joint. Changes in knee kinematics, kinetics, and muscle function are found with ACL injury, specifically, changes in the anterior-posterior (AP) translation and internal-external (IE) rotation of the knee leading to buckling or giving way [1,2]. ACL repair is performed to restore the knee to its normal function, however, the altered kinematic, kinetic, and muscle function may not be completely restored. We hypothesize that knee kinematics may not be restored to normal after ACL reconstruction.

METHODS
Ten subjects participated in this study. Five (two male, three female) ACL reconstructed subjects and 5 (two male, three female) healthy uninjured control subjects were compared. The ACL reconstructed subjects had sustained an isolated unilateral ACL tear during sporting activity and were surgically reconstructed with patellar tendon graft more than 7 months prior to testing (average 52 mo.). All subjects had a normal contralateral knee and were cleared by their orthopedist to participate in normal activity by the time of testing. Control subjects had no history of lower extremity injury or pathology that may have affected the ability to perform the task.

Institutional review board approval of this study was granted, and informed consent was obtained prior to testing. All subjects were tested performing a bilateral squat. Subjects stood with feet shoulder width apart with each foot on one of two force plates (AMTI, Watertown, MA, USA). Subjects were asked to keep the torso as upright as possible and to perform continuous bilateral squats not past a comfortable level of knee flexion. Each subject was allowed to squat at a self-selected pace for an interval of 25 seconds for two trials of data collection.

Prior to testing, retro-reflective markers were placed over bony landmarks on each subject. Kinematic data were collected using Qualisys Track Manager (Qualisys AB, Gothenburg, Sweden). A nine camera video-based optoelectronic system was used to make kinematic and kinetic measurements from the marker position data [4] and to perform data filtering. A measure of tibial translation of the reconstructed knee relative to the contralateral knee was made using markers placed over the inferior pole of the patella, tibial tubercle, and lateral malleolus as described by Beard et al. [3]. For normal subjects, the relative measure of translation was chosen as right to left or left to right based on which measure more closely approached the ACL reconstructed subjects.

All squats were averaged for each subject and normalized from 0-100% of the squat cycle. Relative AP translation and IE rotation were measured at 10 degree increments of knee flexion starting from 10 degrees up to 50 degrees. Finally, data were normalized so that AP translation and IE rotation started at zero for each subject at 10 degrees knee flexion.

The slope of the relative tibial translation over each 10 degree increment of knee flexion was calculated for each subject (Fig. 1). The slope with the maximum magnitude, retaining sign, was determined for each subject. These values were averaged for the two groups, ACL reconstructed and normal (Table 1). Results were compared using a two sample t-test assuming equal variances. Similar results were produced for the slope of relative IE rotation versus knee flexion angle.

For the normal subjects, the relative measures could be made as right relative to left or vice versa determining whether the value took on a positive or negative value. Therefore, the measure chosen for each normal subject was made to parallel the direction of the ACL reconstructed subjects. The measure chosen for comparison is represented by the solid curves and their unutilized counterparts as the dotted curves (Fig. 1). Thus, the differences between the normal and ACL reconstructed groups were intentionally biased in favor of minimizing the differences.

RESULTS AND DISCUSSION
ACL reconstructed knees analyzed in early flexion displayed a 5-fold greater rate of change in posterior tibial translation in the reconstructed knee relative to the contralateral side than did a similar comparison of normal knees (p = 0.01). The relative rate of change of external rotation of the tibia with respect to the femur appeared to be 3 times greater in the ACL reconstructed group (p = 0.1).
CONCLUSIONS
ACL reconstructed knees in this study displayed a greater rate of change in posterior tibial translation and external rotation with flexion in the reconstructed knee relative to the contralateral side than did a similar comparison of normal knees.

REFERENCES

Table 1: Side to side differences in maximum rate of change (mean ± SD; range) of tibial translation (tibia with respect to femur, +Posterior) and IE rotation (tibia with respect to femur, +Internal) with knee flexion angle.

<table>
<thead>
<tr>
<th>Group</th>
<th>Relative tibial translation/flexion (mm/deg)</th>
<th>Relative IE rotation/flexion (deg/deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACL (reconstructed – contralateral)</td>
<td>0.19 ± 0.10; 0.10 to 0.34</td>
<td>−0.24 ± 0.22; −0.56 to −0.06</td>
</tr>
<tr>
<td>Normal</td>
<td>0.04 ± 0.04; −0.02 to 0.08</td>
<td>−0.07 ± 0.06; −0.17 to −0.01</td>
</tr>
<tr>
<td>P-value (two-tail)</td>
<td>0.01</td>
<td>0.1</td>
</tr>
</tbody>
</table>