ACL Injury Combined with Medial or Lateral Meniscus Tear Altered the Knee Joint Kinematics Differently

Li, JS; Hosseini, A; Finn, R; Cancre, L; Gill, TJ; +Li, G
+Bioengineering Laboratory, Harvard Medical School/Massachusetts General Hospital, Boston, MA
gill1@partners.org

INTRODUCTION:
Anterior cruciate ligament (ACL) is the most commonly injured ligament of the knee joint. Meniscus tears usually accompany ACL tears [1, 2]. No data has been reported on the effect of medial meniscus or lateral meniscus tears affecting kinematics. The purpose of this study is to investigate the knee kinematics of ACL deficient patients with either medial meniscus or lateral meniscus injuries during the step-up exercise. We hypothesize that an ACL injury will cause different knee kinetic responses if combined with a medial meniscus injury or combined with a lateral meniscus injury.

METHODS:
17 unilateral ACL injured patients were recruited in this study with informed consents. All subjects were classified by operative notes and separated into medial meniscus injured group (MM, 7 subjects, 5M 2F, age 39±8yrs) and lateral meniscus injured group (LM, 10 subjects, 8M 2F, age 36±10yrs). Both injured and contralateral healthy knees were scanned using a 3-Tesla magnetic resonance scanner and manually digitized to reconstruct the knee models including the tibia and femur. The motion during the one-stair step-up exercise was captured by a dual fluoroscopic imaging system. The knee models were imported into a solid modeling software and matched to the outlined silhouettes of the tibia and femur on dual fluoroscopic images in a virtual environment. This method has been validated with an accuracy of 0.1mm in translation and 0.3° in rotation [3]. To measure the kinematics, the femoral and tibial coordinate systems were built from anatomical landmarks. The femoral coordinate system includes the transepicondylar axis (TEA), long axis of femur and the origin which was set to the midpoint of the TEA. The tibial coordinate system includes tibial mediolateral axis connecting the center of the medial and lateral plateau, long axis of tibia and the origin which was set to the midpoint of the mediolateral axis. The changes in tibial internal/external, valgus/varus rotations and anteroposterior translation of the ACL deficient knees relative to those of intact contralateral knees at every 20% of the step-up exercise were determined.

RESULTS:
The average time for performing the step-up exercise is shown in Table 1. In flexion/extension, both the LM and MM groups showed similar trends with an average of 52.7° and 53.7° for the LM group, and 51.7° and 48.3° for the MM group at 0% progress of the activity compared to intact knees (Fig. 1a). In valgus/varus rotation, the MM group kept a slight varus posture during the step-up exercise compared to contralateral side. In internal/external rotation, the tibia of the MM group tended to rotate externally during the last 20% of step-up exercise compared to contralateral side, with an average of 3° less change than that was observed in the LM group (Fig. 1b). In valgus/varus rotation, the MM group kept a slight varus posture during the step-up exercise compared to contralateral knees. The MM group started in a more varus position with 1.8° at 0 % and show a valgus rotation trend during the rest of step-up exercise compared to intact knees (Fig. 1c).

DISCUSSION:
This study investigated the changes of the tibiofemoral joint kinematics during the step-up exercise between contralateral healthy knees and ACL deficient knees with unilateral meniscus injury. At the beginning of step-up exercise, the knee flexion angle is about 50 degrees and reached fully extension at the end of exercise. An increasing trend of anterior tibial translation was found in ACL deficient knees with the LM group. In internal/external rotation, the group showed a trend of tibial external rotation at the end of stepping up. In valgus/varus rotation, both the MM and LM were more prone to valgus and varus, respectively during stepping up. This behavior is reasonable because the meniscus injury may reduce the joint space of medial or lateral compartment. In conclusion, this study represented the tibiofemoral joint kinematics during the step-up exercise in contralateral healthy and ACL deficient knees. Medial and lateral meniscus injuries affect the knee joint kinematics differently.

Table 1: Average time (second) for step-up exercise.

<table>
<thead>
<tr>
<th></th>
<th>Healthy</th>
<th>ACL deficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medial meniscus</td>
<td>0.74±0.17</td>
<td>0.79±0.15</td>
</tr>
<tr>
<td>Lateral meniscus</td>
<td>0.73±0.14</td>
<td>0.74±0.20</td>
</tr>
</tbody>
</table>

SIGNIFICANCE:
ACL deficient patients combined with meniscus injury are common. This study revealed that the medial or lateral meniscus injuries may cause different knee kinematics responses, which may provide applications to treatment of the ACL injuries.

ACKNOWLEDGEMENTS:
The authors thank National Institute of Health for financial support (R01 AR055612) and the Department of Orthopaedic Surgery at Massachusetts General Hospital.

REFERENCES: