INTRODUCTION:
Anatomic double-bundle anterior cruciate ligament (ACL) reconstruction has been advocated, as conventional single-bundle ACL reconstruction does not completely restore normal knee kinematics. There are, however, few reports comparing anatomic single- and double-bundle ACL reconstruction. Many previous studies compared double-bundle ACL reconstruction to conventional single-bundle ACL reconstruction. The purpose of this study is to compare the biomechanics of anatomic single-bundle ACL reconstruction and anatomic double-bundle ACL reconstruction.

METHODS:
Sixteen fresh-frozen human cadaveric knees were tested using a robotic universal force/moment sensor testing system. The femur was fixed to a rigid base the tibia to the robotic/UFS testing system. A CASPAR Stäubli RX90 robot (Orto MAQUET, Germany) was used to manipulate the joint. A universal force/moment sensor (UFS-Model 4015; JR3 Inc. Woodland, CA) was used to measure the forces and moments for 6-degrees-of-freedom (DOF) (Fig. 1).

Eight knees (n=8) were used for the anatomic single-bundle ACL reconstruction, which was placed from the center of tibial ACL footprint to the center of femoral ACL footprint. Another eight knees (n=8) were used for anatomic double-bundle ACL reconstruction. (Fig. 2)

Table 1. Experimental Protocol and Data Acquired

<table>
<thead>
<tr>
<th>Step</th>
<th>Status of knee</th>
<th>Loading condition</th>
<th>Data Acquired</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Intact ACL</td>
<td>Applied 2 loads</td>
<td>Intact knee kinematics</td>
</tr>
<tr>
<td>2</td>
<td>ACL deficient</td>
<td>Repeat kinematics</td>
<td>In situ force of ACL in intact knee</td>
</tr>
<tr>
<td>3</td>
<td>Anatomic SB</td>
<td>Applied 2 loads</td>
<td>ACL-deficient knee kinematics</td>
</tr>
<tr>
<td></td>
<td>SB graft released</td>
<td>Repeated kinematics</td>
<td>In situ force of SB graft</td>
</tr>
<tr>
<td>4</td>
<td>Anatomic DB</td>
<td>Applied 2 loads</td>
<td>DB reconstructed knee kinematics</td>
</tr>
<tr>
<td></td>
<td>DB graft released</td>
<td>Repeated kinematics</td>
<td>In situ force of DB graft</td>
</tr>
</tbody>
</table>

For this study, the loading conditions included (1) a 89 N anterior tibial load with the knee at full extension and at 15°, 30°, 60° and 90° of knee flexion and (2) a combined rotatory load of 7 N-m of valgus torque and 5 N-m of internal tibial torque at 0°, 15°, 30° and 45° of knee flexion.

The in situ force in the ACL was determined after transecting the ACL arthroscopically. The in situ force of the reconstructed graft was measured at subsequent states (intact, single-bundle ACL reconstructed knee, double-bundle ACL reconstructed knee).

RESULTS:
In response to anterior loading, both single- and double-bundle grafts had an in situ force equal to the intact ACL at 0°, 15°, and 30° of knee flexion, however, both had significantly lower in situ force than the intact ACL at 60° and 90° of knee flexion (Fig.3-a).

In response to the pivot loading, there was no significant difference in the in situ forces among the groups (Fig. 4-a).

When compared to the intact ACL, the double-bundle ACL reconstructed knee had significantly lower ATT at 0° of knee flexion angle during anterior load (Fig.3-b) and pivot moment (Fig.4-b).

CONCLUSION:
Antero-posterior and rotatory stability were similar in both anatomic single- and double-bundle ACL reconstructions. In full extension, the double-bundle reconstructed knee had less antero-posterior translation when compared to the single-bundle reconstructed knee.

REFERENCES: