TIBIOFEMORAL MOVEMENT OF ACL DEFICIENT LIVING KNEE UNDER THE “PIVOT SHIFT STRESS” AND DEEP KNEE BENDING USING OPEN MRI

Introduction

ACL deficient knees show excessive anteroposterior (AP) translation and rotation instability. While rotational instability is clinically presented as the pivot shift test in which tibial internal rotation, valgus and compression forces are applied, AP translation instability is presented as anterior drawer test and Lachmann test clinically and is measured quantitatively with several devices such as KT-1000, Stryker laxity tester or CA4000. However, rotational instability is difficult to analyze quantitatively. To date, most of quantitative analysis about rotational instability of ACL deficient knees has used cadaveric knees. Recently, MRI has been widely used and allowed us to examine living knee subjects under stress.

Some authors reported knee kinematics from extension to deep flexion in cadaver and living normal knee and measured the relative movements of femur to tibia medio-laterally.

To investigate the knee kinematics of deep flexion and pivot shift test in ACL deficient knees, we applied deep knee bending and pivot shift tests on both knees of patients with rupture of the ACL in one side and intact in the other side using an open-access MRI and analyzed them.

Material and Methods

Informed Consent was obtained from 9 patients (4 men, 5 women) with unilateral rupture of the ACL who had been diagnosed by MRI findings and clearly positive at pivot shift tests. Contralateral normal knees were also scanned in all positions as a control. The mean age of the patients was 21.4 years (range, 14-45 years) with the mean time from injury to performing the MRI scan 1 months (range, 3-months-3 years). MRI showed asymptomatic medial meniscus tears in three of the patients and lateral meniscus tear in two. All patients were scanned using the Sigma profile Imaging System (General Electric Medical Systems, Milwaukee, Wis). This consists of a 0.2 tesla superconducting magnet with two coils. The patients positioned the longitudinal axis of the foot in the sagittal plane (neutral rotation).

Sagittal T1 images (5-mm thick) across the entire knee articulation were taken with the patient at supine position and the knee scanned at 10°, 30°, active deep flexion (non-stressed condition), 10° and 30° flexion of pivot shift test stress (tibia internal rotation and valgus and compression, stressed condition) of the both knees.

The position of the posterior femoral condyle relative to the tibia was measured in the midmedial and mediolateral sagittal sections of the knee according to the method of Iwaki et al. The centers of the posterior circular surfaces of the femoral condyles named “the flexion facet centers (FFCs)” were identified by placing acetate overlays with circles of varying diameters over the midmedial and mediolateral compartments of the knees on sagittal imaging. The distance between this center and a vertical line drawn from the posterior tibial cortex was measured for each position. (fig 1)

![Fig 1](Image)

Measurement of the distance between the centers of the posterior circular surfaces of the femoral condyles (FFCs) and a vertical line drawn from the posterior tibial cortex

Result

In the medial compartment of normal knee, distance of FFC didn’t move from 10° to 135° of flexion, while distance of FFC to posterior tibial cortex in the lateral compartment moves 7.8mm posteriorly from 10° to 135° flexion as described previously. There was no significant difference between normal and ACL-deficient knees in medial and lateral tibiofemoral motion from 0° to 135° of flexion at non-stressed condition. (Table 1)

At 10° of pivot shift stress, the lateral compartment of the femur of ACL-deficient knees was subluxed 7.7mm posteriorly on the tibia in comparison with the normal knees. Distance of FFC of the lateral compartment means of 8.0 mm ± 1.7 in the ACL-deficient knees compared to 15.7 mm ± 1.9 in the normal knees. (Fig 2)

![Table 1](Image)

<table>
<thead>
<tr>
<th></th>
<th>10°*</th>
<th>30°*</th>
<th>135°*</th>
<th>10° pivot</th>
<th>30° pivot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal medial(mm)</td>
<td>16.3±1.9</td>
<td>17.3±1.6</td>
<td>16.0±3.1</td>
<td>17.8±2.0</td>
<td>20.6±1.7</td>
</tr>
<tr>
<td>ACL-deficient medial(mm)</td>
<td>16.9±2.3</td>
<td>18.6±2.1</td>
<td>15.5±2.5</td>
<td>16.8±2.2</td>
<td>20.2±1.5</td>
</tr>
</tbody>
</table>

![Fig 2](Image)

Normal knee

10° pivot stress

ACL-deficient knee

10° pivot stress

Discussion

Clinically, MRI scanning is getting the evaluation as an important tool in diagnosis of ACL rupture. Advantage of MRI scanning is not invasive, simultaneous imaging of bone, tendon and meniscus. Additionally, knee kinematics can be done using MRI by catching the relationship between femur and tibia.

In the current study, the tibiofemoral movement of ACL deficient living knee showed medial pivot pattern from 10° to 135° flexion, same as normal knees under the non-weight bearing condition using open MRI. The position of lateral femoral condyle at 10° under a pivot shift stress condition was 7.7 mm posterior in the ACL-deficient side compared to normal side, where is similar to the position of 150°. This subluxation suggests that the instability with ACL-deficient knees occurred under the axial and rotational force at early flexion, which may represent “giving way”. We also showed that tibiofemoral movements of ACL-deficient knees with deep knee bending did not differ from those of healthy knees.