Evaluation of Tibial Angular Velocity in the ACL Deficient and the Posterior Horn Medial Meniscal Tears During a Reverse Pivot-Shift Test Using a Gyrosensor

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Disclosures:

Introduction: Anterior cruciate ligament (ACL) reconstruction is one of the most common operations for orthopedic surgeons. Recently, researchers have concluded that anatomical double-bundle ACL reconstruction was of critical importance for restoration of native knee kinematics and improved postoperative function. Therefore, there has been a shift from single-bundle to double-bundle ACL reconstruction. Biomechanical studies have shown that the two bundles have different respective roles in the knee. The anteromedial bundle mainly stabilizes anterior tibial translation, and the posterolateral bundle stabilizes rotational knee laxity.

Pre-postoperative tests such as the Lachmann test, Anterior drawer test, and Pivot-shift test are generally used to evaluate knee function. The pivot-shift test has been defined as a combination of valgus stress and tibial internal rotation during limb flexion. This test is commonly used for patients with suspected ACL deficit to evaluate knee stability. However, this test is evaluated by surgeons subjectively, and lacks a quantitative measurement.

The purpose of this study was to investigate the dynamic rotational instability of ACL deficient knee and knee on which double-bundle ACL reconstruction has been performed, and to clinically confirm the utility of a gyrosensor for quantitative assessment during a reverse pivot-shift test.

ACL deficient knees increase rotational knee instability, therefore we hypothesized that ACL deficient knees might significantly increase maximum rotational angular velocity in comparison with ACL intact knees, and that angular velocity would significantly decrease after ACL reconstruction.

Methods: Four freshly frozen human cadaveric knees were used in this study. The gyrosensor was fixed on the tibial tuberosity with tape. A single examiner performed the reverse pivot-shift test on the following four groups, (1) Intact group (I); (2) ACL deficient group (D) in which the ACL was resected completely; (3) Reconstruction group (R) in which a senior orthopaedic surgeon performed anatomical double-bundle ACL reconstruction using hamstrings autograft; (4) Meniscus tear combined with ACL deficient group (M) in which the posterior horn of the medial meniscus was cut off after removing reconstructed hamstrings graft. We defined a superoinferior axis parallel to the tibial axis as the x direction for the gyrosensor. The maximum rotational angular velocity in the x direction was repeatedly measured with a gyrosensor during the reverse pivot-shift test. Initial and final measurements were deleted and in total an average of three measurements were used.

Statistical analysis for differences in median angular velocity among the four groups was performed using the Kruskal-Wallis test, and differences between two groups were then tested by a post hoc Mann-Whitney U test. Statistical significance was defined as p < 0.05.

Results: The maximum tibial internal angular velocity on average was I : 56.8±16.9 deg/s, D:129.4±48.0 deg/s, R:78.3±33.5 deg/s, M:215.3±83.2 deg/s respectively. In the intact group, the maximum tibial internal angular velocity was smallest among the four groups. In comparison with this group, significant differences were found between the Deficient group (p < 0.05) and Meniscus tear group (p < 0.05). Significant difference was also found between the Reconstruction group and Meniscus tear group (p < 0.05). No statistically significant difference was found in the other relationships between groups. (Fig.1) (Table1)

Discussion: Recently several studies have reported on quantitative assessment of dynamic rotational knee instability using such means as electromagnetic device, navigation and triaxial accelerometer. Hoshino et al. concluded that tibial anterior translation and tibial posterior acceleration increased during the pivot-shift test in ACL-deficient knees using an electromagnetic system. They also noted that this increase correlated with clinical grading. (1) From the results of a positive correlation between an accelerometer and navigation system, Lopomo et al. concluded that the accelerometer was a valid method to assess dynamic joint laxity. (2) According to Maeyama et al, overall magnitude acceleration was observed to increase during the pivot-shift test for ACL deficient knees by use of triaxial accelerometer. (3) Our study evaluated rotational knee instability by angular velocity using a gyrosensor. The gyrosensor is a non-invasive instrument and is also easy to use in an office setting.
We hypothesized that the gyrosensor could identify rotational knee instability of ACL deficient knees by larger angular velocity. The results of this study support our initial hypothesis.

Our study indicated that the maximum tibial internal angular velocity of ACL deficient knee was significantly larger than for the intact knee, and that the ACL deficient knee complicated with posterior horn medial meniscal tears further increased this angular velocity during the reverse pivot-shift test. No statistical difference was observed between the Intact group and Reconstruction group, but it was thought that ACL repair significantly improved rotational instability in ACL deficient knees. Ahn et al. showed that medial meniscus posterior horn longitudinal tears in ACL-deficient knees resulted in a significant increase in anterior-posterior tibial translation. They also reported this result very closely matched the result for total medial meniscectomy in ACL-deficient knee. Our study demonstrated that the maximum tibial internal angular velocity increased most in medial meniscus posterior horn tears in ACL-deficient knees.

There are some limitations in this study: (1) The sample size was small. (2) The cadaveric knee does not represent the whole cadaver. (3) The sensor was skin-fixed, therefore soft tissue artifacts may have influenced the result of angular velocity. (4) Doctors who performed anatomical ACL reconstruction were different in each case. (5) Our study did not evaluate the quantity of power gained against cadaveric knees by the examiner during the reverse pivot test.

Regarding clinical relevance, these findings may help to improve preoperative or postoperative quantitative measurement in ACL deficient patients. In addition, the increase in maximum tibial internal angular velocity during the reverse pivot-shift test might suggest the possibility of the posterior horn medial meniscus tears in ACL deficient patients. In conclusion, maximum tibial internal angular velocity increased when the ACL was resected. The posterior horn of the medial meniscus was cut off, which further increased maximum tibial internal angular velocity. Our study indicates that the gyrosensor may indeed be useful for quantifying the reverse pivot-shift test.

**Significance:**

**Acknowledgments:**

**References:**


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<tr>
<th>Group</th>
<th>Maximum tibial internal angular velocity (deg/s) Mean ± SD</th>
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<tbody>
<tr>
<td>ACL intact</td>
<td>56.8 ± 16.9</td>
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<tr>
<td>ACL deficient</td>
<td>129.4 ± 48.0</td>
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<tr>
<td>Reconstruction</td>
<td>78.3 ± 33.5</td>
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<tr>
<td>ACL &amp; Meniscus tear</td>
<td>215.3 ± 83.2</td>
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* : p < 0.05 Significant difference

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