Comparison of different knee laxities in the anterior cruciate ligament injured knees based on quantitative evaluation of the manual tests using an electromagnetic sensor

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We have no financial conflicts to disclose.
Introduction

Lachman test (LT) and pivot-shift test (PST) are gold standard for knee joint laxity evaluation in the anterior cruciate ligament (ACL) injured knees. Those two manual tests are known to assess different knee laxity, i.e. anterior laxity and rotatory knee laxity [1,2].

There are various reports comparing LT and PST

- Ostrowski et al. reported that LT is known to have better sensitivity to detect the ACL deficiency, while PST has greater specificity [3,4].
- Bull et al. reported qualitative differences in evaluation methods. [5]

The Lachman test can be classified into static instability assessment, and it reflects the amount of displacement due to joint laxity and load stress. On the other hand, the Pivot-shift test was classified as a dynamic instability assessment, suggesting the possibility of involving secondary restraints.

- Ruiz et al. reported the results of comparing the detection rates of high grade laxity by manual test. [6]

There is a difference between the detection rate of over 10mm translation of LT and that of IKDC grade 3 PST.

These are evaluated by manual tests that can be effected by the examiner’s bias.
Introduction

Various non-invasive devices have been developed to quantify knee laxity during the pivot shift test. There are reports such as KiRA that measures only the acceleration of the tibia [7], an iPad that measures only the amount of movement around the tibia [8], and a navigation system that can measure multiple parameters [9].

Not only displacement but also acceleration should be measured for quantitative evaluation of the pivot-shift test. And, accelerometer-only evaluation may misrecognize non-pivot-shift motion acceleration.

The Electromagnetic Measurement System (EMS) (JIMI Kobe™, Tokyo, Arthrex Japan) we use confirm the occurrence of Pivot-shift motion that occurs in the tibial anteroposterior movement. Then record the acceleration that occurs.

The detailed knee movement analysis during the manual tests is currently possible by using EMS and might characterize the different knee laxities in the ACL injured knees.
The purpose of this study was to quantitatively evaluate the knee movements during LT and PST using EMS and to compare them in terms of positive rate in the ACL injured knees.
### Materials and Methods

90 ACL injured knees were enrolled.

<table>
<thead>
<tr>
<th>Period</th>
<th>November 2014-April 2018</th>
</tr>
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<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
</tr>
<tr>
<td>Age</td>
<td>20 ± 12 years</td>
</tr>
</tbody>
</table>

#### Exclusion criteria
- re-operation case
- concomitant fractures
- other knee ligament injuries, including those of the medial collateral ligament and posterior cruciate ligament, in the ipsilateral or contralateral knee

The knee movement during the LT and the PST was evaluated by using EMS. The assessment was measured under general anesthesia prior to ACL reconstruction.
This system includes a transmitter that produces an electromagnetic field and 3 electromagnetic receivers. Two of the receivers were firmly attached on the thigh and calf with a plastic brace and used to track femoral and tibial motion, respectively. The third receiver was used to register seven anatomic landmarks of the femur and the tibia.

The three-dimensional position of the femur and the tibia was recognized in a virtual space based on the registered landmark locations. Each femoral and tibial coordinate system was then configured to provide the 6-degrees-of-freedom of knee joint kinematics, as described by Grood and Suntay [10].

The tibial acceleration of the PST was calculated by the secondary derivative of the anteroposterior translation data over time during the PST. The anteroposterior translation of LT was measured at the maximum value during LT.

Each test was measured 5 times, and the average was calculated excluding the upper and lower 10% of each value.
Methods

_outcomes Assessment_

The anterior tibial translation (ATT-LT, mm) was provided as a parameter for the LT assessment. The anterior tibial translation (ATT-PST, mm) and the acceleration (ACC-PST, m/sec^2) of the pivot-shift were calculated for the PST assessment. More than 2mm of ATT-LT and ATT-PST, 0.5 m/sec^2 of ACC-PST, was considered as abnormal [11-13].

_statistical analysis_

The number of cases where abnormalities were detected in these three assessment was compared using a chi-square test. Significance was set at p <0.05.
The overall detection rate was 75/90 knees (83%).

<table>
<thead>
<tr>
<th>The overall detection rate</th>
<th>75/90 knees</th>
<th>83%</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATT-LT</td>
<td>62 abnormal</td>
<td>28 normal</td>
</tr>
<tr>
<td>ATT-PST</td>
<td>35 abnormal</td>
<td>55 normal</td>
</tr>
<tr>
<td>ACC-PST</td>
<td>40 abnormal</td>
<td>50 normal</td>
</tr>
<tr>
<td>Either ATT-PST or ACC-PST</td>
<td>51 abnormal</td>
<td>39 normal</td>
</tr>
</tbody>
</table>

There were significant differences in detection rates of ATT-LT and ATT-PST, and ATT-LT and ACC-PST, respectively (p<0.01).

There was no significant difference in the detection rates of Lachman test and Pivot-shift test.

Cross-tabulation of Lachman test and Pivot-shift test detection rates:

<table>
<thead>
<tr>
<th>Lachman test</th>
<th>51</th>
<th>39%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pivot-shift test</td>
<td>90</td>
<td>25%</td>
</tr>
</tbody>
</table>

Out of 51 knees which were abnormal in PST, 13 knees (25%) demonstrated normal LT.

Conversely, there were 24/62 knees (39%) of abnormal LT that showed normal PST.
Discussion

This study

The detection rate of ATT-LT was 69%, while ATT-PST was 39%, ACC-PST was 45% and PST was 57%.

These detection rates were similar to previous reports.

- Ostrowski et al. [3] reported that authors of 9 studies examined the LT and reported sensitivity values ranging from 0.63–0.93, while authors of 6 studies examined the pivot shift test and reported sensitivity values ranging from 0.18–0.48.

- Hoshino et al. [8] reported that valid data sets were obtained in 59 % of ACL deficient knees by using iPad.

- Maeda et al. [9] reported that the difference in measurement being within 2 mm in 64 % of cases by using navigation system.
Discussion

This study

Different positive rate was demonstrated by the two gold standard tests for the ACL injured knees based on the quantitative measurements of those manual tests.

Each ACL injured knee could have an individually different laxity in combination of anterior and rotatory knee laxity depending on its original joint laxity, magnitude of the ACL injury and concomitant soft tissue injuries.

Clinical relevance

Both LT and PST are clinically important to have different features to assess the joint laxity in the ACL injured knees. Further studies are wanted to identify the factors affecting each laxity in the ACL injured knees.
Conclusion

There was a significant difference in detection rate between Lachman test and Pivot-shift test, and there was a certain number of ACL injured knees in which only one test was abnormal.
References


