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Quantitative Comparison of the Pivot Shift Test Between Pre- and Post-operative Conditions can be Achieved by Acceleration Measurement

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Summary:
Increase of the rotational instability due to ACL injury and restoration of such increased instability by ACL reconstruction was quantitatively evaluated by measuring the acceleration during the pivot shift test using electromagnetic measurement system.

Abstract:
Introduction:
The pivot shift test 1) is commonly performed in a clinical setting and sometimes demonstrates positive results in anterior cruciate ligament (ACL) reconstructed knees in which anterior laxity has been successfully restored. The presence and magnitude of the pivot shift, a pathological abnormal motion of the knee, is evaluated by hands during dynamic testing movement depending on surgeons' feeling. The criteria for classifying the pivot shift have not been strictly defined and there is no established quantitative evaluation method. Therefore, it is difficult to compare the rotational stability between different surgeons and/or between different time points, i.e. pre- and post-operatively. Recently, a quantitative assessment of the pivot shift test has been experimentally conducted by measuring tibial acceleration 2). However, clinical application of this measurement, especially for testing the result of the ACL reconstruction, has not fully examined. The purpose of this study was to measure and compare the tibial acceleration during the pivot shift test between pre- and postoperative conditions in the ACL injured patients.

Methods:
The subjects were 70 unilateral ACL injury patients (39male/31female, 28±10 y.o.) who underwent ACL reconstruction between October 2007 and February 2011. Tibial acceleration during the pivot shift test was measured using an electromagnetic device (LIBERTY, Polhemus, Colchester, VT, USA) 2). This system consists of a transmitter that produces an electromagnetic field and three electromagnetic receivers . Two of the receivers were firmly attached on the thigh and the calf with a plastic brace and were used to track the femoral and tibial motion respectively. Each femoral and tibial coordinate system proposed by Grood was configured from the three dimensional position data of anatomical landmarks which were digitized by the third receiver and provided six degree-of-freedom knee kinematics. Tibial acceleration during the pivot shift test was then calculated in both injured and contralateral intact knees prior to the ACL reconstruction, and the measurement was repeated at 1 year postoperatively in both knees. Student's t-test was used to compare the tibial acceleration between side to side and between pre- and post-operative conditions in each ACL injured and contralateral intact knee. $P<0.05$ was considered statistically significant.

Results:
The tibial acceleration during the pivot shift test was larger in the ACL injured knee, 1.9±1.2 m/sec2, than that in the contralateral intact knee, 0.8±0.3 m/sec2 ($p<0.01$). The acceleration significantly reduced by the ACL reconstruction down to 0.9±0.3 m/sec2 at 1 year follow-up ($p<0.01$), which was equivalent to that of the contralateral knee ($p = 0.42$) . The acceleration measurement in the contralateral knees was consistent between pre- and post-operatively (pre-op: 0.8±0.3 m/sec2; post-op: 0.8±0.3 m/sec2 , $p = 0.97$).

Discussion:
The pivot shift test result after ACL reconstruction is correlated with knee function and patient satisfaction3), but the clinical grading has been subjectively judged and normally classified into only four levels of instability. Therefore, quantitative assessment of the pivot shift test seems to be desirable for the more objective and sensitive assessment. In the present study, tibial acceleration during pivot shift test was measured using an electromagnetic system. It was demonstrated that the rotational instability of the knee existed in the ACL injured knees and that it could be restored by the ACL reconstruction. Additionally, consistent measurement was obtained in the ACL intact knees at different time points, i.e. pre- and post-operative assessments. This electromagnetic measurement of the tibial acceleration could provide quantitative evaluation of rotational stability as a reliable follow-up evaluation.

References:
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