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Clinical Usability Assessment of Non-Invasive Quantitative Measurement Devices for the Pivot Shift Test

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Summary:
Clinical usability of non-invasive measurement systems for the pivot shift test was assessed in the ACL deficient patients. Electromagnetic system (EMS), KiRA and iPad provided acceptable diagnostic values for the ACL deficiency. Although the system setting of the EMS was more complicated than the others, the diagnostic reliability of the EMS for the ACL deficiency was superior to the others.

Abstract:
Introduction:
The pivot shift test is a quite important clinical exam to assess knee rotational laxity in anterior cruciate ligament (ACL) deficient and reconstructed patients. However, the testing results are hard to compare between different surgeons and institutions due to its subjective judgment and wide variation of testing techniques. Several measurement devices have been developed to quantitatively assess the pivot shift phenomenon. Some of them are non-invasive and readily available in clinical setting, but clinical usability of those measurements has yet to be determined. The purpose of this study was to evaluate the capacity of three different non-invasive devices to quantitatively evaluate the pivot shift in clinical setting.

Methods:
Thirty unilateral ACL injured patients (22.9 ± 10.1 y.o., 12 males, 18 females) were examined. The pivot shift tests were performed for both sides under general anesthesia. Three non-invasive measurement devices (triaxial accelerometer system KiRA, simple image analysis using iPad, and electromagnetic measurement system EMS) were used simultaneously to provide quantitative evaluation of the pivot shift test. The tibial acceleration of the pivot shift was monitored by KiRA and EMS, while the anterior tibial translation during the pivot shift test was recorded by iPad and EMS. Side-to-side difference of each measurement was tested using t-test, and correlation of the measurement results were tested between KiRA and EMS for the tibial acceleration and between iPad and EMS for the tibial translation using pearson correlation coefficient. In addition, the receiver operator characteristic (ROC) curve was plotted, and area under the curve (AUC), sensitivity and specificity were calculated for each parameters. P-value < 0.05 was considered statistically significant.

Results:
Significant differences between healthy and injured side were observed in acceleration parameter in both KiRA and EMS (KiRA: 2.0 ± 1.3, 4.4 ± 2.9 m/s^2; P < 0.01, EMS: 0.93 ± 0.58, 2.2 ± 1.3 m/s^2; P < 0.01). KiRA demonstrated moderate correlation with EMS for the acceleration parameter (r = 0.54; P < 0.01). AUC, sensitivity and specificity of

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acceleration were 0.76, 59%, 82% in KiRA, and 0.84, 77%, 82% in EMS when the cutoff levels were 3.0 and 1.5 m/s^2, respectively. There was a statistically significant side-to-side difference in tibial translation measured by both iPad and EMS (iPad: 0.7 ± 0.6, 1.7 ± 1.5 m/s^2; P < 0.01, EMS: 3.0 ± 2.0, 13.0 ± 5.0 mm; P < 0.01). iPad demonstrated poor correlation with EMS for the translation parameter (r = 0.28; P < 0.01). AUC, sensitivity and specificity of translation were 0.77, 71%, 71% in iPad, and 0.96, 79%, 91% in EMS when the cutoff levels were 0.73 and 9.0 mm, respectively.

Conclusion:
The electromagnetic measurement system has the advantage of comprehensive evaluation of the pivot shift test by evaluating both tibial acceleration and translation. KiRA and iPad measurements could provide clinically acceptable evaluation in a much simpler way than EMS, but clinical usability of KiRA and iPad was somewhat inferior to that of EMS.