ISAKOS

International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine

11th Biennial ISAKOS Congress • June 4-8, 2017 • Shanghai, China

Paper #84

Utility of a New Developed Motion Capture with Infrared Camera System in ACL-Insufficient Knees by the Comparison with the Validated Navigation System

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Summary:
Based on the quantification of a dynamic rotatory knee laxity reproduced and evaluated by the pivot-shift test, our newly developed noninvasive system (MCICS) could be as accurate as the validated navigation system, particularly within range of knee flexion during the pivot-shift test, which could be useful in diagnosis of ACL pathology and the postoperative evaluation of surgical reconstruction.

Abstract:
[Purpose]
Development of more objective clinical evaluation of the rotational instability in the ACL - insufficient knee is critical to evaluate its function extensively and to improve the outcome in the ACL reconstructive surgery. However, there are few available quantitative methods for the rotational instability in a clinical use. We have developed a new noninvasive motion capture with infrared camera system (MCICS; Anima Co. Ltd.,Tokyo, Japan) for analysis of in vivo three-dimensional kinematics of the knee. The purpose of this study are to compare our MCICS with the standard validated commercial navigation system in terms of reliability and repeatability of the rotational kinematics in the ACL-insufficient knee, and to validate the utility of our MCICS.
[Patients and Methods]
Thirteen unilateral ACL injured patients (mean age 18 y.o.) were enrolled in this study. The injured knees in all patients were evaluated during the pivot shift test by a single surgeon (E.N.) before reconstruction under anesthesia using two imaging equipment; one is a commercial image-free navigation system (Brain Lab, ACL 2.0, Heirnstettern, Germany) with trackers secured by bone screws (Navi) , and the other is our MCICS. During the pivot-shift test, the starting angle of the pivot-shift phenomenon (SA; °), and tibial rotational angle defined as the amount of rotational angle when an anterior subluxation and a subsequent reduction in the tibial plateau from the femoral condyle(TRA; °), were extracted from the kinematics data recorded by both system. The verification of the MCICS was analyzed using the interclass correlation coefficient (ICC) for those values between both system. A p-value less than 0.05 were considered to be statistically significant.
[Results]
The pivot-shift phenomenon in all patients was determined as a sudden tibial external rotational movements in both system (Figure 1 and 2). The averaged SA in the MCICS and Navi was 12.5° (range; 5° to 30°) and 11.0° (range; 4.2° to 18.4°), respectively, showing the great consistency (ICC 0.808, $p<0.001$). The averaged TRA in the MCICS and Navi was 7.7° (range; 4.5° to 15°) and 6.2° (range; 2.7° to 9.1°), respectively, also showing the great consistency (ICC 0.840, $p<0.001$).
[Discussion and Conclusions]
These results indicate that based on the quantification of a dynamic rotatory knee laxity reproduced and evaluated by the pivot-shift test, our newly developed noninvasive system (MCICS) could be as accurate as the validated

navigation system, particularly within range of knee flexion during the pivot-shift test. Our MCICS also has some advantages such as no limitation of the measurement location or an examining room, and capability of the analysis on the performance at high speed, which could be useful in diagnosis of ACL pathology and the postoperative evaluation of surgical reconstruction.