Quantitative measurement of the Lachman test using an electromagnetic measurement system

Daisuke Araki1, Ryosuke Kuroda1, Hidenori Murata2, Kouki Nagamune3, Koji Nishimoto1, Yuichi Hoshino1, Seiji Kubo1, Masahiro Kurosaka1
1Orthopaedic Surgery, Kobe University Graduate School of Medicine, Kobe, Japan; 2Orthopaedic Surgery, Yamaguchi University School of Medicine, Ube, Japan; 3Human and Artificial Intelligent Systems, Fukui University Graduate School of Engineering, Fukui, Japan
isuke@pop21.odn.ne.jp

Introduction: The Lachman test has become recognized as the most reliable for evaluating the anterior cruciate ligament (ACL) injuries. Since the grading is influenced by differences in the examiners' estimates of the displacement, manual examination and subjective classifications lack objectivity. To evaluate subjectively, KT-1000 provides acceptable accuracy and reproducible within certain limitation. But it has been also suggested that experience in using KT-1000 is related to its reliability, more subjective device is required to evaluate precisely.

We use a noninvasive three-dimensional electromagnetic device (FASTRAK, POLHEMUS, VT, USA), and analyze by a newly developed software to assess the anterior knee laxity performing the Lachman test. So, we hypothesize that this electromagnetic measurement system (EMS) provides more useful for quantifying anterior knee instability.

Materials and Methods: The comparative measurements were undertaken on 82 knees of 41 patients (30 of isolated ACL deficient and 11 of ACL reconstructed) under anesthesia using the EMS, KT-1000 and the fluoroscopy, for the manual assessment of the anterior tibial translation in 30 degrees flexion by one of our experienced surgeons.

(1) The EMS: This system consists of a transmitter that produces an electromagnetic field and three electromagnetic receivers. Two of the receivers are used for motion measurement of the tibia and femur and were attached to a plastic brace by a circumferential Velcro strap placed 10 cm above the patella on the thigh and 7 cm below the tibial tubercle on the calf (Fig. 1-A). A third receiver, which was attached to a specially made stylus, is used for digitizing anatomical landmarks before the 6 degrees of freedom kinematics measurement is performed. The 6-DOF of knee kinematics were calculated by modifying the principle of a 3-cylinder open-chain mechanism proposed by Grood using the bone axis of the femur instead of the mechanical axis [1]. This system can be recorded at the sampling rate of 60 Hz and the static error of position and orientation are 0.8mm RMS and 0.15 degrees RMS. It enables monitoring of instantaneous 3D position and calculates the A/P value of the tibia. One experienced examiner performed the Lachman test 5 times and recorded by this system at the same time. A newly developed software established by our department was used to analyze the A/P laxity. The first and the last results among 5 times were excluded as a representative value to compare among knees. The median data of the other 3 records was used to assess the A/P value.

(2) KT-1000: Tibial displacement was evaluated under manual maximum force by the same examiner.

(3) The fluoroscopy: The same examiner performed the Lachman test 5 times under fluoroscopy and the A/P laxity of the tibia was analyzed. The magnifying rate was revised by a steel ball (φ9.6mm) put on the tibial tubercle (Fig. 1-B). The first and the last results among 5 times were excluded as a representative value to compare among knees. The median data of the other 3 records was used to assess the A/P value.

Results: The good correlation was obtained between KT-1000 and the fluoroscopic measurements (R=0.616, p<.0001) (Fig. 2-A). And the good correlation was also obtained between the EMS and KT-1000 (R=0.635, p<.0001) (Fig. 2-B). However, the more correlation was obtained between the EMS and the fluoroscopic measurement (R=0.961, p<.0001) (Fig. 2-C). In patients with ACL rupture the mean side-to-side difference of A/P value was 7.44 ± S.E. 0.75 mm using the fluoroscopy and 7.74 ± 0.79 mm using the EMS (Fig. 3). The statistical evaluation was carried out by means of Pearson's correlation coefficient and Student's t-test at a significance level of 1%.

Discussion: This study shows that the exactitude and reliability of KT-1000 are favorable compared with the fluoroscopic measurement. However, the EMS shows higher exactitude than KT-1000 compared with the fluoroscopic measurements. This enables the EMS is applied for the quantitative evaluation of the knee laxity during the Lachman test more precisely and the useful device for the diagnosis of anterior cruciate ligament rupture.


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