Use of computer-aided navigation systems in static and dynamic stability testing of ACL-deficient and reconstructed knees: in-vivo evaluation with Orthopilot ACL 3.0

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Introduction: Anterior cruciate ligament injury can cause disabling instability of the knee. The evaluation of the degree of instability has been largely limited to static measurements of anterior-posterior translation (anterior drawer test, Lachman maneuver) with a hand-held device to assess purely anterior translation (KT-1000). Dynamic rotational and translational evaluation has been performed using the "pivot shift" test, but this does not provide objective data about knee laxity. With the development of new software (ACL 3.0), the Orthopilot system is able to provide objective information about dynamic anterior-posterior translation and rotation during a pivot shift maneuver. We describe results of static and dynamic testing pre- and post-ACL reconstruction, and the relationship between static and dynamic parameters.

Materials & Methods: Five patients underwent ACL reconstruction with image-free computer-assisted navigation guidance (Orthopilot ACL 3.0) using either single or double bundle techniques, based on the size of the tibial ACL footprint and surgeon preference. Static and dynamic stability evaluation was performed both pre- and post-operatively. Static measurements were performed with the knee at 30^{o} flexion with manual maximum anterior-posterior translation and internal-external rotation by a single experienced knee surgeon. Dynamic measurements were performed during a pivot-shift maneuver performed by a single experienced knee surgeon through an arc of motion from 0-60 ^{o}. Data was collected and subjected to standard statistical analysis.

Results: Statistically and clinically significant improvements were seen in both AP translation and rotation in both static and dynamic stability testing. In the static measurements, the AP translation improved from a mean 15.25 $\pm$ 4.5 mm to 5.5 $\pm$ 1.73mm, and the arc of rotation from 30.5 $\pm$ 3 to 24.25 $\pm$ 1.5 degrees. In the dynamic (pivot shift) measurements, the AP translation improved from 11.25 $\pm$ 3.2 to 6.7 $\pm$ 2.6 mm, and the arc of rotation from 19.75 $\pm$ 6.1 to 13.5 $\pm$ 3.7 degrees ($p < 0.05$). The values obtained statically and dynamically were different, with manual static values larger. The magnitude of improvement in AP translation and rotation was similar in both series of tests; however, the Pearson correlation coefficient was 0.42 for AP translation and 0.51 for rotation in comparing static to dynamic measurements. The correlation coefficient improved to 0.74 when both translation and rotation were taken into account, suggesting a high degree of correlation between combined translational and rotational static and dynamic laxities. Within this pilot group, no significant differences between double and single bundle reconstructions could be identified. The pivot shift as indicated by a sudden change in curves of AP translation and rotation typically occurred between 15-18 degrees. Dynamic testing demonstrated excellent reproducibility of pivot shift testing by a single examiner; however, the specific three-dimensional pathway of motion varied between examiners.

Conclusions: Computer-assisted navigation techniques can provide valuable information regarding static and dynamic knee stability. The relationship between static and dynamic stability measurements is relatively weak for translation and rotation individually; however, when the static measurements are combined, the correlation with dynamic stability improves. This suggests that the ability of individual single dimensional static tests to assess functional dynamic stability is limited, and that dynamic navigation systems can be utilized to accurately discriminate between stable and unstable knees.

Dynamic navigation systems can document knee instability and the provide objective correlation for the pivot shift phenomenon.