Reliability of KT1000 Knee Arthrometer Measures Obtained at Three Knee Joint Positions

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Abstract:

The reliability of KT1000 knee arthrometer measurements has been established at a flexion angle of 20° to 30°. However, no studies have assessed its reliability at multiple joint positions. This study was conducted in order to compare the displacement at three positions (20°, 45°, and 90°) and to determine the test-retest reliability at each position. Twenty subjects having no history of knee pathology participated in the study. A KT1000 knee arthrometer (MEDmetric Corporation, San Diego, CA) was positioned on the leg to measure anterior displacement of the proximal tibia at the three knee joint positions in random order. Post-hoc analysis indicated greater displacement at the 20° and 45° positions than at the 90° position. Intraclass correlation coefficients for the test- retest sessions were R=.92, .84 , and .90 for the 20°, 45°, and 90° positions, respectively. These findings suggest that the KT1000 is a reliable instrument for measurement of passive anterior displacement throughout the knee joint's range of motion. Injury to the anterior cruciate ligament may involve rupture of the entire ligament, or may be isolated to a particular portion of the ligament. As such, assessment of anterior displacement at multiple joint angles is recommended to most accurately evaluate the integrity of the anterior cruciate ligament.

Article:

The recent development of knee arthrometers has enabled objective measurement of knee joint displacement. The KT1000 arthrometer (MEDmetric Corporation, San Diego, CA), the Stryker knee laxity tester (Stryker, Kalamazoo, MI), and the Genucom knee analyzer (FARO Medical Tech. Inc., Montreal, Canada) are examples of instruments that have been designed to objectively measure laxity of the knee joint. These instruments appear to be correct 70 to 75% of the time in determining cruciate ligament integrity (1). The results of arthrometer measurements help to increase confidence in clinical diagnosis.

Several investigators have examined the reliability of these instruments with the knee in a flexion angle of 20° to 30°. Highenboten et al. (8) found that the three previously-mentioned knee laxity testing devices provided reproducible quantitative measurements of knee laxity. Others have reported high correlation coefficients for the KT1000 with the knee in the standard 20° to 30° flexion angle (2,6). However, the reliability of measurement with this instrument at multiple joint positions has not been established.

The rationale for obtaining anterior displacement measurements at multiple knee angle positions is that the anterior cruciate ligament (ACL) has distinct bundles with different functions (4,5,10). The variations in tension of different bundles of the ACL throughout the range of motion suggest a need to assess displacement at multiple joint positions.

The purpose of this study was to compare the anterior displacement of the tibia at three positions of knee flexion (20°, 45°, and 90°), and to determine the test-retest reliability of the KT1000 knee arthrometer in obtaining these measurements.

METHODOLOGY

The subjects for this study included 20 men and women (age = 20.2±1.4 yrs, ht = 173.0±13.5 cm, wt = 71.6 ±13.8 kg). Each subject read and signed a form giving his or her consent to participate in this study. Persons were disqualified as subjects if they had recently sustained an acute knee injury or muscular strain of the lower extremity or if they had a history of injury to the knee joint. The subjects were asked to refrain from exercise of any form on the day of testing.

A KT1000 knee arthrometer (MEDmetric Corporation, San Diego, CA) was used to measure proximal anterior tibial displacement. The KT1000 quantifies the amount of anterior and posterior (A-P) tibial displacement at a known force, with respect to the femur (12).

The arthrometer detects relative A-P motion between two sensor pads, one in contact with the patella, and the other in contact with the tibial tubercle (3). A force-sensing handle is used by the examiner to apply anterior and posterior displacement forces. Successive audible "beeps" are emitted when loads of 67N (15 lbs), 89N (20 lbs), and 133N (30 lbs) are applied through the force-sensing handle. We used a 133N (30 lbs) force for this study. The millimeters of tibial displacement were indicated by a dial on the top of the instrument that was read to the nearest 0.5mm (3).

An Orthotron KT isokinetic dynamometer (Cybex, Ronkonkoma, NY) was used to statically position the knee in flexion angles of 20°, 45°, and 90° (Figure 1). A goniometer was used to position the knee at each of the three positions of flexion.

To provide consistency among subjects, the dominant leg was used for the study and was deter mined by having each subject kick a soccer ball against a wall. Each subject was then seated comfortably on the dynamometer. Velcro straps stabilized the femur and tibia to the dynamometer. The dynamometer's exercise velocity was set at 0 °/second to hold the knee statically at the desired flexion angle.

The arthrometer was placed on the anterior surface of the tibia and was held in place with Velcro straps. A passive measurement at 133N (30 lbs) of anterior force was recorded at 20°, 45°, and 90° of knee flexion in random order. The instrument was removed from the tibia and then reapplied for each joint position measured.

Subjects were asked to relax as much as possible while the instrumented laxity tests were performed. The anterior tibial displacement values at each position were communicated by the examiner to an assistant who recorded the measurement. Each subject returned one week later to be tested under the same protocol.

Two one-factor (knee position) analyses of variance (ANOVAs) were computed on the test and retest measurements. Scheffe post-hoc tests were used to determine the source of significant differences. Intraclass correlation coefficients (ICC) were computed for the test-retest values for each joint angle assessed.

RESULTS

The test and retest displacement values and the reliability correlation coefficients are presented in Figure 2. The mean anterior tibial displacements produced at 20° (x=7.0±2.3mm) and 45° (x=7.1±2.1mm) were significantly greater than at 90° (x=3.1±1.0mm; $F(2,38) = 35.34$, $p<.0001$). For the retest, the mean anterior tibial displacements produced at 20° (x=6.9±2.1mm) and 45° (1=7.2±1 .7mm) were significantly greater than at 90° (x=3.4±1.0mm; $F(2,38) = 42.42$, $p<0001$).

The test-retest reliability coefficients at 20° ($R = .92$) and 90° ($R = .90$) were slightly higher than at 45° ($R = .84$).

DISCUSSION

The variations in tension of the anterior cruciate ligament throughout the knee joint's range of motion are well-documented in the literature. The ACL is composed of discrete anteromedial and posterolateral ligamentous fascicles (4), with an intermediate bundle between them (10). The anteromedial bundle is taut in flexion, while the posterolateral bundle is relaxed in flexion and becomes progressively more tense as the knee is extended (4,5).

Henning et al. (7) studied the elongation of the ACL in two patients with acute grade II sprains using an in vivo strain gage technique. Their strain gage technique measured the elongation of the distal 1 cm of the anteromedial fibers of the ACL. They found that the Lachman test (20° to 30° knee flexion) produced greater elongation of the anteromedial fibers of the ACL than either the anterior drawer (90° knee flexion) or pivot shift tests.

Rosenberg and Rasmussen (11) used an in vivo arthroscopic method to assess the tension of the anteromedial and posterolateral portions of the ACL in 20 young adult patients with normal knee ligaments and menisci before and during an anterior drawer and Lachman test. The Lachman test produced maximal tension in the majority of the ligaments while the anterior drawer did not produce maximal tension in any portion

Figure 1. KT1000 positioned on the leg with the knee in 90° of flexion

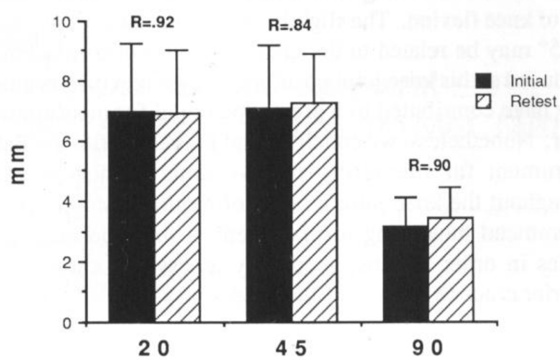

Figure 2. Initial and retest displacement values and intraclass correlation coefficients for the three test positions

of the ligament (11).

Kennedy et al. (9) described the function of the anterior cruciate ligament without delineation between bundles. These authors reported that the ACL is taut when the knee is in full extension and in 5° to 20° of flexion; it is most relaxed between 40° to 50° of flexion, and then becomes increasingly taut as flexion approaches 70° to 90°. Injury to the ACL may involve rupture of the entire ligament, or may be isolated to a particular portion (bundle) of the ligament. As such, the value of assessing displacement at multiple angles appears justified.

The KT1000 arthrometer is normally used to assess knee joint displacement at the standard Lachman position (approximately 20° to 30° of knee flexion). The reliability of measurements at this knee angle has been documented. Hanten and Pace (6) reported an intraclass correlation coefficient for a single examiner of R = 0.84 for anterior tibial displacement produced with 89N of passive force. Our correlation coefficients were slightly higher at both 20° (R = .92) and 90° (R = .90) of knee flexion.

We also found high reliability correlation coefficients at 90° of knee flexion. The slightly lower correlation coefficient at 45° may be related to the greater amount of displacement produced at this knee joint position. The greater displacement may have contributed to a greater potential for measurement error. Nonetheless, we conclude that the KT1000 is a reliable instrument for measuring passive anterior displacement throughout the knee joint's range of motion. Moreover, we recommend measuring displacement at multiple knee joint angles in order to most accurately assess the status of the anterior cruciate ligament following injury.

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