

Arthrometric Evaluation of Knees That Have a Torn Anterior Cruciate Ligament*

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ABSTRACT: We used the KT-1000 arthrometer to test the knees of 107 patients who had an acute tear of the anterior cruciate ligament, 153 patients who had a chronic tear, and 141 control subjects, for a total of 401 individuals. The three testing parameters were the extent of anterior translation at eighty-nine newtons of force and at maximum manual force, and the compliance index.

The differences between the involved and the uninvolved knees were calculated. At eighty-nine newtons, all but one of the control subjects had anterior translation of ten millimeters or less, compared with 58 per cent of the patients who had a chronic tear. At maximum manual force, all but two of the control subjects had translation of ten millimeters or less, compared with 20 per cent of the patients who had an acute or a chronic tear.

Analysis of variance showed that the clinical diagnosis correlated well with the results for all tests ($p < 0.001$). However, when the uninjured knees of patients who had an acute or a chronic tear were compared with the knees of the control subjects, significant differences were noted ($p < 0.001$ to 0.006). In the patients who had a chronic tear, there was no relationship between the time from injury to operation and the extent of anterior translation. The arthrometric test at maximum manual force was the strongest discriminant; it differentiated normal from abnormal knees ($p < 0.001$) with high sensitivity (92 per cent), high specificity (95 per cent), and high positive predictive accuracy; the cut-off point was eleven millimeters or less. In general, the differences between values for the involved and the uninvolved knees were more sensitive and less specific when a cut-off point of two millimeters or more (compared with three millimeters or more) was used.

We recommend the use of an arthrometer in the clinical evaluation and follow-up of patients who have a tear of the anterior cruciate ligament.

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During the 1980's, the diagnosis and treatment of patients who had a tear of the anterior cruciate ligament of the knee improved greatly. However, difficulties remain in evaluation of the results of treatment, because the evaluation systems that are in use do not have the requisite objective accuracy.

In an attempt to improve the objective parameters, we used the KT-1000 arthrometer (Medmetric, San Diego, California). The major goal was to determine how much anterior displacement (translation) of the tibia on the femur occurred with standard tests, in order to characterize the normal range of laxity as well as that in the involved compared with the uninvolved knees.

Materials and Methods

The KT-1000 arthrometer measures the extent of anterior-posterior translation of the tibia on the femur (Fig. 1). The arthrometer is secured to the lower limb with two Velcro straps, and the two sensing pads are positioned on the patella and on the tibial tubercle. The anterior translation is the relative motion between these two pads, and as little as one millimeter of translation can be detected²⁻⁵. The gauge is calibrated in one-millimeter increments. A force is applied just distal to the joint line of the knee, through a handle. With the patient supine on a firm examining table, the thighs are placed on a bolster, which maintains the knees in 30 ± 5 degrees of flexion. The heels rest on a positioning cup, which maintains the tibia in a prescribed degree of external rotation. During testing, each individual was repeatedly requested to relax the lower limbs so that we could verify the determination of the zero point. We did several test runs, as described by Daniel et al.^{8,9}. The sixty-seven-newton force test preceded the eighty-nine-newton force test; they are distinguished by different audible tones. Two tests were performed on each individual, and the average translations were used for all calculations. Before each test, the arthrometer was reset to zero. Data for posterior translation also were obtained, but they were excluded from the study, as were the data obtained at sixty-seven newtons except as they entered into the calculation of the compliance index.

Measurements were made for both knees in each individual in the same sequence. First, a force of eighty-nine newtons (twenty pounds) was applied, and then maximum manual force was applied by the examiner with the hand under the posterior aspect of the calf, thus simulating a clinical Lachman test. Next, the compliance index (the dif-

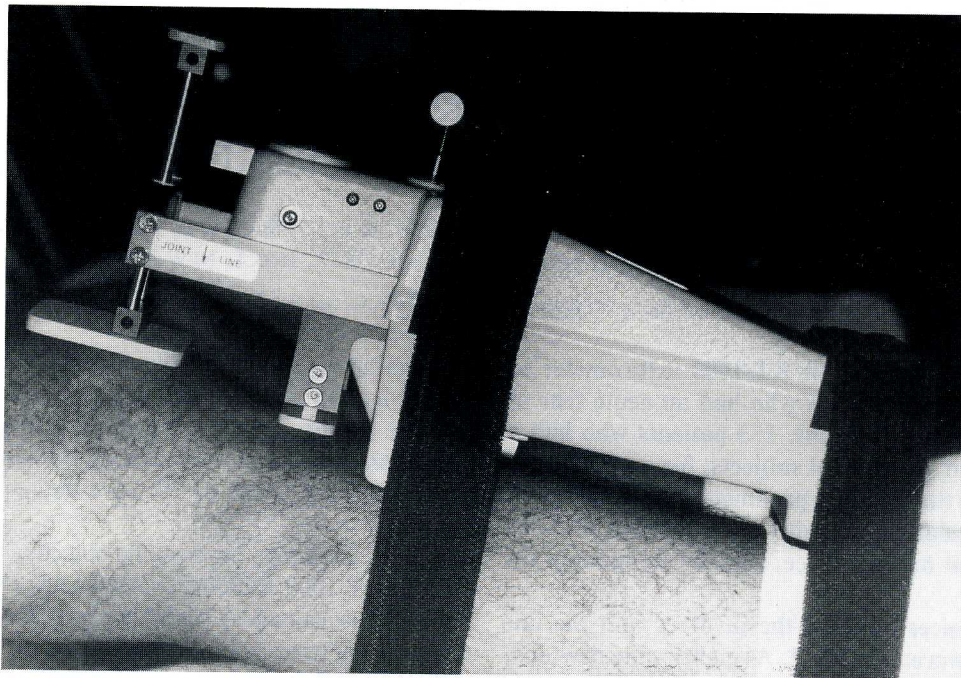


FIG. 1

Photograph showing the KT-1000 arthrometer.

ference in translation between the eighty-nine and sixty-seven-newton tests) was calculated, as was the difference in translations for the involved and the uninvolved knees.

Both knees of all individuals were examined before the tests. We recorded alignment and varus-valgus stability at 0 and 30 degrees of flexion. The results of the Lachman and anterior-posterior drawer tests were rated as follows: grade 1, zero to five millimeters; grade 2, six to ten millimeters; and grade 3, ten millimeters or more. We also performed the pivot-shift test and graded the result as 1+ (slide), 2+ (jump), or 3+ (momentary locking). All patients who had an acute or a chronic tear had a positive pivot-shift test.

Data obtained at 90 degrees of flexion of the knee were not included in this study. Generalized ligamentous laxity was categorized, and its effects on the arthrometric measurements will be reported elsewhere. We did not attempt to correlate the individual's level of activity or the radiographic findings with displacements recorded by the arthrometer. The reproducibility of the tests was not assessed, and the results that were obtained with the KT-1000 arthrometer were not compared with those that were obtained with other commercially available arthrometers.

Between January 1983 and May 1986, three groups of individuals were tested: control subjects (group C), patients who had an acute tear (group AT), and patients who had a chronic tear (group CT). We excluded from the study any patient who had a clinical diagnosis of a bilateral tear of the anterior cruciate ligament, a history of repair or reconstruction of the anterior cruciate ligament of the contralateral knee, a tear of the posterior cruciate ligament, a posterolateral rotatory deficiency, or a partial tear of the anterior cruciate ligament as determined arthroscopically. Group C

comprised 141 normal volunteer subjects who were selected randomly from the population of our Sports Medicine Clinic. None of these subjects had a medical history suggestive of injury to the menisci, the collateral ligaments, or the cruciate ligaments, and this was confirmed by physical examination. Group AT comprised 107 patients (identified retrospectively) who had sustained the index injury within one month before they were seen at our institution, as documented by history and physical examination and as confirmed at operation. Group CT consisted of 153 patients who had had a diagnosis of a chronic tear of the anterior cruciate ligament, also identified retrospectively. The patients in group CT were tested before arthroscopy or operative reconstruction or before non-operative treatment and rehabilitation. All of these patients were seen more than one month after the index injury. Clinically, all of the patients had positive Lachman and pivot-shift tests.

All tests were conducted by a trained examiner. At the conclusion of each test, the data were transferred from our standardized forms to an IBM-XT computer. Statistical analysis was performed on a Digital VAX System with Minitab (State College, Pennsylvania) and BMDP (Los Angeles, California) statistical software packages. Descriptive statistics, analysis-of-variance testing, chi-square analysis, two-sample t tests, and linear-regression analysis were performed. Sensitivity was defined as the prevalence of true-positive results and specificity, as the prevalence of true-negative results. Various cut-off levels were used to generate results for specificity, sensitivity, and predictive accuracy.

Results

There were no statistically significant differences in age, height, and weight between the female control subjects

