Arthrometric Evaluation of Knees
That Have a Torn Anterior Cruciate Ligament

BY BERNARD R. BACH, JR., M.D.†, RUSSELL F. WARREN, M.D.‡, WILLIAM M. FLYNN, M.D.‡,
MICHAEL KROLL, M.A.P.T.§, AND THOMAS L. WICKIEWIEZ, M.D.‡, NEW YORK, N.Y.

From the Department of Sports Medicine, The Hospital for Special Surgery, New York City

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.

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 detected. 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. 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-
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.
and the female patients, regardless of clinical diagnosis (Table I). The male control subjects had significant differences in height and weight compared with the male patients; these differences were attributable to the presence of ten professional football players in groups CT and AT. The heights and weights of the male patients in group AT did not differ from those in group CT. The patients in group CT were significantly older than the control subjects (F = 12.2).

All three groups had significant differences in translation on both tests (p < 0.001) (Table I). At eighty-nine newtons of force, the mean anterior translations were 6.3, 9.6, and 11.4 millimeters for groups C, AT, and CT, respectively, with wider ranges in the two groups of patients. All but one of the control subjects had ten millimeters or less of translation, compared with more than half of the patients (Fig. 2).

At maximum manual force, the results were similar. The mean translations in groups AT and CT were similar (13.0 and 13.5 millimeters), somewhat greater than at eighty-nine newtons and nearly twice the mean in the control subjects (7.0 millimeters). In the two groups of patients, the ranges were similar and were much wider than in the control subjects. All but two control subjects had ten millimeters or less of translation, compared with 23 per cent for group AT and 22 per cent for group CT (Fig. 3).

The mean compliance index (translation at eighty-nine newtons subtracted from that at sixty-seven newtons) was 1.1 millimeters for the control subjects and about twice that amount for the patients (2.2 and 2.1 millimeters for groups AT and CT). Seventy-nine per cent of the control subjects had a compliance index of one millimeter or less; this was true of only 3 per cent of the patients in group AT and 25 per cent of the patients in group CT. All but two control subjects had a compliance index of 2.0 millimeters or less.
Comparison of translation in the knees of normal subjects and of patients who had an acute or chronic tear of the anterior cruciate ligament, tested at maximum manual force.

Comparisons of the knees in group C with the uninvolved knees in groups AT and CT showed significant differences. The uninvolved knees in group CT had more translation (p < 0.002) at eighty-nine newtons and at maximum manual force (p < 0.006). However, no significant difference was evident when we compared the knees in groups AT and CT.

At eighty-nine newtons, 87 per cent of the patients in group AT had a difference of 2.0 millimeters or less between the involved and uninvolved knees. All but one control subject had a difference in translation of three millimeters or less when the two knees were compared. This is in strong contrast to group CT, in which only 12 per cent of the patients had a difference of 2.0 millimeters or less between the involved and uninvolved knees. Eighty-four per cent of the patients who had an acute tear and 88 per cent of those who had a chronic tear had a difference of 2.0 millimeters or more. Nearly 80 per cent of the patients who had a chronic tear had a difference of 3.0 millimeters or more between the involved and uninvolved knees. On maximum manual testing of the knees of the control group, 91 per cent of the subjects had a difference of 2.0 millimeters or less, and nearly all (99 per cent) had a difference of 3.0 millimeters or less. About 90 per cent of the patients in group AT had a difference in translation of 2.0 millimeters or more between the involved and uninvolved knees on the eighty-nine-newton test and a difference of 3.0 millimeters or more on the maximum manual-force test. Nearly all (99 per cent) of the control subjects had a difference in the compliance index of 1.0 millimeter or less, compared with 59 per cent of the patients who had an acute tear and 63 per cent of the patients who had a chronic tear.

The mean differences in translation between the two knees in each individual in groups C, AT, and CT were 0.2, 4.8, and 5.5 millimeters, with ranges of −4 to +4, −7 to +12, and −6 to +16. The comparisons between the control subjects and both groups of patients showed significant differences (p < 0.001), whereas there was no significant difference between the two groups of patients (AT and CT).

Analysis of variance demonstrated incremental increases that were significant for grades I, II, and III on the Lachman test (translations of twelve, thirteen, and sixteen millimeters, respectively) (p < 0.034) and for 1+, 2+, and 3+ on the pivot-shift test (translations of thirteen, fourteen, and seventeen millimeters) (p < 0.027) when compared with the maximum manual test. The differences on maximum manual-force testing were also compared with the results of the Lachman and pivot-shift tests. An increasing trend was noted for grades I, II, and III on the Lachman test (translations of three, four, and eight millimeters) and for 1+, 2+, and 3+ on the pivot-shift test (translations of four, five, and eight millimeters), but this was not statistically significant.

The maximum manual-force test in group AT was most sensitive (90 per cent) at a cut-off of translation of two millimeters or more for involved compared with uninvolved knees. At that cut-off, both the AT and the CT group had tests that were more sensitive and less specific, and a higher negative predictive accuracy was obtained, than with a cut-off of translation of three millimeters or more. The maximum manual-force test was the best screening test (89 per cent negative predictive accuracy) in the AT group (Table II). When the cut-off of translation was three millimeters or more for the involved compared with the uninvolved knees, the tests were less sensitive in groups AT and CT.
but were highly specific (90 per cent). The maximum manual-force test was a better screening test in group AT (84 per cent) than in group CT (76 per cent) at this cut-off level.

Sensitivity for maximum manual force-testing was 93 and 91 per cent for groups AT and CT, whereas at ten millimeters or less of translation, specificity increased to 95 per cent for both groups, with a higher positive predictive accuracy (92 and 94 per cent). For involved compared with uninvolved knees, at a cut-off of translation of three millimeters or more, specificity and positive predictive accuracy were high (94 per cent) at eighty-nine newtons for patients in groups AT and CT.

Cut-off levels of translation of 1.6 millimeters or less and 2.0 millimeters or less were established for the compliance index in groups AT and CT. In general, the cut-off of 1.6 millimeters or less was more sensitive, with equal specificity. The positive predictive accuracy was higher in both groups of patients at 2.0 millimeters or less. The negative predictive accuracy was highest (89 per cent) in group AT at 2.0 millimeters or less.

We used a difference between knees of three millimeters or more and ten millimeters or more of absolute anterior displacement on maximum manual force as diagnostic criteria for differentiating normal from abnormal knees. In patients who had a difference of three millimeters or more between knees and ten millimeters or more of anterior displacement on maximum manual-force testing, the sensitivity was 99 per cent (chi square = 65.2); with the same difference and ten millimeters or less of anterior displacement, no significant differences were noted. A significant difference (chi square = 79.3) was observed between normal and abnormal knees when we used diagnostic criteria of a difference of three millimeters or less between knees and ten millimeters or less of anterior displacement on maximum manual-force testing.

When we compared the data on uninvolved knees in groups AT and CT with the data for group C, significant differences were found with the eighty-nine-newton test (p < 0.002) and the maximum manual-force test (p < 0.006). The compliance indices also were in accord (p < 0.001). No such differences were noted when we compared the uninvolved knees in group AT with those in group CT. For group CT, linear-regression analysis revealed no relationship between the interval from injury to operation and the arthrometric data. However, we could not follow a specific knee over time to ascertain if there was a pattern of change on continued follow-up. A step-wise discriminant analysis of the sixteen possible predictors, as described already, revealed that the maximum manual-force test was the strongest predictor in differentiating normal from abnormal knees (p < 0.001), whereas the compliance index was the strongest predictor in discriminating between a patient who had an acute tear and one who had a chronic tear.

Discussion

A critical issue involving KT-1000 arthrometric evaluation of normal knees and knees that have a tear of the anterior cruciate ligament is whether the tests yield accurate quantitative data. Hanten and Pace studied examiner reliability in an attempt to determine inter-examiner, intra-examiner, and intra-class reliability coefficients in examinations of the normal knees of forty-three collegiate athletes. They found high reliability coefficients (R = 0.85) and intra-class coefficients (R = 0.92) and concluded that the data from the KT-1000 arthrometer were reliable; however, the levels of significance were slightly less than reported by Daniel et al. (R = 0.93). There are no comparable data, to our knowledge, on the accuracy of the KT-1000 arthrometer for normal knees compared with abnormal knees. In abnormal knees, the reduced stiffness (resulting in increased translation and a wider range of values) may lead to decreased inter-examiner and intra-examiner accuracy in the knees of patients who have a tear of the anterior cruciate ligament.

It is encouraging that increasing numbers of authors have reported their clinical observations using tests with the KT-1000 arthrometer as objective assessments of laxity. When we compared the arthrometric data on anterior translation that we recorded at 30 and 90 degrees of flexion of the knee, the magnitude of the translation was greater at 30 degrees for all tests in all three groups of individuals (p < 0.001). This correlates well with clinical
studies that have compared use of the anterior drawer and Lachman tests in examination of the knees of patients who had a torn anterior cruciate ligament.5,10,16,17,19,23

To our knowledge, only Malcom et al. and Daniel et al.8,9 have studied large series of subjects to characterize data from the KT-1000 arthrometer in normal knees and in knees that had a tear of the anterior cruciate ligament. Daniel et al.9 reported on the knees of thirty-three cadavers, 306 normal volunteers, and eighty-nine patients who had a tear of the anterior cruciate ligament; they also reported on 120 normal subjects and on 138 patients who had an acute tear of the anterior cruciate ligament who were tested within two weeks after injury.8 The results of these two studies are comparable with our findings. In their first series (338 subjects), Daniel et al. noted a mean anterior translation of 5.7 millimeters with eighty-nine newtons of force; in the second series (120 subjects), the mean translation was 7.3 millimeters. They attributed the difference of 1.6 millimeters to increased experience of the evaluators, improved techniques of relaxing the experimental subjects, and changes in the limb-support system. The results of maximum manual-force testing were specified in the second but not the first report.

In our group of 141 normal subjects, the mean anterior translation was 6.3 millimeters on the eighty-nine-newton test — between the two averages reported by Daniel et al.8,9. We noted wide ranges of translation among our normal subjects for all testing parameters (sixty-seven newtons, eighty-nine newtons, and maximum manual force), but less so than in the knees that had a torn anterior cruciate ligament. Daniel et al. compared the two knees in normal subjects and found a difference in translation of 2.0 millimeters or less in 92 per cent.6 We confirmed that finding; 87 per cent in our series had a difference of two millimeters or less and 99 per cent had a difference of 3.0 millimeters or less. These three studies8,9 indicate that the difference in translation in the two knees of 567 normal subjects was minimum. Only when the difference between involved and uninvolved knees exceeds two millimeters and, more importantly, 3.0 millimeters should the observer suspect a tear of the anterior cruciate ligament. Daniel et al., reporting on patients who had a chronic tear of the anterior cruciate ligament, noted differences in translation of more than two millimeters between the involved and uninvolved knees in 96 per cent, compared with the prevalence of 88 per cent in our series, of 84 per cent of the patients in the AT group, and of 88 per cent of those in the CT group. Eighty per cent of the patients in the CT group had a difference in translation of 3.0 millimeters or more. Ninety-nine per cent of the normal subjects had translation of ten millimeters or less with the eighty-nine-newton test.

Maximum manual-force testing was discussed in one of the articles by Daniel et al.8. Differences of 3.0 millimeters or more were noted in all twenty-five patients, examined under anesthesia, who had a chronic tear of the anterior cruciate ligament. The differences, as recorded with and without use of anesthesia, varied considerably. As we also showed in our CT group, a pivot-shift phenomenon was noted in all patients who, with the maximum manual-force test, had a difference between knees of 3.0 millimeters or more. We agree with Daniel et al. that that difference is diagnostic of a tear of the anterior cruciate ligament. They concluded that the presence of a traumatic hematoma, a difference between knees of three millimeters or more of translation on the eighty-nine-newton and maximum manual-force tests, and a difference in the compliance index of 1.5 millimeters or more are indicative of a tear of the anterior cruciate ligament.

In our series, the mean translation on maximum manual-force testing in the control subjects was 7.0 millimeters, but the range was wide (four to eleven millimeters). The mean value was nearly half that recorded for groups AT and CT. In 94 per cent of the control subjects, the value was ten millimeters or less; in 91 per cent, the two knees differed by two millimeters or less; and nearly all knees (99 per cent) differed by three millimeters or less.

In the control subjects, the compliance index never exceeded 2.0 millimeters, and the mean index was 1.1 millimeters, almost identical to that observed by Daniel et al. (1.2 and 1.3 millimeters).8,9 In their studies and ours, we have noted a mean index of the knees that had a torn anterior cruciate ligament was nearly double that in the normal knees. We noted a mean compliance index of 2.2 and 2.1 millimeters for groups AT and CT, and Daniel et al. found a mean compliance index of 2.9 millimeters in the knees of their patients who had a chronic tear.6 They noted that 93 per cent of control subjects had a difference in the compliance index of 0.5 millimeter between knees6, and we confirmed that observation. In our groups AT and CT, the difference in the compliance index between the involved and uninvolved knees was 1.0 millimeter or more in 80 per cent of the patients.

Dahlstedt and Dalén examined forty-one patients without and then with anesthesia. When the patient was under anesthesia, the increases in translation were significant (p < 0.001) for both the involved and the normal knees that were tested at eighty-nine newtons and at maximum manual force. Anderson and Lipscomb, in fifty patients, obtained measurements similar to those of Dahlstedt and Dalén, as did Harter et al., who studied fifty patients before and after the anterior cruciate ligament was reconstructed. The data of Dahlstedt and Dalén, Harter et al., and Anderson and Lipscomb therefore complement those of Daniel et al.8,9 and Malcom as well as the data from the current study.

Daniel et al. previously recommended diagnostic cutoff points for so-called equivocal and diagnostic translations in patients who have an acute deficiency of the anterior cruciate ligament5. They recommended that anterior translation of ten to 13.5 millimeters at eighty-nine newtons of force be the limit of equivocal laxity, and that any value of more than 14.0 millimeters be considered diagnostic. Only one of our normal subjects had anterior translation of more than ten millimeters (twelve millimeters), whereas 95 per cent of the patients in group AT had values of fourteen millimeters or less (the diagnostic cut-off of Daniel et al.).
About one-third had values between ten and fourteen millimeters, and the remainder had values of less than ten millimeters. Daniel et al. considered twelve to fifteen millimeters to be equivocal and higher values to be diagnostic when the maximum manual-force test was used. Only two of our control subjects had anterior translation of ten millimeters or more on maximum manual-force testing. In contrast, 44 per cent of the patients in group AT had anterior translation of twelve millimeters or less (the lowest level of equivocal laxity, according to Daniel et al.). Sixty-one per cent of the patients fell within the equivocal range of Daniel et al., and only 16 per cent met their diagnostic criterion (15.5 millimeters or more). As noted, wide ranges were seen in normal and abnormal knees. Our data indicate that virtually all normal knees have translation of eleven millimeters or less at eighty-nine newtons of force and on maximum manual-force testing. The criteria established by Daniel et al. appear to be too strict. We recommend that anterior translation of eleven millimeters or more at eighty-nine newtons of force or on maximum manual-force testing be considered diagnostic of a tear of the anterior cruciate ligament.

Daniel et al. recommended that a compliance index of 2.0 to 2.5 millimeters be considered equivocal and 3.0 millimeters or more, diagnostic of an acute tear of the anterior cruciate ligament. All of our control subjects had a compliance index of two millimeters or less; 42 per cent of the patients in the AT group had a compliance index within the equivocal range of Daniel et al., and only 28 per cent met their diagnostic criterion of 3.0 millimeters or more, so the values for 30 per cent were within the normal range. Of the patients in group CT, the values for 35 per cent were below the equivocal range; 38 per cent, within it; and 28 per cent, within the diagnostic range. Because all control subjects had a compliance index of 2.0 millimeters or less, we believe that an index of more than 2.0 millimeters is diagnostic of a tear of the anterior cruciate ligament.

An important finding in our study was that the uninjured (contralateral) knees in group CT had higher values of statistical significance on both the eighty-nine-newton force test (p < 0.002) and the maximum manual-force test (p < 0.006), and the compliance index also differed (p < 0.001) from that in the control group. However, comparison of groups AT and CT showed no significant differences in the uninjured knees. Since the compliance indices for the uninjured knees in both groups of patients were significantly larger than those for the control subjects, systemic ligamentous laxity must be considered a likely explanation. This implies that individuals who have ligamentous laxity are at increased risk for a tear of the anterior cruciate ligament.

Another important observation was that, in group CT, no correlation was found between the time from injury to operation and the KT-1000 arthrometer values. Although the translations in group CT were greater than those in group AT with the eighty-nine-newton force test, they did not differ with the maximum manual-force test, and the compliance indices also were virtually identical. It may be surmised that, in a knee that has a chronic tear, an increase in laxity may develop with time as the secondary ligamentous restraints are stretched. We did not demonstrate a relationship between time to operation and the amount of translation in patients who had a chronic tear. Clearly, longitudinal studies are needed to determine whether anterior translation increases with time after a tear of the anterior cruciate ligament. However, in our groups AT and CT, the translations were elicited with forces that were far less than those applied even during ordinary walking and athletic activity.

The maximum manual-force test was the strongest variable for discrimination between a normal knee and one that had a tear of the anterior cruciate ligament. This test corresponds to the clinical Lachman test, and various studies have demonstrated that the Lachman test is superior to the anterior drawer test. The compliance index, an indicator of stiffness, was the strongest variable for differentiation between an acute and a chronic tear of the anterior cruciate ligament. apprehension by the patient, mild pain, spasm of the hamstrings, hemorrhasia of the knee, and intact secondary restraints may have affected this determination.

The determinations of sensitivity (true-positive results), specificity (true-negative results), negative predictive accuracy (rule-in test), and positive predictive accuracy (screening test) help to determine the usefulness of any specific test. In our evaluations with the KT-1000 arthrometer, the cut-off of two millimeters of difference in translation between involved and uninvolved knees resulted in a more sensitive but less specific test than the cut-off of three millimeters. The maximum manual-force test had the highest sensitivity (90 per cent) for differences between involved and uninvolved knees. Maximum manual-force testing had high sensitivity for differentiating knees that had an acute tear (93 per cent) and those that had a chronic tear (91 per cent) from normal knees, high specificity (95 per cent), and high positive predictive accuracy (92 per cent) when a cut-off of translation of ten millimeters or more was stipulated.

Biomechanical studies with equipment other than the KT-1000 arthrometer during the last decade have characterized the quantification of anterior translation of the knee with different testing techniques and various forces. Butler et al. popularized the concept that there are primary and secondary ligamentous restraints of the knee and established that the anterior cruciate ligament was the primary restraint (86 per cent) to anterior translation at 30 degrees of flexion of the knee. Markolf et al. also reported results with an instrumented knee-testing apparatus, as did Fukubayashi et al. These biomechanical studies complement our clinical data and those of Malcom et al., Daniel et al., Dahlstedt and Dalén, and Anderson and Lipscomb.

The KT-1000 arthrometer allows objective evaluation of the extent of anterior translation in normal knees and in those that have a tear of the anterior cruciate ligament, with use of different forces. However, variables such as the weight of the leg, the tightness of the strap, the placement
of the sensing pads, asymmetrical placement of the arthrometer with reference to the joint line or to tibial rotation, muscular spasm, and angle of flexion of the subject’s knee may affect the results. Experience and strict attention to detail are critical if consistent and reliable results are to be obtained.

We have found the KT-1000 arthrometer to be a helpful adjunct to a careful history and meticulous physical examination of patients who had symptoms indicative of a lesion of the knee. We use the KT-1000 arthrometer in the office routinely, and at regular intervals, to evaluate our postoperative results. We have also used the KT-1000 arthrometer when examining patients under anesthesia before arthroscopy or reconstruction of a ligament. In addition, we use it to follow patients who are treated non-operatively. It is useful only for measurement of anterior-posterior translation; it does not allow assessment of rotational or varus-valgus instability.

References