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Intratester and Intertester Reliability of the KT-1000 Arthrometer in the Assessment of Posterior Laxity of the Knee

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ABSTRACT

We measured tibial translation in the knees of 22 subjects with posterior cruciate ligament tears or reconstructions by using the KT-1000 arthrometer. To assess the reliability of the device, two testers made measurements. One tester was a novice and the second tester had substantial clinical experience with the KT-1000 arthrometer. The quadriceps neutral angle was found for the uninvolved knee. Anterior and posterior translation and total anterior-posterior excursion were then measured. The quadriceps neutral angle was then reproduced in the involved knee and the same measurements were taken. Each subject was tested twice by each tester. The intraclass correlation coefficient values for the novice, experienced, and intertester reliability were 0.67, 0.79, and 0.62, respectively, for corrected posterior translation; 0.59, 0.68, and 0.64, respectively, for corrected anterior translation; 0.70, 0.74, and 0.29, respectively, for quadriceps neutral angle; and 0.84, 0.83, and 0.62, respectively, for total anterior-posterior excursion. Ninety-five percent confidence intervals for the novice, experienced, and intertester reliability were ±2.95, ±2.53, and ±3.27 mm, respectively, for corrected posterior translation; ±3.99, ±3.89, and ±3.74 mm, respectively, for corrected anterior translation; and ±10.70°, ±11.73°, and ±16.25°, respectively, for quadriceps neutral angle. The KT-1000 arthrometer was found to be a moderately reliable tool for the measurement of tibial translation in patients with posterior cruciate ligament tears and reconstructions.

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This study was done to determine the reliability of the KT-1000 arthrometer (MedMetric, San Diego, California) when used to assess anterior and posterior translation in patients after PCL injury or surgery. Assessment of knee laxity in the clinic is done subjectively and requires "feel" and experience to establish the correct diagnosis. Arthrometers have been designed to objectively measure the amount of tibial translation on the femur when forces are applied. An objective measure of tibial translation is helpful to diagnose injury to the PCL and to assess the effects of treatment over time.

PCL INJURIES

Diagnosis

One of the reasons it is difficult to determine the natural history of a PCL injury is that the diagnosis is often missed on initial evaluation.[6,15] These delays can be attributed to the facts that PCL injuries often occur in conjunction with other ligamentous injuries about the knee[6] and that the presence of acute pain, swelling, hemarthrosis, and protective muscle spasm make it difficult to accurately examine the knee.[15]

The first indication of PCL involvement is the mechanism of injury. The most common mechanism of injury, as reported by Loos et al.,[15] is high-velocity trauma that occurs during motor vehicle accidents when the dashboard strikes the knee, producing posterior translation of the tibia on the femur. Other mechanisms of injury to the PCL include hyperflexion,[6] a fall on a flexed knee with the ankle plantar flexed such that the proximal tibia is displaced posteriorly on the femur,[17,20] hyperextension,[20] and varus or valgus stress with hyperextension or rotational stress.[12,15,20] Loos et al. stated that isolated PCL injuries are rare primarily because the forces required to injure the ligament are extraordinarily high.

Physical findings after PCL injury may include mild-to-moderate effusion,[6,15,16,20] local edema with possible subcutaneous ecchymosis in the popliteal fossa,[15,20] an abrasion over the proximal anterior aspect of the tibia,[6,15,20] a positive sag test or Godfrey's sign,[6] and limited range of motion secondary to pain, swelling, or muscle spasm.[15] Loos et al. indicated that a positive posterior drawer test and varus or valgus laxity at 0° of extension are the most reliable physical findings to assess acute PCL injuries. However, Hughston et al.[12] stated that the posterior drawer test is of little value in diagnosing acute PCL injuries.

Clinical Assessment of Ligamentous Laxity

Several tests to assess the integrity of the PCL have been described and include the posterior drawer test, the posterior sag sign, and Godfrey's sign. The posterior drawer test is performed with the patient supine with the hip flexed to 45° and the knee flexed to 90°. The examiner applies a posteriorly directed force on the proximal tibia while palpating the joint line to assess the amount of posterior laxity at the knee.[10] Authors disagree about whether the posterior drawer test will be consistently positive in the PCL-deficient knee. Hughston et al.[11] attributed a false-negative posterior drawer result to an intact posterior oblique ligament or arcuate complex. However, with continued stress to the secondary restraints, posterior laxity will develop in the chronic PCL-deficient knee.[12]

The posterior sag sign is best seen with the patient lying supine with the hips flexed to 45° and both knees flexed to 90° with the feet flat on the table. From the lateral side, the tibial tubercle of the affected side will appear to sag posteriorly when compared with the uninvolved side. Godfrey's test is similar to the posterior sag sign except it is performed with the hips and knees flexed to 90°. A positive Godfrey's test occurs then the tibia subluxates posteriorly so that the tibial tubercle on the affected side is more posterior than the contralateral tibial tubercle and the normal contour of the knee is lost.

Daniel[3] demonstrated significant discrepancies among experienced testers when estimating the amount of joint displacement during standardized tests to clinically assess laxity of the knee. He attributed much of this variation among examiners to the selection of a neutral starting position from which one can assess anterior-posterior translation. This was demonstrated by the results, which showed better correlation for total anterior-posterior motion than for individual determination of anterior or posterior displacement.

Determining the neutral starting position of the knee joint is important for accurate measurement of anterior or posterior translation, especially when both the ACL and PCL are injured. With the patient in the supine position, with the knee flexed, the PCL passively supports the weight of the lower leg. When the PCL is disrupted, the tibia will subluxate posteriorly. Therefore, to test posterior laxity of the knee with the patient in the supine position, the tibia must first be brought into a neutral position.

Daniel et al.[5] introduced the quadriceps active test as a way to determine whether the tibia is subluxated posteriorly. The test is performed with the patient supine, with the knee flexed to 90°, and the thigh supported while the patient performs a gentle isometric contraction of the quadriceps muscle. In the PCL-deficient knee, the tibia will shift anteriorly 2 mm or more with contraction of the quadriceps muscle (Fig. 1).

Once it is determined that the PCL is disrupted, the quadriceps neutral angle can be used to establish a neutral position for assessment of anterior-posterior laxity. The quadriceps neutral angle in the normal knee is defined as the angle of knee flexion at which there is no anterior or posterior shift of the tibia with active contraction of the quadriceps muscle[5] (Fig. 2). This position of the knee is not dependent on the integrity of the knee ligaments, and therefore it can be used as a reference from which to distinguish anterior and posterior laxity.[5] At the quadriceps neutral angle, the patellar tendon is perpendicular to the tibial plateau. At angles of knee flexion less than the quadriceps neutral angle, the patellar tendon lies anterior to a line drawn perpendicular to the tibial plateau so that contraction of the quadriceps muscle causes anterior translation of the tibia on the femur. At angles of flexion greater than the quadriceps neutral angle, the

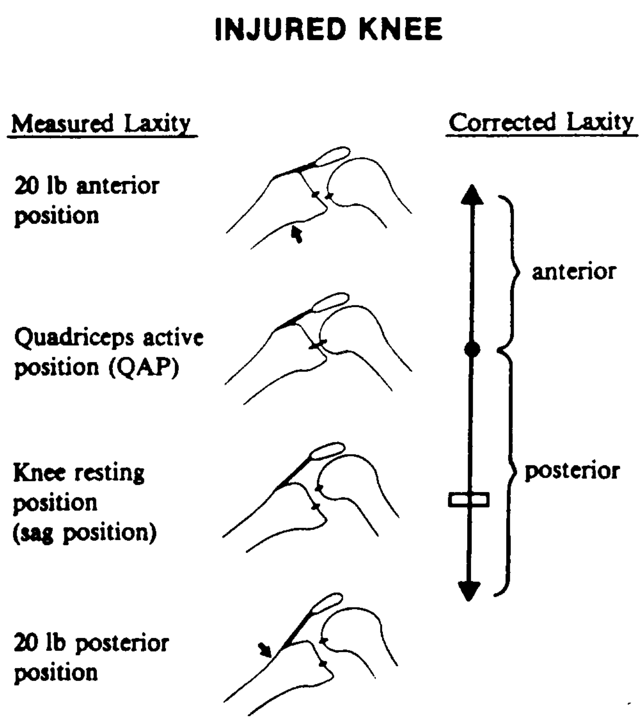

Figure 1. In the injured knee, the measured anterior tibial displacement is the distance from the resting position (rectangle) to the superior arrowhead (10 mm) and the measured posterior displacement, from the resting position to the inferior arrowhead (3 mm). With contraction of the quadriceps muscle, the tibia moves forward from the resting position to the quadriceps active position (dark circle). Reprinted with permission from Daniel et al.[5]

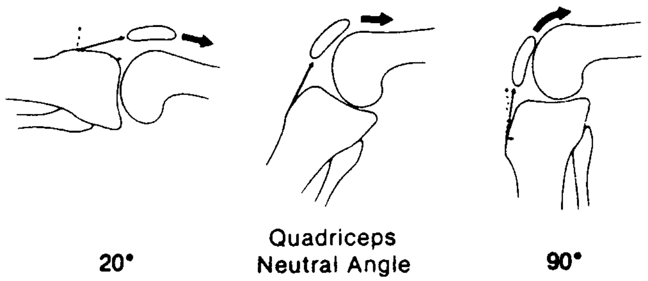

Figure 2. Vector analysis of patellar tendon pull. As the knee flexes, the femur rolls posteriorly on the tibia under the control of the cruciate ligaments. The thick arrows represent the pull of the quadriceps tendon. The direction of the patellar tendon changes continuously from an anterior to a posterior orientation, relative to a line drawn perpendicular to the surface of the tibial plateau (slender arrows). The patellar tendon force can be divided into two components (broken arrows): a normal component, perpendicular to the tibial plateau, and a shear component, parallel to the tibial plateau. The angle of flexion at which there is no shear component is called the quadriceps neutral angle. Reprinted with permission from Daniel et al.[5]

patellar tendon passes posterior to a line drawn perpendicular to the tibial plateau so that contraction of the quadriceps muscle produces posterior translation of the tibia.

The quadriceps neutral angle in an uninjured knee is determined by placing the patient in the supine position with the knee flexed to approximately 70° with the thigh supported. The patient is asked to contract the quadriceps muscle, and the resultant anterior or posterior shift of the tibia is palpated. The examiner than adjusts the angle of knee flexion and repeats the test until there is no palpable shift of the tibia. The quadriceps neutral angle has been found to range from 60° to 90° of knee flexion, with an average of 71°.[5] Once the quadriceps neutral angle is found on the uninvolved side, the involved knee is placed at the same angle of flexion for testing.

Instrumented Testing of Ligament Laxity

The KT-1000 arthrometer was designed to objectively measure anterior and posterior translation of the knee. The device measures displacement, in millimeters, between two sensing pads placed at the patella and the proximal tibia when anterior or posterior forces are applied to the tibia.

The majority of research done to establish reliability and validity of the KT-1000 arthrometer has been done on uninjured or ACL-deficient knees.[2,4,7–9,18,19] The results generally indicate that the KT-1000 arthrometer is a reliable and valid tool. The studies that have assessed the effectiveness of the KT-1000 arthrometer to objectively measure posterior tibial translation have not described use of the quadriceps neutral angle starting position in their methodology.[9,19]

Anderson and Lipscomb[1] compared the results of KT-1000 arthrometer assessment with results of a clinical examination on 50 patients with suspected cruciate ligament tears. The KT-1000 arthrometer was correct in diagnosing the status of the PCL in 50% of cases. The other 50% of the patients could not tolerate the testing position. The KT-1000 arthrometer assessment for posterior translation was done at 70° to 90° of knee flexion, but no mention was made regarding determination of the quadriceps neutral angle on the uninvolved limb.

A study involving use of uninjured subjects showed reliability of 0.79 for assessment of posterior translation between two tests on each knee with the KT-1000 arthrometer.[9] However, assessment of posterior translation was done using the same testing position as assessment for anterior translation, without mention of the quadriceps neutral angle.

Although researchers are reluctant to use the KT-1000 arthrometer exclusively to diagnose a knee ligament injury, some have concluded that the KT-1000 arthrometer may be useful as a tool for confirmation of diagnosis or to compare changes in laxity over time before and after treatment.[1,18] However, to assess posterior tibial translation with the KT-1000 arthrometer, the testing procedure must incorporate use of the quadriceps neutral position.[5]

Studies done to determine the value of the KT-1000 arthrometer for clinical use have concentrated primarily on its use to assess anterior translation of the knee after ACL injury. Because the procedure for determining anterior and posterior translation in a PCL-deficient knee differs significantly from the procedure used to assess translation in an ACL-deficient knee, the reliability of the KT-1000 arthrometer when used to measure translation in knees with PCL tears or reconstructions must be assessed.

The purpose of this study was to determine intratester and intertester reliability of the KT-1000 arthrometer when used to assess anterior and posterior translation in subjects after PCL rupture or reconstruction.

MATERIALS AND METHODS

Patients who had PCL tears or had undergone PCL reconstruction served as subjects for this study. The clinical diagnosis of PCL injury in the nonoperative subjects was determined by positive findings on at least two of the following tests: posterior drawer, posterior sag, or Godfrey's sign. Additionally, the diagnosis was confirmed by either magnetic resonance imaging or arthroscopic evaluation. Subjects who had PCL reconstructions were at least 9 months postsurgery. For all subjects, the uninvolved knee was free from ligamentous or meniscal injury and had a full pain-free range of motion. At the time of testing, both knees were free from active inflammation. A signed consent form was obtained from each subject before the initiation of testing. This study was approved by the Institutional Review Board for Biomedical Research at the University of Pittsburgh, Pittsburgh, Pennsylvania.

All subjects were tested by two testers. One tester was considered a novice with knowledge of the correct testing procedure but less than 20 hours of clinical experience with the KT-1000 arthrometer. The second tester was considered an experienced tester with more than 1000 hours of clinical experience with the KT-1000 arthrometer for assessment of anterior and posterior laxity of the knee.

The quadriceps neutral angle was determined on the uninvolved limb for each subject as described by Daniel et al.[5] The angle of knee flexion at which no palpable tibial translation occurred with isolated contraction of the quadriceps muscle was defined as the quadriceps neutral angle and was recorded in degrees with a goniometer by an independent observer to reduce tester bias.

With the knee positioned at the quadriceps neutral angle, the uninvolved knee was tested with the KT-1000 arthrometer, and the amount of tibial translation was recorded in millimeters for the quadriceps active test and for anterior and posterior translation at 20 pounds of force. To confirm the correct position for the quadriceps neutral angle, the quadriceps active test was performed by having the subject contract the quadriceps muscle while the knee was positioned in the quadriceps neutral angle with the KT-1000 arthrometer applied, and the amount of tibial translation was recorded. An anteriorly or posteriorly directed force of 20 pounds was applied three times and maximal translation was recorded in millimeters by another unbiased observer. The quadriceps neutral angle was then reproduced, using a goniometer, on the involved side and the same testing procedure was then performed.

Each subject was tested four times, twice by the novice tester and twice by the experienced tester. The order of testing between the experienced and the novice tester was randomized by flipping a coin. The same testing procedure was used for each test. All the testing occurred in a single day for each subject with approximately 10 to 15 minutes between tests.

Corrected posterior translation was calculated by adding the amount of displacement found when exerting a 20-pound posterior force with the amount of displacement recorded during the quadriceps active test. Corrected anterior translation was calculated by subtracting the quadriceps active test score from the amount of anterior translation produced with a 20-pound anterior force (Fig. 1).

An intraclass correlation coefficient (formula 2,1[14]) was used to determine within- and between-tester reliability for corrected posterior translation, corrected anterior translation, total anterior-posterior excursion, and quadriceps neutral angle. Formula 2,1 allows for the results to be generalized to testers not participating in the study. Absolute values were used for statistical analysis. The standard error of measure was used to calculate 95% confidence intervals for the novice and experienced testers. The confidence interval represents a range about an observed score in which the true score falls. For two scores to be significantly different, their values must fall outside the 95% confidence interval. For example, if a tester finds 5 mm of posterior displacement, with a standard error of the mean of ±1.0, a score greater than 6 mm or less than 4 mm would be considered different.

RESULTS

Six subjects (5 men and 1 woman; average age, 25.2 years; range, 18 to 34) had PCL injuries that were managed nonoperatively, with an average length of followup of 37.3 months (range, 10 to 156) from the time of injury. There were 5 isolated PCL tears confirmed by magnetic resonance imaging or arthroscopic examination and one complete PCL tear and partial ACL tear confirmed by arthroscopic examination. Sixteen subjects (12 men and 4 women; average age, 28.8 years; range, 18 to 52) were evaluated an average of 24.9 months (range, 9 to 81) after PCL reconstruction. Ten subjects in the surgically treated group had isolated PCL reconstructions. The remaining six patients had PCL reconstructions combined with other procedures. Surgical procedures performed on those subjects are listed in Table 1. Table 2 lists mean values, standard deviations, and ranges for corrected posterior translation, corrected anterior translation, total anterior-posterior excursion, and quadriceps neutral angle.

Intrarater reliability was assessed for both the novice and the experienced tester using intraclass correlation coefficients. Intraclass correlation coefficients for the experienced tester were higher than those for the novice tester for corrected posterior translation (0.79 versus 0.67), corrected anterior translation (0.68 versus 0.59), and quadriceps neutral angle (0.74 versus 0.70). Intratester reliability for assessment of total anterior-posterior excursion was similar for the novice and experienced testers (0.84 versus 0.83). Reliability between testers was calculated by arbitrarily using the highest absolute score found by each tester for each measurement. For example, if the tester found the scores to be 12, 10, and 9 mm for the three trials of posterior translation at 20 pounds of force, the 12 mm figure was used for the statistical analysis. Intertester reliability was 0.62 for corrected posterior translation, 0.64 for corrected anterior translation, 0.29 for quadriceps neutral angle, and 0.62 for total anterior-posterior excursion.

The standard error of measure was also calculated to construct 95% confidence intervals. The results are listed in Table 3. The 95% confidence intervals were smaller for the experienced tester for the assessment of corrected posterior translation (±2.53 versus ±2.95) and corrected anterior translation (±3.89 versus ±3.99). However, the 95% confidence interval for assessment of the quadriceps neutral angle was lower for the novice tester (novice ±10.70 and experienced ±11.73).

TABLE 1
Surgical Procedures Combined with PCL Reconstructions in the Surgically Treated Group

Surgical procedure	Number
Isolated PCL reconstruction	10
ACL/PCL reconstruction	2
MCL/PCL reconstruction	1
LCL/PCL reconstruction	1
ACL/PCL reconstruction & meniscal repair	1
ACL/PCL/LCL reconstruction	1

TABLE 2
Corrected Posterior Translation (CPT), Corrected Anterior Translation (CAT), Total Anterior-Posterior Excursion (TAPE), and Quadriceps Neutral Angle (QNA) Measurements for Both the Novice and the Experienced Tester[a]

Measurement	Novice	Experienced	Overall
CPT (mm)	5.8 ± 2.6 (0.5–13)	6.6 ± 2.8 (2–13)	7.1 ± 2.7
CAT (mm)	4.4 ± 3.2 (−4–13)	4.2 ± 3.5 (−1–20)	5.4 ± 3.2
TAPE (mm)	10.3 ± 3.9 (1.5–18.5)	10.8 ± 5.28 (2–31)	11.5 ± 4.5
QNA (deg)	75.0 ± 10.0 (60–104)	75.5 ± 11.7 (64–105)	77.9 ± 9.8

[a] Values represent mean ± SD. Values in parentheses represent range.

TABLE 3
95% Confidence Intervals for the Novice Tester, Experienced Tester, and Intertester Reliability

Measurement	Novice tester	Experienced tester	Intertester[a]
Corrected posterior translation (CPT)	±2.95	±2.53	±3.27
Corrected anterior translation (CAT)	±3.99	±3.89	±3.74
Quadriceps neutral angle (QNA)	±10.70	±11.73	±16.25

[a] The largest measurement for each tester was used to assess intertester confidence intervals.

DISCUSSION

Assessment of reliability of the KT-1000 arthrometer for a single tester and between testers in subjects after PCL injury or surgery is important clinically. First, the PCL is recognized as an important stabilizer of the knee. It has been shown to be the primary restraint against posterior translation at the knee. A reliable measure of posterior translation of the tibia may be helpful to establish an accurate diagnosis after PCL injury. Second, a reliable measure of tibial translation in a PCL-deficient knee or after PCL reconstruction is necessary to compare results of treatment in a given subject or population over time. Subjects treated both nonoperatively and operatively were included in this study to improve our ability to generalize the results. The length of time from injury or surgery may affect laxity of the knee. It has been hypothesized that after PCL injury activities such as walking and running stress the secondary restraints and cause development of further laxity.[12] Reliability of an instrument to measure laxity is important when considering changes in laxity over time.

This study was designed to duplicate practices that occur in the clinical setting for assessment of tibial translation after PCL ruptures or reconstructions. Instrumented testing, as described in this study, is indicated when one suspects the involvement of the PCL based on the mechanism of injury, physical examination, and overall clinical presentation. The diagnosis of PCL injury or assessment of outcome after PCL injury or surgery does not depend solely on the results of instrumented testing. Devices such as the KT-1000 arthrometer are used to confirm and quantify the amount of laxity present in the knee after injury or surgical intervention. Theoretically, an objective measure of laxity may be used to determine the proper course of treatment for the patient, whether it be operative or nonoperative. Also, this objective measurement may be used to quantitatively assess outcome in terms of joint stability after treatment of the knee. To be used as a device to determine treatment and outcome for a particular patient, the KT-1000 arthrometer must first be determined to be reliable in the clinical setting on subjects with documented PCL injury.

Intratester reliability scores for the novice tester were comparable with scores for the experienced tester when determining quadriceps neutral angle (0.70 and 0.74, respectively) and total excursion (0.84 and 0.83, respectively), but they were lower for assessment of corrected posterior translation (0.67 and 0.79, respectively) and corrected anterior translation (0.59 and 0.68, respectively). The standard error of the mean was used to construct 95% confidence intervals, which showed disparity between the novice and experienced testers. Intertester reliability was found to be moderate for corrected posterior translation (0.62), corrected anterior translation (0.64), and total anterior-posterior excursion (0.62). The intertester reliability for determination of quadriceps neutral angle was low (0.29). The average quadriceps neutral angle was found to occur at a higher degree of knee flexion, with greater variability than that reported by Daniel et al.,[5] possibly because of the comparatively lower number of subjects in this study.

The 95% confidence intervals were lower for the experienced tester for assessment of both corrected posterior and anterior translation. Knowledge of this is important when interpreting the results of a KT-1000 arthrometer test for a subject with PCL involvement. The novice tester in this study, who was familiar with proper procedure but had less than 20 hours of actual clinical experience using the KT-1000 arthrometer had a 95% confidence interval of ±2.95 mm for corrected posterior translation and ±3.99 mm for corrected anterior translation. This indicates that for a novice tester, the true amount of tibial translation falls within those ranges about an observed score. On the other hand, the tester with more than 1000 hours of clinical experience with the KT-1000 arthrometer had a 95% confidence interval of ±2.53 mm for corrected posterior translation and ±3.89 mm for corrected anterior translation. This somewhat reduces the range within which the true score lies. However, the 95% confidence interval was higher for the experienced tester for the assessment of quadriceps neutral angle, leading to the conclusion that factors other than level of experience of the tester may be involved in the determination of a true score.

There are several potential problems associated with assessment of tibial translation in a knee after PCL injury or reconstruction with the KT-1000 arthrometer that may explain the limited reliability found in this study. The first is determination of the quadriceps neutral angle. Intertester reliability for assessment of the quadriceps neutral angle was low. The quadriceps neutral angle is determined by palpating the tibia to find the position of the knee in which there is no anterior or posterior translation of the tibia during an isolated contraction of the quadriceps muscle. It may be very difficult to assess excursion of the tibia with an active quadriceps muscle contraction if the subject does not relax, has injury to multiple ligamentous structures, or if the examiner has poor palpation skills and therefore is unable to detect tibial translation for the initial assessment of the quadriceps neutral angle. Determination of the quadriceps neutral angle may be the most important issue for reliable measurement of tibial translation in the PCL-deficient or PCL-reconstructed knee because this procedure determines the neutral reference position for the knee.

Many of the manual examination procedures take place with the tibia in a gravity-dependent position. In a PCL-injured knee, gravity subluxates the tibia posteriorly, thus making determination of the neutral position difficult. A neutral starting position is critical to distinguish anterior from posterior laxity at the knee. This factor may explain why reliability measures for both the novice tester and experienced tester were higher for total anterior-posterior excursion than for either corrected posterior translation or corrected anterior translation. Assessment of total anterior-posterior excursion is not dependent on a neutral starting position.

Position of the foot at time of testing was not mentioned in the article by Daniel et al.[5] Internal or external rotation of the tibia, however, may affect stresses on the secondary restraints to tibial translation and alter the amount of tibial translation.[10,13] Care should be taken by the tester to ensure that the tibia is positioned in neutral rotation when testing the integrity of the PCL.

Another important issue is relaxation of the hamstring and quadriceps muscles when measuring anterior and posterior translation, respectively, with the KT-1000 arthrometer. This may be a problem in a patient with anxiety or pain during testing. Hamstring muscle contraction at the time of testing will decrease the amount of anterior tibial translation. On the other hand, incomplete relaxation at the quadriceps muscle invalidates the results by holding the tibia in a relatively anterior position so that full posterior excursion is not measured.

Relaxation of the lower extremity musculature may be particularly difficult in patients with acute injury because testing must be done at a higher angle of knee flexion than the subject can often comfortably tolerate. This procedure to assess tibial translation cannot be performed under anesthesia because the subject must actively participate in portions of the examination. For the purposes of this study, we attempted to monitor the amount of muscle activity during testing by having an assistant support the lower extremity while the test was performed. The assistant palpated both the quadriceps and hamstring muscles to ensure isolated activity of the quadriceps muscle during the quadriceps active test.

Another concern when performing and interpreting the KT-1000 arthrometer test to assess tibial translation is the presence of associated ligamentous injury. Rupture of the PCL requires a great amount of force; therefore, injury to the PCL is often accompanied by injury to other supporting structures of the knee.[15] The concept of the quadriceps neutral angle considers only translation in the sagittal plane; however, motion occurs in six degrees of freedom at the knee. For example, if the quadriceps neutral angle is accurately found in the involved knee, laxity in the transverse plane (i.e., posterolateral or posteromedial rotation) may affect the results of testing.

Another possible source of error is movement of the KT-1000 arthrometer over the bony landmarks during testing. If the KT-1000 arthrometer moves in a medial, lateral, superior, or inferior direction after the zero position has been determined, the device must be realigned. To improve the reliability of the device, the forces should be delivered through the KT-1000 arthrometer in a straight anterior-posterior direction.

The final limitation of this study is the number of subjects who participated. Posterior cruciate ligament injuries occur less commonly than ACL injuries. Furthermore, PCL injuries are often missed on initial diagnosis and may be diagnosed years after the injury when the patient is seen for secondary problems such as degenerative changes of the tibiofemoral or patellofemoral joints. The number of subjects who undergo PCL reconstruction is limited. These factors made it difficult to identify patients for inclusion in this study.

Recommendations for use of the KT-1000 arthrometer to assess posterior laxity of the knee are as follows. First, the novice tester should be intent on acquiring clinical experience with the use of the device on both normal subjects and subjects with documented PCL injury. This should include familiarization with the procedures to determine the quadriceps neutral angle and to measure anterior and posterior tibial translation. The results of the novice tester should be compared with those of an experienced tester as well as with the results of magnetic resonance imaging or arthroscopic examination. This comparison will allow one to determine and improve reliability and accuracy for assessing tibial translation in knees with PCL tears or reconstructions. Reliability, standard error of the mean, and 95% confidence intervals should be determined for each tester. In addition, the tester should ensure that the angle of knee flexion is the same when testing the involved and noninvolved knees and that this angle does not change while the test is performed. This is necessary to ensure that the effects on the secondary restraints are the same on each side. Testers should also employ an assistant to palpate both the hamstring and quadriceps muscles to ensure that the muscles are relaxed and that an isolated quadriceps muscle contraction occurs during testing. Lastly, when interpreting the KT-1000 arthrometer scores, total anterior-posterior translation may be the best indicator of ligamentous laxity as shown by reliability scores.

Future directions for research concerning this topic include assessment of reliability for a larger number of subjects with isolated PCL involvement, as well as in subjects with combined laxity at the knee. Studies using stress radiography should be performed to determine validity or accuracy of the KT-1000 arthrometer when measuring laxity of the PCL-deficient or PCL-reconstructed knee. Also, because different portions of the PCL are taut in flexion and extension by virtue of the fiber bundle orientation, a procedure should be designed to test the integrity of the PCL in different angles of knee flexion.

SUMMARY

Twenty-two subjects with PCL tears or reconstructions were tested with the KT-1000 arthrometer to assess tibial translation. Each subject was tested twice by two testers to assess intratester and intertester reliability of the KT-1000 arthrometer. One tester was considered a novice tester with less than 20 hours of experience with use of the KT-1000 arthrometer. The second tester was an experienced tester with more than 1000 hours of clinical use of the KT-1000 arthrometer to assess anterior and posterior laxity of the knee.

Moderate reliability was found within and between testers. Ninety-five percent confidence intervals were found to be lower for the experienced tester for assessment of anterior and posterior tibial translation. Aspects of testing that may contribute to lower reliability scores include level of tester experience, ability to determine the quadriceps neutral angle on the uninvolved side and to reproduce the correct angle of knee flexion on the involved side, and ability of the subject to maintain hamstring muscle relaxation during the quadriceps active test and during anterior and posterior testing. It is recommended that the KT-1000 arthrometer be used cautiously to diagnose injury and to document changes in laxity over time in knees with PCL tears or reconstructions.

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