ABSTRACT

The KT-1000 knee arthrometer (KT-1000) is an objective instrument to measure anterior tibial motion relative to the femur for anterior cruciate ligament (ACL) reconstruction. Four studies between 1950 and 2007 regarding validity of the KT-1000 were identified using a Medline search. One had interpretable information on sensitivities, specificities, and predictive values to validate the instrument as a diagnostic tool in patients with acute or chronic ACL injuries. Three had limitations in methodology. We suggest that the KT-1000 should be used with caution as an objective instrument. Rather, using a KT-1000 score derived by subtracting the anterior tibial motion relative to the femur of the injured knee to that of the uninjured knee may be more appropriate as a dichotomous diagnostic test with a threshold of 2 or 3 mm.

Key words: anterior cruciate ligament; arthrometry, articular; reproducibility of results; review

INTRODUCTION

The anterior cruciate ligament (ACL) is the primary restraint to anterior tibial motion in relation to the femur. ACL deficiency can be evaluated using clinical tests (namely the anterior drawer test, Lachman test, and pivot shift test), magnetic resonance imaging, arthroscopy, and arthrometric testing. Comparing surgical outcomes using imaging modalities or arthroscopy is not objective. Although clinical tests are useful for diagnosis and treatment, their interpretation can vary among clinicians.

The KT-1000 knee arthrometer (KT-1000) is an objective instrument for ACL reconstruction, which measures anterior tibial motion relative to the femur. The test involves strapping the KT-1000 to the leg, pulling the tibia anteriorly, and quantifying the amount of movement in millimeters (mm). A KT-1000 score is derived by subtracting the anterior tibial motion relative to the femur of the injured knee to that of the uninjured knee. 15, 20, and 30 pounds (67, 89, and 133 Newtons, respectively) of anterior displacement force are applied to the knee joint. The compliance index is the difference in anterior excursion between 15 and 20 pounds of displacement forces, providing an
indication of the extent to which anatomic structures resist anterior displacement.\(^1\)

Clinical trials involving ACL Reconstruction often use the KT-1000 as an objective outcome instrument. However, using the KT-1000 as a tool to compare the derived scores as a continuous variable has not been validated. There have been attempts to establish the validity of the KT-1000 as a diagnostic test with derived sensitivities and specificities. The objective of this systematic review is to evaluate the validity of the KT-1000.

**METHODS**

Prospective studies published in peer-reviewed journals between 1950 and 2007 with the primary objective to establish the validity of the KT-1000 were identified using a Medline search. Studies with an objective to establish reliability or responsiveness of the KT-1000, or validity of other knee arthrometers (e.g. KT-2000), or those using the KT-1000 as an objective instrument were excluded.

Validity was defined as the ability to distinguish between presence (sensitivity) and absence (specificity) of disease. Reliability was defined as consistency of the measurement, or the degree to which the repeated measurements on the same subjects obtained under similar test conditions. Responsiveness was defined as the ability to detect a clinically important change, usually as a result of an intervention.

**RESULTS**

Four studies were identified. Only one had interpretable information on sensitivity, specificity, and predictive values to validate the KT-1000 as a diagnostic tool in patients with acute or chronic ACL injuries.\(^2\) Three had limitations in methodology.\(^1,3,4\)

In a well-designed, methodologically robust study,\(^2\) 141 patients with no ACL injury (controls), 107 patients with acute (≤1 month old) and 153 patients with chronic (>1 month old) ACL injuries were assessed. Patient characteristics (age, height, and weight distribution) were retrieved. The gender distribution was not explicitly stated, but matched controls were based on gender. The comparative gold standard was a thorough history and clinical examination. The outcome variables were assessed using the 15, 20, and 30 pound tests and the compliance index. Respectively for acute and chronic ACL injuries, the sensitivities were 0.77 and 0.72, the specificities were 0.90 and 0.90, the positive predictive values were 0.86 and 0.98, and the negative predictive values were 0.84 and 0.76, when using the 30 pound test and >3 mm as the diagnostic threshold for ACL injury. Using 2 mm as the diagnostic threshold, the corresponding figures were 0.90 and 0.77, 0.64 and 0.64, 0.65 and 0.68, and 0.89 and 0.73. Therefore, KT-1000 scores using a diagnostic threshold of >2 or >3 mm was preferred, but the KT-1000 was not recommended as a diagnostic test, rather as an adjunct to clinical examination and follow-up.

In a study comparing 138 patients with an acute ACL injury (<14 days old) with 120 controls,\(^1\) the outcome variables were assessed using the 15, 20, and 30 pound tests and the compliance index. It was concluded that the KT-1000 score of >3 mm was diagnostic of an ACL disruption, but sensitivity, specificity, and predictive values of the score were not provided. The limitations in methodology were (1) patient characteristics were not included; (2) whether a blinded examiner performed the clinical evaluations was not stated; (3) only 75 of the 138 patients underwent diagnostic arthroscopy (probably because it was unethical to do so without a definite indication and magnetic resonance imaging); and (4) the spectrum effect (bias) was not considered. It exists when the relationship between disease state and test performance changes according to patient characteristics.\(^5\) Patients with chronic ACL injuries were excluded; they may respond differently to those with acute injuries.

In a study on 68 patients with unilateral ACL deficiency,\(^6\) the comparative gold standard was a history and clinical examination and the outcome variables were assessed using the 15, 20, and 30 pound tests and the compliance index. It was concluded that the KT-1000 score using the 30 pound test and >2 mm as the diagnostic threshold had a specificity of 0.72 and a sensitivity of 0.90. The limitations in methodology were unknown population characteristics, enrolment criteria not stated explicitly, no consideration of the spectrum effect (the acuteness of the ACL injuries was not described), and whether the examiner was blinded was not stated.

In a study of 38 patients with ACL injury confirmed by diagnostic arthroscopy,\(^4\) the outcome variables were assessed using the 15, 20, and 30 pound tests. No control group was included; results were thus limited to sensitivity. Patient demographics (age and gender distribution) were reported. Assessments were made within 3 weeks of acute injury. All patients underwent clinical examinations and KT-1000 test by a single experienced examiner as well as magnetic resonance imaging by a team of radiologists. The sensitivity of the KT-1000 was 0.84, 0.87, and 0.97 using the 15, 20, and 30 pound tests, respectively. Limitations in the methodology were (1) the spectrum effect was
not considered because all patients had an acute ACL injury; (2) the sample size was small; (3) patient recruitment was based on arthroscopic ACL deficiency; (4) there was no control group; and (5) the examiner was not blinded to the patients’ injury status. Selection bias may therefore have been present. Specificity or predictive values could not be derived because of the lack of a control (uninjured) group.

**DISCUSSION**

In clinical trials, the KT-1000 is used to evaluate differences between surgical techniques, and the KT-1000 score is used as a continuous variable for comparison between groups. Yet, no study sought to validate the KT-1000 as an outcome tool for measuring anterior tibial motion as a continuous variable. Rather, it has been validated as a diagnostic tool for ACL injury. Therefore, using the KT-1000 as an outcome tool to evaluate continuous variables may be inappropriate. We recommend using it as a dichotomous diagnostic tool.

An *in vivo* study compared KT-1000 scores with dynamic radiographs of 100 patients with an ACL injury in order to establish their correlation. Radiographs were taken in the position with an anterior pull on the tibia to reproduce the KT-1000 test. The correlation between the dynamic radiographs and the KT-1000 was 0.67 for absolute values of the injured knees and was 0.46 when comparing dynamic radiographs to the KT-1000 score (injured knee minus normal knee range of motion). The ability to interpret the correlation was limited because the distribution (i.e. scatter plot) was not provided. As such, it is difficult to interpret the coefficients. The overall correlation between dynamic radiographs and the KT-1000 is weakly positive.

The KT-1000 should be used cautiously as a continuous outcome tool for ACL injury in clinical trials. Rather, using the KT-1000 score may be more appropriate as a dichotomous diagnostic test with a threshold of 2 or 3 mm.

**REFERENCES**