

A STUDY ON THE DIAGNOSTIC ACCURACY OF THE ARTHROMETER KT1000™ IN ANTERIOR CRUCIATE LIGAMENT INJURIES

RENE JORGE ABDALLA¹, GILBERTO LUÍS CAMANHO², MOISÉS COHEN³, LEONARDO DIAS⁴, SÉRGIO LUÍZ JEREMIAS JÚNIOR⁵, ANDREA FORGAS⁶

SUMMARY

The main objective of this study was to verify the sensitiveness of the Electronic Arthrometer KT-1000™ in detecting ACL injuries. Thirty-six patients with knee sprain history and clinical tests compatible to ACL injury were evaluated. Group 1 was composed of 18 patients evaluated within less than four weeks after the sprain episode. Group 2 (two) was formed by 18 patients evaluated within more than 4 (four) weeks after the sprain episode. Both Groups were submitted to arthrometric (KT-1000™) and magnetic resonance imaging (MR) evaluation. After the analysis of data obtained from imaging and arthrometric evaluations, the patients

were submitted to arthroscopic procedures for injury evaluation and treatment, enabling the comparison of arthroscopic findings to the results of arthrometry and Magnetic Resonance Imaging. The diagnostic accuracy of the arthrometer KT-1000™ was 100% for both groups, with the most sensible test regarding the presence of ACL injury being the Maximum Manual Traction Test. The diagnostic accuracy of the magnetic resonance imaging test was 94.4% for Group 1 and 100% for Group 2.

Keywords: Knee; Anterior cruciate ligament; Arthroscopy.

INTRODUCTION

The electronic arthrometer KT1000™ consists of an instrumented system for measuring the tibial anteroposterior dislocation compared to femur. This instrument has a wide acceptance in the scientific field, because it has been proven as a very useful tool for evaluation and documentation of knee anterior cruciate ligament injuries. Among the advantages of using the electronic arthrometer KT1000™, we can highlight the potential to repeat tests (allowing a comparison with subsequent tests) and also the ability to numerically measure the knee anteroposterior laxity, which does not happen with manual tests, since they fully depend on evaluator's sensitiveness.

This study aims to analyze the data found on the arthrometric evaluation (KT1000™) and by magnetic resonance (MR) of 36 patients with clinical signs of ACL rupture, randomly selected at the Sports Orthopaedics and Rehabilitation Center of the Hospital do Coração (CORE), comparing those data to surgical findings obtained from arthroscopic procedures performed thereafter.

MATERIALS AND METHODS

Thirty-six patients with history of knee sprain and clinical signs compatible to ACL injury, randomly selected at the Sports Orthopaedics and Rehabilitation Center of the Hospital do Coração (CORE), were assessed and divided into two groups:

The first group consisted of 18 patients assessed within up to four

weeks after the sprain episode, being 17 male patients and one female patient, with eight left knees and 10 right knees. The mean age of patients was 29.1 years old (17-46 years old).

The second group consisted of 18 patients assessed within more than four weeks after the initial sprain episode, being 14 male patients and four female patients, with six left knees and 12 right knees. The mean age of patients was 28.4 years old (16-43 years old).

Patients from both groups were submitted to imaging evaluation through Magnetic Resonance test, with all individuals included in this study being evaluated by the same radiologists' team.

In addition to the imaging evaluation, all patients were submitted to arthrometric evaluation of the knee by the same evaluator through the following tests: anterior Traction Test with strengths of 15, 20 and 30 pounds (strength is applied through a handle connected to the dynamometer), Dislocation Test by active contraction of the quadriceps (in this test, anteriorization external strengths are not applied to the tibia, with the anterior dislocation being caused by the patellar tendon traction force vector, during muscle contraction) and Maximum Manual anterior Traction Test (the anteriorization strength of the tibia is applied directly on the popliteal region, not using the dynamometer). For the interpretation of arthrometric findings, the values of differences between the affected limb and the normal limb were considered, taking difference values bigger than 3 mm as suggestive of ACL injury; in addition, if any of the four tests provided a positive result, then the patient would be

Study conducted by the C.E.T.E. (Sports Traumatology Center, Department of Orthopaedics and Traumatology - UNIFESP - EPM). C.O.R.E. (Sports Orthopaedics and Rehabilitation Center - Hospital do Coração)

Correspondences to: Andrea Forgas - Av. Abílio Soares, 227 cj.31 Paraíso São Paulo, SP cep: 04005-000

1. PhD in Orthopaedics and Scientific Coordinator of C.E.T.E. (Sports Traumatology Center, Department of Orthopaedics and Traumatology - UNIFESP - EPM), and C.O.R.E. (Sports Orthopaedics and Rehabilitation Center - Hospital do Coração).
2. Full Professor of Orthopaedics and Traumatology, IOT - FMUSP and Director at CORE (Sports Orthopaedics and Rehabilitation Center - Hospital do Coração).
3. Full Professor of Orthopaedics, Department of Orthopaedics and Traumatology - UNIFESP - EPM and Director at C.E.T.E. (Sports Traumatology Center, Department of Orthopaedics and Traumatology - UNIFESP - EPM).
4. Doctor Orthopaedic at Hospital Santa Marcelina and Trainee at CORE - Sports Orthopaedics and Rehabilitation Center - HCOR.
5. Physical Therapist at C.O.R.E. (Sports Orthopaedics and Rehabilitation Center - Hospital do Coração).
6. Physical Therapist at CORE (Sports Orthopaedics and Rehabilitation Center - Hospital do Coração) and Scientific Coordinator of CECORE (Studies Center, Sports Orthopaedics and Rehabilitation Center - Hospital do Coração).

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considered as having an ACL injury. All tests were performed by the same examiner (Figure 1).

After the analysis of data obtained from imaging and arthrometric evaluations, the patients were submitted to arthroscopic procedures for diagnostic confirmation and treatment.

RESULTS

Group 1:

Data obtained through the Magnetic Resonance evaluation indicated that 17 (94.4%) of the 27 patients assessed presented with suggestive image of ACL injury. However, through arthrometric evaluation, values compatible to ACL injury were obtained in each of the 18 patients (100%).

All patients categorized as ACL injury carriers were subsequently submitted to arthroscopic procedures for end-point evaluation, in which injury was really verified in all of the 18 patients. Thus, the MR evaluation achieved a diagnostic agreement of 94.4% regarding arthroscopic findings ($P < 0.0001$), and could not diagnose the ACL injury in only one patient. During the arthroscopic evaluation, the existence of related injuries was also seen: Medial meniscus - 10 cases (55.5%); Medial condyle cartilage - three cases (16.6%), and medial meniscus associated to medial condyle cartilage - two cases (11%). In the remaining 16.9% no related injuries were found.

By correlating the arthrometric results to the arthroscopic findings (considering that if any of the four KT1000 tests was positive, this fact would determine the existence of injury), we achieved an agreement of 100% between arthrometry and arthroscopic findings ($P < 0.0001$). However, by separately analyzing each of the four tests, we achieved the following diagnostic agreement values: Anterior Dislocation Test at 20 pounds: 38.8%; Anterior Dislocation Test at 30 pounds: 66.6%; Quadriceps Active Dislocation Test: 61.1%; and, Maximum Manual Anterior Dislocation Test: 100%.

Group 2 :

Data gathered by Magnetic Resonance evaluation showed that all 18 patients (100%) assessed presented an image suggesting ACL injury. Similarly, during the arthrometric evaluation, we also noticed values compatible to ACL injury in all patients assessed.

By repeating the methodology used for Group 1, those patients categorized as ACL-injured (assuming a positive result of the MR and/or of the KT1000™) were submitted to subsequent arthroscopic procedures for end-point evaluation, through which the presence of ACL injury could be confirmed in all 18 individuals assessed. Thus, the MR evaluation had a diagnostic agreement of 100% with the arthroscopic findings ($P < 0.0001$). In addition, during the arthroscopic evaluation, the existence of related injuries was also seen: 38.8% Medial meniscus, 5.5% Lateral meniscus, 5.5% Medial condyle cartilage, and 22.2% Medial meniscus associated to Medial condyle cartilage.

By correlating arthrometric results to the arthroscopic findings (considering that if any of the four (4) KT1000 tests was positive, this fact would determine the existence of injury), we achieved an agreement of 100% in our evaluations between the arthrometry and the arthroscopic findings ($P < 0.0001$). However, by separately

analyzing each of the four tests, we achieved the following diagnostic agreement values: Anterior Dislocation Test at 20 pounds: 38.8%; Anterior Dislocation Test at 30 pounds: 94.4%; Quadriceps Active Dislocation Test: 88.8%; and, Maximum Manual Anterior Dislocation Test: 100%.

DISCUSSION

In our study, we noticed that the 36 patients (group 1 and group 2, with 18 patients each), submitted to arthroscopic procedure, presented the following correlations among the arthroscopic, MR and knee arthrometry findings.

The evaluation by magnetic resonance in Group 1 was able to correctly diagnose the ACL injury in 17 patients (94.4%), with only one patient being not diagnosed due to the absence of image suggesting the injury; however, this patient showed arthrometric values indicating ACL injury (dislocation difference between knees > 3 mm). During the arthroscopic procedure subsequently performed, the full ACL injury could be verified, characterizing a diagnostic accuracy of 100% (18) for the arthrometry performed in Group 1. Other study has also demonstrated a little accuracy advantage of knee arthrometry compared to knee MR. Liu et al.⁽¹⁾ assessed 38 patients with total ACL rupture, arthroscopically confirmed, presenting an accuracy of 97% for arthrometry compared to 82% of the MR.

In group 2, the evaluation by magnetic resonance presented a diagnostic accuracy of 100% compared to subsequent arthroscopic findings.

In our study, considering that a positive result in only one of the four tests performed with the arthrometer determined the existence of ACL injury, we had a diagnostic accuracy of 100% for both groups assessed. However, this accuracy suffered a variation among the four tests performed, being necessary to separately discuss each of these tests:



Figure 1 - KT1000™ Test

ANTERIOR DISLOCATION TEST WITH 20 POUNDS

The Anterior Dislocation Test with 20 pounds presented, as compared to arthroscopic data, only 38.89% agreement on the evaluation of both groups.

Many authors have also noted in their studies with the 20-pound test a low sensitiveness in detecting the ACL injury. Among those studies, we can highlight the one by Strand and Solheim⁽²⁾, in which, after the arthrometric evaluation of 42 patients with total ACL rupture, confirmed by arthroscopy, an accuracy of 88% with the Maximum

Manual Test was achieved, compared to only 23.8% with the Anterior Dislocation Test with 20 pounds.

Dahlstedt and Dalén⁽³⁾ reported a sensitiveness of 56% with the 20-pound Test, adopting as a parameter dislocations > 3 mm as suggestive of ACL injury.

Highgenboten et al.⁽⁴⁾ achieved 64% of accuracy in acute phase and 72% in chronic phase, using the Anterior Dislocation Test with 20 pounds.

Strand and Solheim⁽²⁾ noted in their study a sensitiveness of 59.5% in perceiving ACL injuries by using the Anterior Dislocation Test with 20 pounds.

Other studies presented more exciting values regarding the 20-

pound test; Daniel⁽⁵⁾ evaluated 105 patients with acute rupture and 159 patients with ACL chronic rupture, being the arthrometric evaluations performed under anesthesia and without anesthesia. On the evaluations of acute-phase patients without anesthesia, values above normal levels (3mm or +) were seen in only 66% of the cases; but, when they were evaluated patients under anesthesia, this value increased to 72%. Regarding the arthrometric evaluations of patients with chronic ACL ruptures, only 85% of patients presented values above normal levels when tested without anesthesia, and, when tested under anesthesia, the number was 87%. In another study, Daniel et al.⁽⁶⁾ evaluated 53 patients without anesthesia, which were previously submitted to arthroscopy and diagnosed with total ACL rupture, in which the Anterior Dislocation Test with 20 pounds revealed a value indicating injury in 62% of the patients. In that same study, Daniel et al.⁽⁶⁾, during evaluations in 25 patients with total ACL rupture, under anesthesia, observed that the Anterior Dislocation Test with 20 pounds demonstrated an abnormal dislocation in 84% of the cases. Anderson and Lipscomb⁽⁷⁾ reported in their study a sensitiveness of 75% using the Anterior Dislocation Test with 20 pounds.

Although many studies present different values from each other, the majority of the studies demonstrate a low sensitiveness of the 20-pound test in detecting acute and chronic ACL injuries.

Daniel⁽⁶⁾ states that instrumented dislocations may be affected by the contraction of muscles crossing the knee joint. This might explain the low percentage of accuracy in evaluations using the Anterior Dislocation Test with 20 pounds, because patients may present difficulty to reach an ideal muscular relaxation to perform the test, actively masking the positive results of a pathologic anterior dislocation.

According to Daniel et al.⁽⁶⁾, in some patients, specifically those having acute injuries or those with a very hypertrophied musculature, the application of a stronger force for the test is required to obtain the exposure of a pathologic "drawer".

ANTERIOR DISLOCATION TEST WITH 30 POUNDS

In our evaluations with the Anterior Dislocation Test with 30 pounds in 18 patients submitted to arthroscopic procedures, the achieved result was 66.6% (12 patients) of accuracy for Group 1 (patients evaluated up to four weeks after the trauma episode), with this percentage increasing to 94.4% in patients from Group 2 (patients evaluated more than four weeks after the trauma episode). Highgenboten et al.⁽⁴⁾, in a study performed with the KT1000™, in which 68 patients were evaluated, proving the ACL injury, reported that the accuracy of the Anterior Dislocation Test with 30 pounds was 81% for acute-phase patients, and 83% for chronic-phase patients.

The Anterior Dislocation Test with 30 pounds in our study presented an increase in accuracy both for Group 1 and for Group 2 when compared to the 20-pound test. This increase is probably due to the fact of the addition of 10 pounds to traction forces, which helps on the tibial anterior transfer against thigh muscles retraction resistance.

QUADRICEPS ACTIVE CONTRACTION TEST

In our findings during evaluations with the Quadriceps Active Contraction Test, we saw an accuracy of 61.11% (11 cases) for Group 1, and 88.89% (16 cases) for Group 2. Other studies have also demonstrated significant differences among evaluations in initial phases after injury episode and in later phases, when the Quadriceps Active Contraction Test was applied. Among those studies, the one presenting the most significant difference was that of Daniel et al.⁽⁶⁾, which, with the objective of evaluating the

sensitiveness of the Electronic Arthrometer KT1000™ with the Quadriceps Active Contraction Test, evidenced 24% of accuracy in 105 patients presenting with acute ACL rupture, confirmed by arthroscopy, increasing this percentage to 72% in 159 patients with chronic injuries.

In our opinion, the significantly worse results of patients in acute phase are due to the fact that those patients presented with pain during the Quadriceps Active Contraction, which consequently resulted in the restraint of motor units recruiting, making the anterior dislocation force insufficient to overcome muscle retraction and to produce a pathologic "drawer".

Another variant also complicating the evaluation of patients in early phases after the injury is the intra-articular edema. Wright and Luhmann⁽⁹⁾ reported in their study that values ≥ 70 ml of intra-articular effusion promoted patellar instability at the femoral trochlea, which is characterized as a problem for arthrometry, since one of the dislocation sensors of the arthrometer must be steadily positioned on the patella.

MAXIMUM MANUAL TRACTION TEST

Regarding the Maximum Manual Traction Test, Daniel et al.⁽⁸⁾, in a study aiming to demonstrate the anterior dislocation in knee's acute injuries, reported that when 33 patients with total ACL injuries without anesthesia, and confirmed by arthroscopy, were evaluated, this test determined a percentage of 91% of patients as abnormal and 9% as normal. In that same study, the Maximum Manual Dislocation Test was performed under anesthesia in 25 patients with total ACL rupture, with all of them presenting a dislocation considered as abnormal.

In another study, Daniel et al.⁽⁹⁾, reported that the Maximum Manual Dislocation test, when applied on 105 patients determined by arthroscopy as having acute ACL rupture, and evaluated without anesthesia, presented with compatible positive values in 95 % of the cases, with accuracy increasing to 97 % when this evaluation was performed under the effect of anesthesia. Strand and Solheim⁽²⁾ reported that this test reaches magnitude at 150N - 200N. This magnitude is able to promote anteroposterior dislocations in the knee even in the presence of retractions protecting knee's stabilizing muscles.

Liu et al.⁽¹⁾ reported, after an evaluation of 38 patients with acute ACL injuries, that the sensitiveness of the Maximum Manual test was 97 %, considering dislocations above 3 mm as indicative of injury.

Strand and Solheim⁽²⁾, after the evaluation of 42 patients in whom acute ACL injuries were suspected, concluded that the Maximum Manual Traction Test was able to diagnose 37 of the 42 cases of ACL rupture (88 %), a much better performance compared to the 20-pound test, which was able to close a diagnosis in 10 among 42 patients (23.8%).

In our study, the Maximum Manual test demonstrated an accuracy of 100% in diagnosing ACL injury both for Group 1 (assessed within up to four weeks after the trauma episode) and for Group 2 (assessed within more than four weeks after the trauma episode), proving itself as the most efficient of the four tests applied with the arthrometer KT-1000™. Another relevant datum in our study is the fact that evaluations were performed in knees presenting injuries related to ACL rupture; however, as demonstrated during the discussion, the presence of those related injuries did not affect the diagnostic accuracy of arthrometry, which was able to diagnose the ACL injury in 100% of the cases in both groups.

There is a vast number of studies on the sensitiveness of KT1000™ test in international literature; however, somehow they agree with the conclusion by Liu et al.⁽¹⁾, that the sensitiveness of the test with the KT1000™ presents an increase directly proportional to

the force applied during the evaluation, because stronger tibial anterior dislocation forces are more efficient in overcoming the resistance imposed by thigh muscles retraction.

CONCLUSIONS

The arthrometric evaluation of the knee performed by an Electronic Arthrometer KT1000™ is an efficient method for diagnosing Anterior Cruciate Ligament injuries.

The arthrometric diagnosis of ACL injuries is as efficient as

evaluation by magnetic resonance, especially in cases of acute injuries.

The diagnostic accuracy of ACL injuries by arthrometry does not seem to be affected by the presence of injuries related to ACL rupture.

The diagnostic accuracy of the evaluation by electronic arthrometer KT-1000™ is directly proportional to the test application forces, as well as to the ability of the evaluator in achieving the highest level of relaxation as possible from the patient during the assessment.

REFERENCES

1. Liu SH, Osti L, Henry M, Bocchi L. The diagnosis of a cute complete tears of the anterior cruciate ligament: comparison of MRI, the anterior cruciate ligament. *J Bone Joint Surg Br* 1995; 77:586 -8.
2. Strand T, Solheim E. Clinical Tests versus KT1000 instrumented laxity test in acute anterior cruciate ligament tears. *Int J Sports Med* 1995; 16:51-5.
3. Dahlted LJ, Dalén N. Knee laxity in cruciate ligament injury. *Acta Orthop Scand* 1989; 60:181-4.
4. Highgenboten CL, Jackson AW, Jansson KA, Meske NB. KT1000 arthrometer: conscious and unconscious test results using 15, 20, and 30 pound of force. *Am J Sports Med* 1992; 20: 450-4.
5. Daniel MD. Reference, Maintenance & User`s guide for the knee ligament arthrometer. San Diego: MEDmetric , 1993.
6. Daniel DM, Malcom LL, Losse G, Stone ML, Sachs R, Burks R. Instrumented measurement of anterior laxity of the knee. *J Bone Joint Surg Am* 1985; 67: 720-5.
7. Anderson AF, Lipscomb AB. Prooperative instrumented testing of anterior and posterior knee laxity. *Am J Sports Med* 1989; 17: 387-92.
8. Daniel DM, Stone ML, Sachs R, Malcom L. Instrumented measurement of anterior knee laxity in patients with acute anterior cruciate ligament disruption. *Am J Sports Med* 1985; 13: 401-7.
9. Wright RW, Luhmann SJ. The effect of knee effusion on KT-1000 arthrometry. A cadaver study. *Am J Sports Med* 1998; 26: 571-4.