Orthopaedics & Traumatology: Surgery & Research (2013) 99, S297—S300

Available online at
SciVerse ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com/en

ORIGINAL ARTICLE

Anterior knee laxity measurement using stress radiographs and the GNRB® system versus intraoperative navigation

J.-Y. Jenny*, J. Arndt, Computer Assisted Orthopaedic Surgery-France (CAOS)[1]

Centre de chirurgie orthopédique et de la main, hôpitaux universitaires de Strasbourg, Strasbourg, France

Accepted: 13 April 2013

KEYWORDS
Anterior cruciate ligament;
Laxity;
Instrumented measurement;
GNRB®;
Navigation

Summary
Background: Anterior knee laxity measurement serves both to diagnose and to evaluate the severity of anterior cruciate ligament (ACL) damage.
Hypothesis: We tested the hypothesis that anterior laxity measurements of ACL-deficient knees obtained using the GNRB® system and stress radiographs differed from each other and from intraoperative navigation measurement taken as the reference standard.
Material and methods: Twenty-one patients with chronic ACL deficiency underwent arthroscopic ACL reconstruction. Anterior knee laxity was measured preoperatively using the GNRB® system without anaesthesia and anterior-drawer stress radiographs under anaesthesia then intraoperatively using a non-image-based navigation system.
Results: The three measurements differed significantly ($P = 0.05$). A systematic measurement error of −3.7 mm occurred for both preoperative measurements versus the reference standard. No significant difference was found between the two preoperative measurements.
Discussion: The GNRB® system should be preferred over stress radiographs, as reliability is similar but no radiation exposure is required. Both preoperative measurement methods underestimate anterior laxity as measured intraoperatively using the navigation system. This systematic bias may be relevant to treatment decision-making.
Level of evidence: II, development of a diagnostic criterion in consecutive patients versus a validated reference standard.

* Corresponding author. Tel.: +33 3 88 55 21 45; fax: +33 3 88 55 23 57.
E-mail address: jean-yves.jenny@chru-strasbourg.fr (J.-Y. Jenny).
[1] 56, rue Boissonade, 75014 Paris, France.

1877-0568/$ – see front matter © 2013 Elsevier Masson SAS. All rights reserved.
http://dx.doi.org/10.1016/j.otsr.2013.07.008

Introduction

Anterior knee laxity measurement serves both to diagnose and to evaluate the severity of anterior cruciate ligament (ACL) lesions [1,2]. Physical manoeuvres have been proven highly reliable for diagnosing ACL deficiency but perform poorly in quantifying the degree of knee laxity [3]. Instrumented measurements based on stress radiographs or the KT-1000 arthrometer are widely used despite evidence that their reliability may fail to meet expectations [4,5]. The GNRB® system (GeNouRoB, Laval, France) [6] was developed to improve the accuracy and reproducibility of anterior knee laxity measurements [6]. Initial validation studies performed by its designers [6] and by an independent group [7] have produced promising results. However, these studies compared two conventional techniques to each another without using a third method as a reference standard.

Navigation systems have been validated as instruments for anterior knee laxity measurement, although they are rarely used for this purpose in everyday practice [8,9]. The well-documented accuracy and reproducibility of navigation systems support their use as the reference standard against which other methods can be compared.

Our working hypothesis was that anterior knee laxity measurements of ACL-deficient knees obtained using the GNRB® system and stress radiographs differed from each other and from the reference standard consisting in intraoperative measurement using a navigation system.

Material and methods

Patients

We studied 21 patients, 14 men and seven women with a mean age of 28 years, with a diagnosis of chronic ACL deficiency based on conventional manoeuvres (Lachman test and Jerk test) with or without magnetic resonance imaging. All 21 patients underwent arthroscopic ACL reconstruction.

Measurements

Anterior knee laxity was measured immediately before the procedure and anaesthesia using the GNRB® system [6] with the knee in 25° of flexion and an anterior traction load of 250 N calibrated by the system. Then, after anaesthesia induction but before the reconstruction procedure, anterior-drawer stress radiographs were obtained using a protocol similar to that described by Lerat et al. [3], with the knee in 25° of flexion and a 250-N anterior traction load calibrated using the KT2000® arthrometre (Medmetric, San Diego, CA, USA) [10]. Finally, anterior knee laxity was measured intraoperatively, before ACL reconstruction, using the OrthoPilot® navigation system (Aesculap, Tuttlingen, Germany) with the knee in 25° of flexion and maximal uncalibrated manual traction.

Statistical analysis

Laxity values in millimetres were described as mean ± SD and range. The values obtained using the three techniques were compared using the Friedman test with a 5% significance threshold.

GNRB® and stress radiograph values were compared to navigation system values using the Wilcoxon test for paired data and Spearman's correlation test with a 5% significance threshold. Agreement between pairs of values was assessed as described by Bland and Altman. Agreement was considered satisfactory when the correlation between the mean value and the difference between paired values was poor ($R^2 < 0.4$).

Table 1 Measured values of anterior knee laxity, in mm.

	Mean	SD	Minimum	Maximum
GNRB®	8.6	2.8	5	17
Stress radiographs	8.6	3.6	3	17
Navigation	12.3	4.1	5	22

Results

Table 1 reports the results. A significant difference was found among the anterior laxity values obtained using the three methods ($P = 0.05$).

The values obtained using the GNRB® and the navigation system differed significantly from each other ($P = 0.007$). No significant correlation was found between the two values ($R = -0.04$). Agreement between the two values was satisfactory ($R^2 = 0.12$) with a systematic measurement bias of −3.7 mm for the GNRB® values.

The stress radiograph values also differed significantly from the values obtained using the navigation system ($P = 0.01$). There was no significant correlation between the two values ($R = -0.12$). Satisfactory agreement between the two values was noted ($R^2 = 0.02$) with a systematic measurement bias of −3.7 mm for the stress radiograph values.

No significant difference was found between the GNRB® values obtained before anaesthesia and the stress radiograph values obtained under anaesthesia. These two values were not significantly correlated with each other ($R = 0.37$). Agreement between the two values was satisfactory ($R^2 = 0.06$) with a systematic measurement bias close to 0.

Discussion

Our first hypothesis was refuted: no significance difference was found between anterior laxity of ACL-deficient knees measured using the GNRB® system and stress radiographs. Our second hypothesis was confirmed: both the GNRB® and the stress radiograph measurements differed from the intraoperative navigation system value chosen as the reference standard.

Accurate anterior laxity measurement is crucial in ACL reconstruction, both to select the best technique and to evaluate the quality of the result. Pre- and postoperative anterior laxity measurements are usually obtained using either instrumented techniques, such as the KT-1000 [10] or Rolimeter [11], or radiographic techniques [12]. However, the accuracy of these methods has been challenged

[4,5]. Previously published studies suggest that the GNRB® system may significantly improve the accuracy and reproducibility of anterior laxity measurement in ACL-deficient knees [6,7,13].

The navigation system used in our study has been well validated both as an aid to ACL reconstruction [14], and as a tool for measuring anterior laxity [15—17]. It therefore appears as a good reference standard for validating more conventional measurement tools such as the GNRB® system.

In our study, the two conventional measurement techniques (GNRB® and stress radiography) produced similar preoperative anterior laxity values in a given patient. However, overall, these two methods underestimated laxity as measured intraoperatively using the navigation system before ACL reconstruction. The systematic measurement bias was nearly −4 mm, i.e., a decrease of about one-third.

In our study, stress radiography and the GNRB® system were not different in terms of accuracy in measuring preoperative anterior laxity. Therefore, if accuracy is the only point of interest, the choice between the two methods is a matter of schools of thought or individual practice patterns. However, GNRB® measurement does not require radiation exposure and can therefore be used as often as desired without putting the patient at risk [13]. GNRB® would consequently seem to deserve preference as a method for anterior knee laxity measurement before ACL reconstruction, although purchasing the device represents a substantial investment.

Our study has several limitations. The sample size is fairly small, and different results would perhaps have been obtained in a larger sample. However, the use of each patient as his or her own control increased the power of the study despite the limited number of patients. The GNRB® measurements were obtained in the awake patients and the stress radiograph and navigation system measurements under anaesthesia. Hamstring muscle contraction in the awake state but not under anaesthesia is a potential source of significant bias. However, use of the GNRB® system in the operating room after anaesthesia induction was not consistent with good aseptic practice. The absence of a significant difference between the GNRB® values obtained before anaesthesia and the stress radiograph values obtained under anaesthesia with identical calibrated traction loads argues strongly against substantial bias related to variations in hamstring contraction. Absence of calibration of the navigation system measurement may have noticeably biased the comparisons with the GNRB® and stress radiograph measurements. Parasitic rotational laxity, which is not measured by the GNRB® system [17,18], may affect the projections of the measurement points. Finally, with all measurement methods, uncertainty exists regarding the reference position in the absence of anterior traction. This reference position may differ between GNRB® measurement performed in the awake state and stress radiograph or navigation system measurements performed under anaesthesia.

Despite these limitations, our study seems to allow a number of valid conclusions:

- the GNRB® system is as reliable as stress radiography but involves no radiation exposure to the patient and therefore deserves preference;
- preoperative measurements using the GNRB® system or stress radiography may underestimate the actual degree of anterior laxity as measured intraoperatively using the navigation system. This systematic measurement bias should be taken into account when making treatment decisions.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References

[1] Bach Jr BR, Warren RF, Flynn WM, Kroll M, Wickiewiecz TL. Arthrometric evaluation of knees that have a torn anterior cruciate ligament. J Bone Joint Surg Am 1990;72:1299—306.
[2] Zaffagnini S, Bignozzi S, Martelli S, Lopomo N, Marcacci M. Does ACL reconstruction restore knee stability in combined lesions? An in vivo study. Clin Orthop 2006;454:95—9.
[3] Lerat JL, Moyen BL, Cladière F, Besse JL, Abidi H. Knee instability after injury to the anterior cruciate ligament. Quantification of the Lachman test. J Bone Joint Surg Br 2000;82:42—7.
[4] Boyer P, Djian P, Christel P, Paoletti X, Degeorges R. [Reliability of the KT-1000 arthrometer (Medmetric) for measuring anterior knee laxity: comparison with Telos in 147 knees]. Rev Chir Orthop 2004;90:757—64 [In French].
[5] Wiertsema SH, van Hooff HJ, Migchelsen LA, Steultjens MP. Reliability of the KT1000 arthrometer and the Lachman test in patients with an ACL rupture. Knee 2008;15:107—10.
[6] Robert H, Nouveau S, Gageot S, Gagnière B. A new knee arthrometer, the GNRB: experience in ACL complete and partial tears. Orthop Traumatol Surg Res 2009;95:171—6.
[7] Collette M, Courville J, Forton M, Gagnière B. Objective evaluation of anterior knee laxity; comparison of the KT-1000 and GNRB® arthrometers. Knee Surg Sports Traumatol Arthrosc 2012;20:2233—8.
[8] Lopomo N, Bignozzi S, Martelli S, Zaffagnini S, Iacono F, Visani A, et al. Reliability of a navigation system for intraoperative evaluation of antero-posterior knee joint laxity. Comput Biol Med 2009;39:280—5.
[9] Colombet P, Robinson J, Christel P, Franceschi JP, Djian P. Using navigation to measure rotation kinematics during ACL reconstruction. Clin Orthop Relat Res 2007;454:59—65.
[10] Daniel DM, Stone ML, Sachs R, Malcom L. Instrumented measurements of anterior knee laxity in patients with acute anterior cruciate ligament disruption. Am J Sports Med 1985;13:401—7.
[11] Hatcher J, Hatcher A, Arbuthnot J, McNicholas M. An investigation to examine the inter-tester and intra-tester reliability of the Rolimeter knee tester, and its sensitivity in identifying knee joint laxity. J Orthop Res 2005;23:1399—403.
[12] Jardin C, Chantelot C, Migaud H, Gougeon F, Debroucker MJ, Duquennoy A. [Reliability of the KT-1000 arthrometer in measuring anterior laxity of the knee: comparative analysis with Telos of 48 reconstructions of the anterior cruciate ligament and intra- and interobserver reproducibility]. Rev Chir Orthop 1999;85:698—707 [In French].
[13] Beldame J, Mouchel S, Bertiaux S, Adam JM, Mouilhade F, Roussignol X, et al. Anterior knee laxity measurement: comparison of passive stress radiographs Telos(®) and ''Lerat'', and GNRB(®) arthrometer. Orthop Traumatol Surg Res 2012;98:744—50.

[14] Hart R, Krejzla J, Sváb P, Kocis J, Stipcák V. Outcomes after conventional versus computer-navigated anterior cruciate ligament reconstruction. Arthroscopy 2008;24:569—78.
[15] Song EK, Seon JK, Park SJ, Hur CI, Lee DS. In vivo laxity of stable versus anterior cruciate ligament-injured knees using a navigation system: a comparative study. Knee Surg Sports Traumatol Arthrosc 2009;17:941—5.
[16] Monaco E, Labianca L, Maestri B, De Carli A, Conteduca F, Ferretti A. Instrumented measurements of knee laxity: KT-1000 versus navigation. Knee Surg Sports Traumatol Arthrosc 2009;17:617—21.
[17] Jenny JY. Navigation system measures AP and rotational knee laxity in ACL replacement. Orthopedics 2009;32(Suppl. 10): 31—4.
[18] Zaffagnini S, Bignozzi S, Martelli S, Imakiire N, Lopomo N, Marcacci M. New intraoperative protocol for kinematic evaluation of ACL reconstruction: preliminary results. Knee Surg Sports Traumatol Arthrosc 2006;14:811—6.