Knee Surg Sports Traumatol Arthrosc
DOI 10.1007/s00167-013-2384-4

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Validity of GNRB® arthrometer compared to Telos™ in the assessment of partial anterior cruciate ligament tears

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Received: 10 October 2012 / Accepted: 4 January 2013

Abstract
Purpose The main goal of this study was to compare the results of the GNRB® arthrometer to those of Telos™ in the diagnosis of partial thickness tears of the anterior cruciate ligament (ACL).
Methods A prospective study performed January–December 2011 included all patients presenting with a partial or full-thickness ACL tears without ACL reconstruction and with a healthy contralateral knee. Anterior laxity was measured in all patients by the Telos™ and GNRB® devices. This series included 139 patients, mean age 30.7 ± 9.3 years. Arthroscopic reconstruction was performed in 109 patients, 97 for complete tears and 12 single bundle reconstructions for partial thickness tears. Conservative treatment was proposed in 30 patients with a partial thickness tear. The correlation between the two devices was evaluated by the Spearman coefficient. The optimal laxity thresholds were determined with ROC curves, and the diagnostic value of the tests was assessed by the area under the curve (AUC).
Results The differential laxities of full and partial thickness tears were significantly different with the two tests. The correlation between the results of laxity measurement with the two devices was fair, with the strongest correlation between Telos™ 250 N and GNRB® 250 N ($r = 0.46$, $p = 0.00001$). Evaluation of the AUC showed that the informative value of all tests was fair with the best results with the GNRB® 250 N: AUC = 0.89 [95 % CI 0.83–0.94]. The optimal differential laxity threshold with the GNRB® 250 N was 2.5 mm (Se = 84 %, Sp = 81 %).
Conclusion The diagnostic value of GNRB® was better than Telos™ for ACL partial thickness tears.
Level of evidence Diagnostic study, Level II.

Keywords GNRB® · Anterior cruciate ligament · Knee laxity

Introduction

Diagnosis of ACL tears is clinical. The meta-analysis by Solomon et al. [24] has shown that the Lachman test is the most reliable diagnostic test, followed by the anterior drawer test and then the pivot shift test. Nevertheless, objective quantification of anterior tibial translation is a decisional aid for surgeons, both during initial management of the patient and during follow-up [7]. Preoperative differential laxity also helps identify a partial or full-thickness tear. In the presence of a partial thickness tear, the therapeutic value is certain, because conservative treatment can be considered with good long-term results [3, 4, 8].

Several arthrometers are available [1]. The KT-1000™ (MEDmetric®, San Diego, USA) [11] is the most frequently used device at present, because it is simple to use. The Rolimeter™ (Aircast, Summit, USA) is as reliable as the KT-1000™ [13, 23], but both are operator-dependent [6, 14, 18, 20]. The radiological Telos™ stress device (Gmbh, Hungen/Obbornhafen, Germany) seems to be more precise than the KT-1000™ [15]. However, this system is

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Published online: 22 January 2013

expensive and results in radiation exposure even if it is extensively used for preoperative assessment in Europe [10]. The GNRB® system (Genourob, Laval, France), which recently became available, has better reproducibility than the KT-1000™ whatever the operator's experience [9, 22] and non-irradiating device unlike Lerat or Telos™ stress radiographs [5].

The pathological differential laxity thresholds in the literature are 3 mm for the KT-1000™ [2, 11], 3 mm for the GNRB® [22] and 5 mm for Telos™ [25]. Moreover, for Robert et al. [22], the threshold value with GNRB®134 N was 1.5 mm for ACL partial thickness tears with a sensitivity of 80 % and a specificity of 87 %. In our knowledge, no study has compared diagnostic accuracy of GNRB® and Telos™ stress radiographs in partial ACL tears.

The main goal of this study was to compare the diagnostic values of GNRB® and Telos™ for ACL partial thickness tears. The hypothesis of this study was that the diagnostic value of GNRB® was better than that of Telos™.

Materials and methods

A prospective study was performed from January to December 2011 in a Sports Surgery Unit. A local ethics committee approved this study.

Exclusion and inclusion criteria

Inclusion criteria were partial or full-thickness tears of the ACL with a healthy contralateral knee. Exclusion criteria were surgically treated prior tears, pluriligament damage and patient refusal to participate in the study. Diagnosis of the tear was clinical, confirmed by MRI and laxity measurement. Conservative treatment was indicated in case of a partial thickness tear without pain or instability according to the patient, an ACL which appeared to have healed on MRI, and laxity of less than 5 mm with the Telos™ device and/or less than 3 mm with GNRB®. In surgically treated patients, the tear was defined as partial in case of a tear of one of the bundles on visual inspection and a remaining ligament which was still taut, or total if there was a complete tear and/or the ligament was lax and visibly non-functional.

Laxity measurement protocol

Each patient underwent measurement of anterior laxity of the knee by the Telos™ stress device and the GNRB® device either on the same day or few days apart.

GeNouRoB (GNRB®)

The patient was lying in the decubitus dorsal position on the examining table with the knee at 20° of flexion and 0° rotation. The knees were compared and the healthy knee was examined first. An electric pressure pad was placed on the upper calf and a pressure load of 134 N then 250 N was applied. A physical therapist with 2 years experience in laxity measurement with the GNRB® manipulated the device and installed the patient. Data were collected on a computer and three automatic measurements were obtained for each pressure load, and the mean of the three was recorded. The curves obtained for each knee (anterior tibial translation mm/pressure load in Newtons) (Fig. 1) provided an automatic calculation of differential laxity on one hand as well as the differential of the slope of the curves, which reflects ligament elasticity [22].

Telos™

The patient was lying on a radiolucent table with the knee in 20° flexion in the lateral decubitus position to be evaluated on the injured and then the healthy side. A pressure load of 150 N and then 250 N was applied to the proximal posterior thigh. A stress radiograph was obtained in this position. Measurement of differential laxity was based on the anatomical references described by Staubli et al. [25], obtained first by a trained radiology technician and then by the radiologist in the study who had more than 10 years experience with the device. In case of disagreement between the two measurements, a third measurement was obtained.

Patients

During this period, 139 patients corresponded to criteria for inclusion in the study; 86 men and 53 women, mean age 30.7 ± 9.3 years. Most injuries occurred while practicing sports, usually soccer (29.5 %) and skiing (29.5 %). Most patients practiced leisure sports (71 %), 26 % practiced competitive sports and 3 % professional sports. The MRI was performed after a median of 20 days (1–1,588). Laxity measurements were performed with both devices, usually the same day. Arthroscopic reconstruction was performed in 109 patients, 97 ligament reconstructions for complete tears and 12 single bundle reconstructions including 9 anteromedial and 3 posterolateral for a partial thickness tear. Conservative management was proposed to 30 patients with partial thickness tears.

Statistical analysis

Normal distribution was tested by the Shapiro–Wilk test. If the distribution was normal, the parametric Student's *t* test

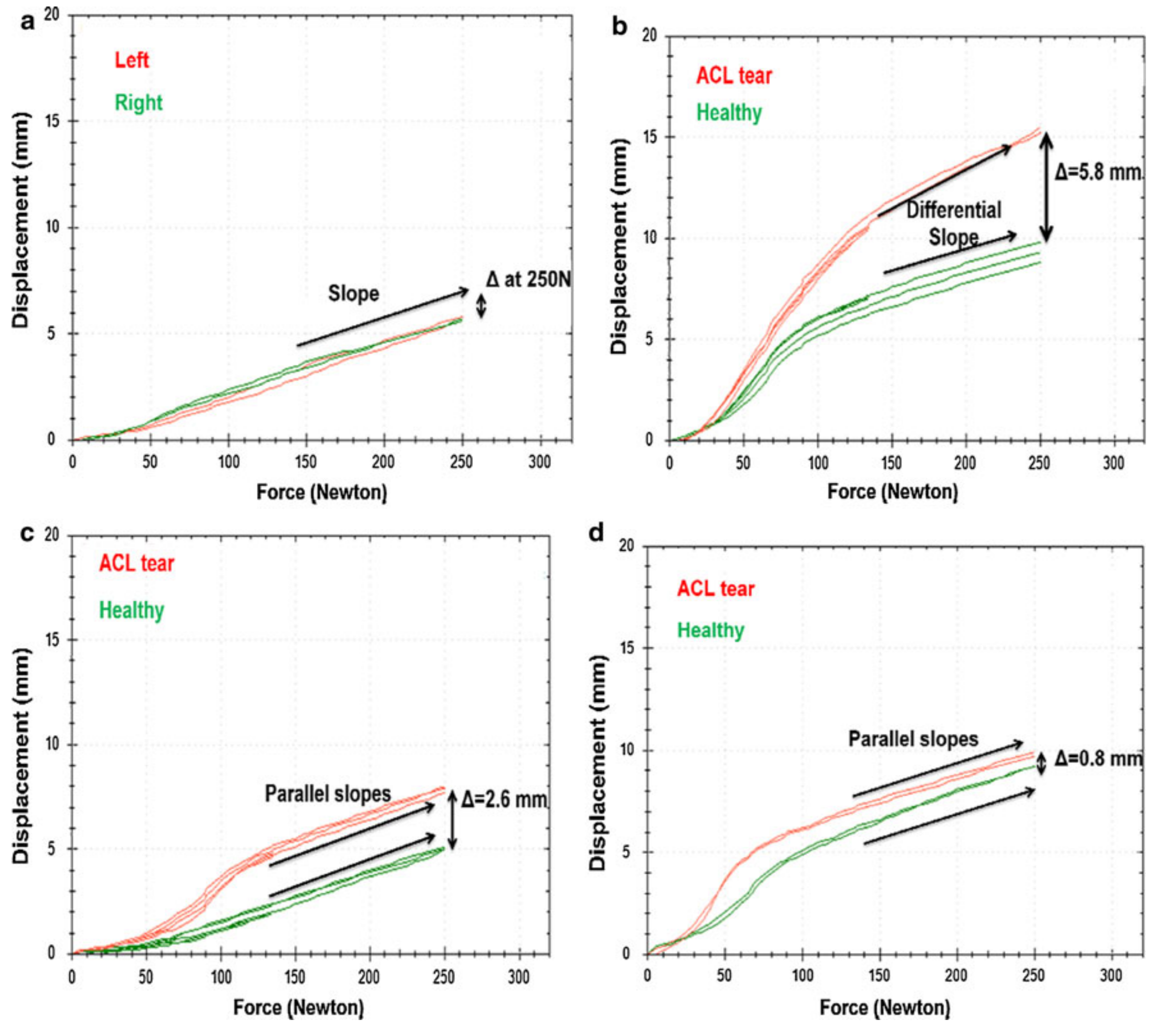

Fig. 1 GNRB® curves: Δ : Differential laxity. **a** Normal knee; **b** complete tear; **c** partial tear with parallel slopes and differential laxity of 2.6 mm; **d** partial tear with parallel slopes and differential laxity of 0.8 mm in no operated patient

was used for quantitative variables. Otherwise, the nonparametric Mann–Whitney test was used. The correlation between the two devices was evaluated by Spearman's correlation coefficient. The optimal laxity threshold values with the two tests and the slopes with the GNRB® were determined with the ROC (receiver operating characteristic) with sensitivity on the x-axis and specificity on the y axis. This threshold value was chosen to obtain the highest sensitivity (Se) and specificity (Sp) possible with the best proportion of correctly classified subjects. The diagnostic value of the tests was evaluated by the area under the curve (AUC) of ROC: null (AUC $= 0.5$), poorly informative ($0.5 < \text{AUC} < 0.7$), fairly informative ($0.7 \leq \text{AUC} < 0.9$), highly informative ($0.9 \leq \text{AUC} < 1$), perfect (AUC $= 1$) [26]. $p < 0.05$ was considered to be statistically significant.

Results

There was a highly significant difference between the differential laxity of complete and partial thickness tears with the two devices whatever the loading pressure applied

Table 1 Differential laxity between the two test devices and the slope differentials of the GNRB®

	Telos™ 150 N (mm)	Telos™ 250 N (mm)	GNRB® 134 N (mm)	GNRB® 250 N (mm)	Slope (mm/N)
Partial tear	2.7 ± 1.9	3 ± 1.8	1.6 ± 1.1	1.7 ± 1.2	2.9 ± 2.3
Complete tear	5.1 ± 3.4	6.8 ± 3.6	3.5 ± 1.9	4.5 ± 2.2	10.8 ± 8.1
p value	0.0002	0.00001	0.00001	0.00001	0.00001

(Table 1). The differential slopes of the GNRB® were also significantly different by depending upon the type of tear (Table 1).

Table 2 Correlation between the two methods of measurement

	Telos™ 150 N/ GNRB® 134 N	Telos™ 250 N/ GNRB® 250 N
Correlation coefficient	0.37	0.46
p value	0.0001	0.00001

The correlation between the two methods of measurement was fair and was better between the Telos™ 250 N and the GNRB® 250 N (Table 2).

The differential laxity threshold values retained with the ROC (Fig. 2) for the diagnosis of full-thickness tears was 4 mm (Se = 62.3 %, Sp = 73.7 %, correctly classified subjects 66.1 %) with Telos™150 N, 3.6 mm (Se = 81.5 %, Sp = 59.5 %, correctly classified subjects 74.6 %) with Telos™ 250 N, 2 mm (Se = 83.2 %, Sp = 64.3 %, correctly classified subjects 77.4 %) with GNRB® 134 N and 2.5 mm (Se = 84 %, Sp = 81 %, correctly classified

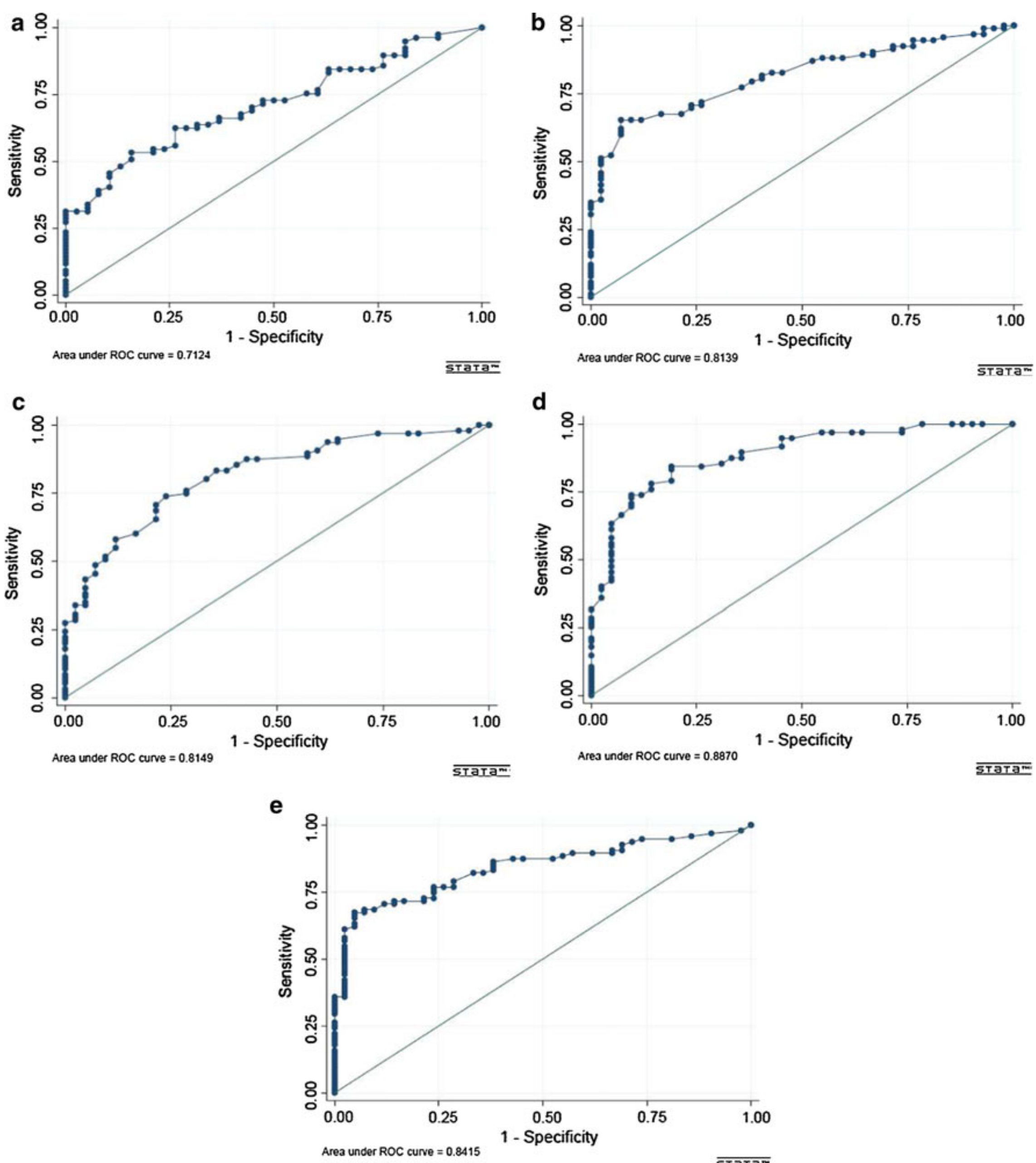

Fig. 2 ROC curves. **a** Telos™ 150 N; **b** Telos™ 250 N; **c** GNRB® 134 N; **d** GNRB® 250 N; **e** slope on GNRB®

Table 3 Area under the curve (AUC) values by laxity measurement and pressure loads applied

Telos™ 150 N	Telos™ 250 N	GNRB® 134 N	GNRB® 250 N	Slope GNRB®
0.71 [95 % CI 0.62–0.80]	0.81 [95 % CI 0.74–0.88]	0.81 [95 % CI 0.74–0.89]	0.89 [95 % CI 0.83–0.94]	0.84 [95 % CI 0.78–0.90]

subjects 83.2 %) with GNRB® 250 N. The best results were obtained with GNRB® 250 N. The threshold value for the slope differentials between results on the healthy and the torn sides was 2.7 mm/N (Se = 86.3 %, Sp = 61.9 %, well classified subjects 78.8 %).

The analysis of the different AUC (Table 3) showed that the tests were all fairly informative with nevertheless, better results with the GNRB® 250 N and the slope differentials.

Discussion

The most important result of this study was that the diagnostic value of GNRB® 250 N was better than Telos™ for the diagnosis of partial ACL tears.

The correlation between Telos™ 250 N and GNRB® 250 N was fair and highly significant. The study by Jardin et al. [16] did not find any correlation between the Telos™ 150 N and the KT-1000™ results after a minimum follow-up of 1 year in a population of 48 patients who underwent surgery.

The differential laxity threshold in this study for GNRB® at 250 N was 2.5 mm with a sensitivity of 84 % and a specificity of 81 %, which allowed correct classification of more than 83 % of patients.

For Robert et al. [22], the differential laxity threshold for GNRB® at 134 N in a group of 24 partial thickness ACL tears was 1.5 mm with a sensitivity of 80 % and a specificity of 87 % and allowing correct classification of 81 % of the patients. These parameters are comparable in relation to the pressure load.

GNRB® designers have emphasized the importance of analysing the slope differentials to evaluate ligament elasticity [22]. In the present study, the slope differentials between the group of partial and complete tears were significantly different. At a threshold of 2.7 mm/N, the sensitivity of the slope differential was more than 86 % with nearly 79 % of correctly classified subjects.

This study also shows a differential laxity threshold for partial ACL tears with the Telos™ device. With a pressure load of 250 N, the threshold was 3.6 mm with good sensitivity (81.5 %) but only fair specificity (59.5 %), which increases the risk of false positives. The study by Osawha et al. [19] showed a mean preoperative differential laxity of 6 ± 2.3 mm with Telos™130 N in case of an anteromedial bundle tear and 4.93 ± 1.73 mm in case of an isolated posterolateral bundle tear. Several studies have suggested that the Telos™ is more effective for measuring posterior laxity [17, 21]; however, Lee et al. [16] have also shown that it is effective in measuring anterior laxity with good intra- and interobserver reproducibility.

The study by Jardin et al. [15] showed that Telos™150 N was more reliable than the KT-1000™ in a population of patients operated for an ACL tear. However, Telos™ is expensive and there is radiation exposure. Recent studies with the GNRB® [9, 22] have shown that measurements were precise up to 1/10 mm, reproducible and not operator-dependent. Moreover, this device includes electrodes that take into account activity of the hamstring muscles to prevent false negatives [15].

This study had certain strong points. It was a prospective study, with systematic measurement procedures. Both laxity measurement devices were used in all patients. The study population was large and representative because it included a continuous series of 139 partial or complete ACL tears, managed by surgery or not. However, it also had limitations. The main bias was the use of the laxity measurement as one of the diagnostic criteria for partial thickness tears. Indeed, this diagnosis was based on a group of clinical, radiological and surgical arguments including differential laxity. At present, there is no preoperative test to confirm the diagnosis of a partial thickness tear [12]. Improving the results of diagnostic tests for ACL partial thickness tears remains real therapeutic challenge because conservative treatment can be considered with good long-term results [3, 4, 8].

Conclusion

The diagnostic value of GNRB® was better than Telos™ for the diagnosis of ACL partial thickness tears. The differential laxity threshold with the GNRB® 250 N was 2.5 mm (Se = 84 %, Sp = 81 %), while that of the slope differential was 2.7 mm/N (Se = 86 %, Sp = 61.9 %). The GNRB® 250 N is a valid device, and this differential laxity threshold could be a useful argument in the day-by-day clinical practice.

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