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REVIEW / SPECIAL ISSUE

Current understanding of static anterior and rotational knee laxity measurements: How can they be of use for athletes' health protection?

Caroline Mouton[1], *Daniel Theisen*[1], *Christian Nührenbörger*[3], *Alexander Hoffmann*[2], *Dietrich Pape*[1,2], *Romain Seil*[1,2]

[1]Sports Medicine Research Laboratory, Luxembourg Institute of Health, Luxembourg, Luxembourg
[2]Department of Orthopaedic Surgery, Centre Hospitalier de Luxembourg – Clinique d'Eich, Luxembourg, Luxembourg
[3]Department of Sports Medicine, Centre Hospitalier de Luxembourg – Clinique d'Eich, Luxembourg, Luxembourg

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Summary

Several devices have been developed to measure anterior and rotational static knee laxity over the last decades. Knee laxity measurements have the advantages of precisely quantifying laxity and are thus potentially more objective than manual tests. They may systematically be part of follow-up of knee injuries as they allow to study laxity in the non-injured knee, to improve the diagnosis of ACL injuries and to follow up reconstructions. Recent advances in physiologic laxity measurements showed that they may be of interest for the identification of knee injury risk factors in athletes. However, further efforts are necessary to improve the use of rotational laxity measurements in the daily clinical practice. Moreover, further prospective follow-ups of knee laxity in the injured/reconstructed knees are required to conclude on the best treatment strategy for knee soft tissue injuries.

Keywords
Anterior cruciate ligament – knee – laxity – diagnosis – reconstruction

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Neue Erkenntnisse zu Laxitätsmessungen im Rahmen von Bandverletzungen des Kniegelenkes

Zusammenfassung

In den vergangenen 10 Jahren wurden einige neue Messgeräte zur Bestimmung der Laxität der Kniegelenke entwickelt. Während sie in der Vergangenheit ausschließlich auf die sagittale Ebene beschränkt waren, so können heute auch Rotationslaxitäten bestimmt werden. Neueste wissenschaftliche Erkenntnisse ergaben interessante Perspektiven zum besseren Verständnis von Bandverletzungen, sowohl präoperativ zur besseren Diagnostik als auch postoperativ zur objektiven Verlaufs- und Qualitätskontrolle nach Bandersatzplastiken. Es konnte ebenfalls gezeigt werden, dass sie interessante Ansätze zur Einschätzung des Risikos einer non contact' VKB-Verletzung liefern. Ihr systematischer Einsatz in der Betreuung von Sportlern ist deswegen von großem Interesse.

Schlüsselwörter
Knie – Bandverletzungen – Laxitätsmessungen – Diagnose – Bandrekonstruktionen

Introduction

Clinical assessment of knee laxity is useful (1) prior to knee soft tissue reconstructions, to assist in establishing the diagnosis of knee injuries [52] and (2) after the surgical intervention, to evaluate the success of reconstruction procedures [49]. Over the last decades, arthrometers have specifically been designed to reproduce the Lachman or pivot shift tests. The use of a measurement device should be complementary to clinical examination. Although it has the theoretical advantage to be purely objective due to examiner-independency, medical conclusions from the measurements can only be drawn in association with clinical findings. A proper use of these devices allow for an objective and standardized evaluation of knee laxity. However, data reporting knee laxity measurements prior of after the surgery remains sparse in the literature and knee laxity remains mainly reported through the Lachman or the pivot shift tests. Recent advances in physiologic laxity measurements opened a new field of investigation by showing that they may play a role in the assessment of knee injury risk factors [2,32, 43,45]. The aim of the present chapter is therefore to provide an overview of current knowledge on static anterior and rotational knee laxity measurements.

Common devices to measure static knee laxity

Non-invasive arthrometers overestimate displacement due to the soft tissue deformation occurring during the test [20]. Their reliability relies on numerous factors like patient positioning, measurement methods and testing protocols which should not be neglected. A useful approach

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to assess the reliability of devices is to compute the minimum detectable change (MDC) [54] which gives a clear information on the smallest amount of change that corresponds to a real change of the measurement and is not the result of a measurement error.

Static anterior knee laxity

Devices designed to measure anterior knee laxity reproduce the position of the Lachman test: the patient is lying prone and his knee is tested at 20° of flexion. A muscle contraction during the force application should be avoided as it may limit the anterior displacement [14]. Furthermore, the tested leg should be evaluated in neutral rotation [15].

- ***KT-1000 and KT-2000 (Medmetric)*** [13]: The KT-1000 is the most commonly used device to measure anterior knee laxity but is no longer manufactured. Although it is considered as "gold standard", its reliability can be questioned as it decreases when the examiner is not experienced [6]. Furthermore, an influence of hand dominance on the measurements has been reported [40]. The inter-rater error was estimated at 2.9 mm for experienced and 3.5 mm for novice examiners [6]. Evaluation with manual maximum force is recommended for diagnostic purposes. In cases of acute complete ACL tears, measurements reach a sensitivity and specificity of 93% [52].
- ***GNRB (Genourob, Laval, France)*** [39]: The GNRB® appears to be more reliable than the KT-1000® regardless of the examiner's experience [11]. A precision (MDC) of 1.2 mm for the anterior displacement at 200 N has recently been reported [31]. For a side-to-side difference (SSD) between knees of 3 mm, the GNRB® reaches a sensitivity of 70% and a specificity of 99% to detect complete ACL tears at 134N [39] and respectively of 92% and 98% at 200N [23]. For all types of ACL tears and regardless of associated injuries, the sensitivity and specificity of the GNRB® reached respectively 75% and 95% for the ATD at 200 N and an optimal threshold of 1.2 mm [33].

Other devices have been reported in the literature such as the Stryker Knee Laxity Tester (sensitivity and specificity of 82% and 90% respectively [52]), the Genucom Knee Analysis System (sensitivity and specificity of 74% and 82% respectively [52]) and the Rolimeter but are not as common as the previous ones. Devices combined with imaging such as the RadioStereometry Analysis, the Telos Stress Device and the Lerat's method are more precise but they are also invasive and require additional resources and are time consuming.

Static rotational knee laxity

Much more complex than anterior knee laxity measurements, rotational knee laxity measurements are not yet used in the daily clinical practice.

- ***Rotameter*** [30]: The second version of the Rotameter has a precision of 4.2° for internal rotation and 5.9° for external rotation [31]. To our knowledge, this is the only device for which the sensitivity and the specificity to detect ACL injuries was reported. For a threshold of 3.2° in internal rotation, a sensitivity of 38% and a specificity of 95% were observed. Although the sensitivity appears to be low, it should be highlighted that a sensitivity of 24% was reported for the pivot shift test in a previous meta-analysis [5].
- ***Robotic Knee Testing system*** [9]: Inter-rater ICC for total range of rotation reaches 0.97 at a torque of 5.65 Nm [8,9]. The expected difference between 2 measurements as calculated with the repeatability coefficient reached 6.9° for internal rotation and 3.5° for external rotation [8].

It should be highlighted that in vivo data have also been reported with devices such as the Rottometer, the Rotational Measurement Device, the Vermont Knee Laxity Device and 2 other devices presented by Musahl et al. and Park et al. To our knowledge, only the reliability of these devices were reported and their applicability in injured patients were not investigated.

Knee laxity in the non-injured knee: athletes with high physiologic laxity may be at higher risk for knee injuries

Physiological laxity is specific to every individual and should not be confounded with knee mobility, evaluated by range of motion including the *recurvatum knee*.

Physiological laxity, knee function and injuries

Anterior and rotational knee laxity appears to be greater in the contralateral, non-injured knees of ACL-injured patients than in healthy controls [9,32,50]. Increased physiological laxity could thus be a risk factor for ACL injuries. Recent investigations have shown that subjects with excessive physiological knee laxity have similar movement patterns than those, which are associated with non-contact ACL injury mechanisms. They display greater hip and knee movements in the