

ASSESSMENT OF ANTEROPOSTERIOR (AP) KNEE JOINT LAXITY USING NON-INVASIVE NAVIGATION IN HEALTHY VOLUNTEERS

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INTRODUCTION

The knee joint displays a wide spectrum of laxity, from inherently tight to excessively lax even within the normal, uninjured population (Kupper 2007, Cross 1996). The amount of anteroposterior (AP) laxity is dependent on the amount of force applied as well as knee positioning (Cross 1996). The assessment of AP laxity in the clinical setting is performed by manual passive tests such as the Lachman and pivot shift tests which are highly specific in the diagnosis of cruciate ligament injuries (Kupper 2007). The Lachman test is usually performed at 30° of knee flexion in a clinical setting.

Non-invasive assessment based on image free navigation has been clinically validated and used to quantify mechanical alignment and coronal knee laxity in early flexion (Clarke 2012). The software (Physiopilot) was further developed to allow the measure of AP laxity. When used on cadavers this software demonstrated good AP laxity results with flexion up to 40° (Russell 2013).

If this technology was validated throughout flexion in live subjects, it could aid clinicians in identifying and quantifying ligamentous injuries in the clinic setting and therefore improve the planning and follow-up of surgical treatments.

This study aimed to validate the repeatability of the assessment of anteroposterior (AP) knee joint laxity using this non-invasive system in normal, healthy subjects.

MATERIALS AND METHODS

Twenty-five healthy volunteers were recruited and examined with ethical approval from the Biomedical Engineering department at the University of Strathclyde. Of the 25 volunteers - 14 were male, 11 female - with an average BMI of 24.3 (18.5 – 46.3), and an average age of 33 years and 2 months (18 – 60 years old). All volunteers were examined using a non-invasive navigation system (PhysioPilot, BBraun Aesculap) consisting of an infrared camera, externally mounted optical trackers and computer software (Figure 1). Each of the volunteers had both legs examined by a single examiner performing two registrations. The registration process included initial identification of key bony landmarks and manipulations of the volunteer's leg to achieve a virtual model of the lower limb. From this registration the supine mechanical femoral-tibial alignment (MFTA) was determined and assessment of AP knee joint laxity through flexion using the Lachman test was carried out in increments of 15°.

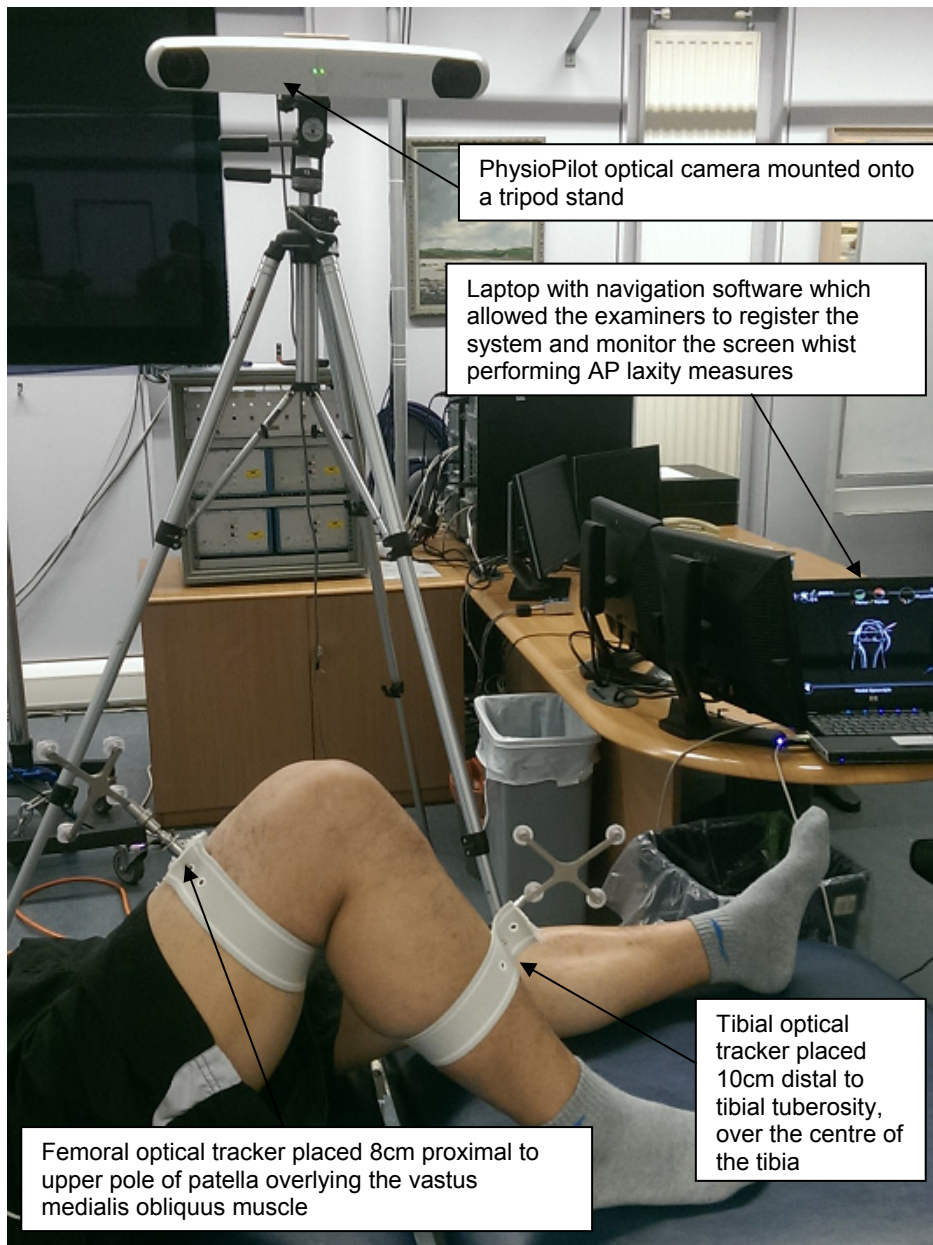


Figure 1: The set-up of each volunteer assessment; with the volunteer relaxed whilst lying supine. Passive optical trackers mounted on the femur and tibia using fabric straps to secure the base plate holding the optical tracker in place, with the laptop visible for the examiner to perform volunteer testing.

Validation of the assessment of AP knee joint laxity was assessed through intra-examiner repeatability using Coefficients of Repeatability (CR) calculated with Microsoft Excel and Interclass Correlation Coefficients (ICC) using SPSS software (Bland 1986). The acceptable limits of agreement for this project were set at 3mm for anteroposterior tibial translation, and 2° for supine MFTA in extension.

RESULTS

Outliers were identified in the first 10 volunteers. For these large variation in supine MFTA in extension was measured indicating poor registrations. Accurate registration

is the key initial step in alignment acquisition required for AP laxity testing. Therefore only the last 15 volunteers (30 knees) were analysed for reliability and repeatability.

The non-invasive system demonstrated consistent and comparable supine MFTA acquisition in extension with a CR=1.6° and good reliability of ICC=0.81.

The most reliable and repeatable AP laxity assessments were at 30° and 45° with both these assessments demonstrating good reliability (ICC 0.82, 0.82) and good repeatability (CR 2.5, 2.9). AP laxity at 60° demonstrated good reliability (ICC 0.79) with acceptable repeatability (CR 3.3mm). The AP laxity assessment at 0°, 15°, 75° and 90° demonstrated moderate reliability (ICC ≤ 0.75), and poor repeatability (CR ≥3.0mm) as shown in Table 1.

Assessment	Degrees	Coefficients of Repeatability (CR)*	Interclass Correlation Coefficients (ICC)**
Supine MFTA in extension (°)	0°	1.6	0.81
AP laxity (mm)	0°	3.7	0.70
	15°	4.8	0.72
	30°	2.5	0.82
	45°	2.9	0.82
	60°	3.3	0.79
	75°	4.6	0.76
	90°	5.6	0.73

Table 1: Summary CR and ICC results for AP laxity assessment

*A CR of under 3mm for AP translation demonstrates good repeatability.

**An ICC of ≥0.9 demonstrates excellent reliability, an ICC between 0.75 and 0.9 demonstrates good reliability, and an ICC ≤ 0.75 indicates moderate to poor reliability (Bland 1986).

DISCUSSION

The PhysioPilot non-invasive system demonstrated consistent and comparable supine MFTA acquisition in extension on all volunteers assessed, consistently within the pre-validated ±1° coronal alignment by Clarke *et al* (Clarke 2012) and Russell *et al* (Russell 2013).

The non-invasive system was able to reliably and consistently measure knee AP laxity between 30° and 45° of flexion, which is the clinically relevant range for this assessment. This system could therefore be used to quantify abnormal knee laxity and improve the assessment of instability in the knee in a clinical setting.

Poor AP laxity results outside the limits of agreement were achieved at 0°, 15°, 75° and 90°, possibly due to difficulties in hand placement and lack of standardisation in the force used during the Lachman examination in early and late flexion. The software has been previously validated to 40° of flexion in cadavers, but due to no standardised force in AP laxity assessment in this study, the software cannot be validated throughout the whole range of flexion in living subjects.

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DISCLOSURES

Mr F Picard has licences and patents with BBraun Aesculap. The Golden Jubilee National Hospital receives grants from BBraun Aesculap.