

DETERMINATION OF THE STRAIN BEHAVIOR OF AXIALLY LOADED COLLATERAL LIGAMENTS OF THE KNEE JOINT - A COMPARISON OF DIGITAL IMAGE CORRELATION AND STRAIN GAUGES.

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Introduction

The response of soft tissues to an applied loading can be determined by strain measurement, which is a key parameter e.g. during experimental testing of joint kinematics using actively controlled motion test rigs. Typically, strain is measured using electrical resistance with strain gauges (SG), or optical sensors based on digital image correlation (DIC), among others [1-3]. These sensor systems are established in other areas of technology. However, these sensors have a limited range of applications in medical technology due to various challenges in handling human soft materials. The aim of this study was to compare directly attached foil-type SG and 3D-DIC to determine the strain of axially loaded human ligament structures.

Methods

Therefore, the medial (MCL) and lateral (LCL) collateral ligaments of 18 human knee joints underwent cyclic displacement-controlled loading at a rate of 20 mm/min in two test trials. In the first trial, strain was recorded with the 3D-DIC system and the reference strain of the testing machine (REF). In the second trial, strain was additionally measured with a directly attached SG.

Results

The most important finding of this study was that only the 3D-DIC provides results comparable to the reference. The SG demonstrate significantly lower strain values in comparison to the 3D-DIC and the reference ($p < 0.0001$).

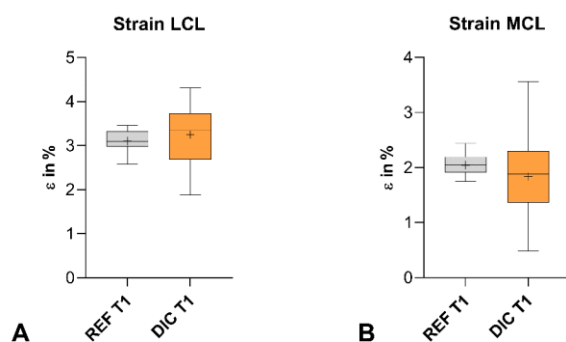


Figure 1: Strain of LCL (A) and MCL (B) measured by REF and 3D-DIC during the first trial (T1) (+: mean value).

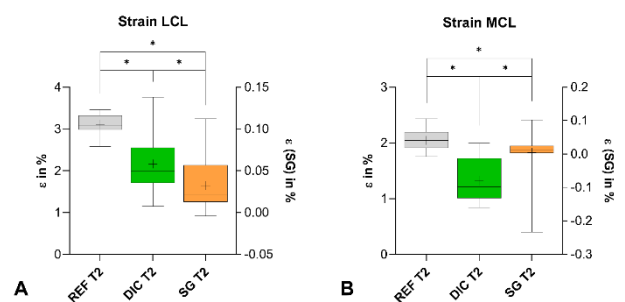


Figure 2: Strain of LCL (A) and MCL (B) measured by REF, 3D-DIC and SG in the second trial (T2) (*significance, second y-axis for SG values, +: mean value).

Discussion

According to our results, both systems allow strain assessment within the range of elastic behavior of the ligament, however only the 3D-DIC provides results comparable to the reference. As described in the literature, the 3D-DIC method provides quantitative and qualitative results through full-field analysis of superficial ligaments. Nevertheless, SGs can be used to study the behavior of ligaments in joints, even if they are not superficial, and especially if they are optically inaccessible for 3D-DIC.

References

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