Singapore General Hospital
SingHealth

SingHealth DukeNUS ACADEMIC MEDICAL CENTRE
MUSCULOSKELETAL SCIENCES

Simultaneous strain measurements of the knee ligaments in intact and ACL deficient knees

A cadaver study using a 6-degrees of freedom robotic simulator

Study conducted at Singapore General Hospital

Winston Lim, Ajinkya Achalare, Jun Liang Lau, Andy Yew, Pivatidevi Pareatumbee, Siaw Meng Chou, Denny Lie

Disclosures

We have no conflicts of interest to disclose

This research is supported by SingHealth Academic Medicine Research Grant Call FY2021 (AM/TP051/2021)

Introduction

The anterior cruciate ligament is the most commonly injured ligament in the knee.

Previous studies have only focused on strain measurement of ligaments in isolation.

No studies have examined the simultaneous strain behaviours of the knee cruciate and collateral ligaments.

Introduction

AIMS:

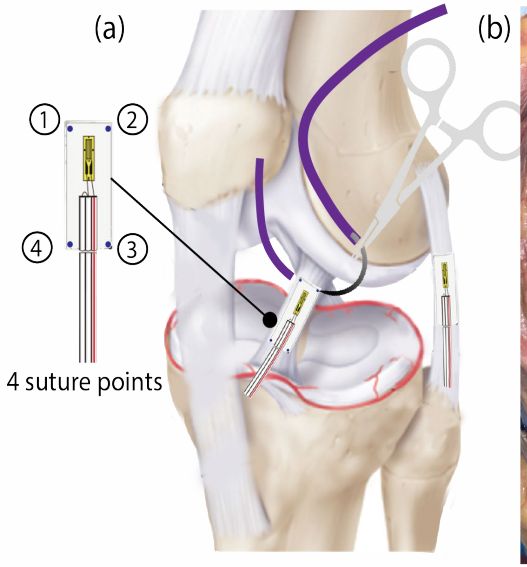
Simultaneous measurement of strain on the knee cruciate and collateral ligaments under a common force.

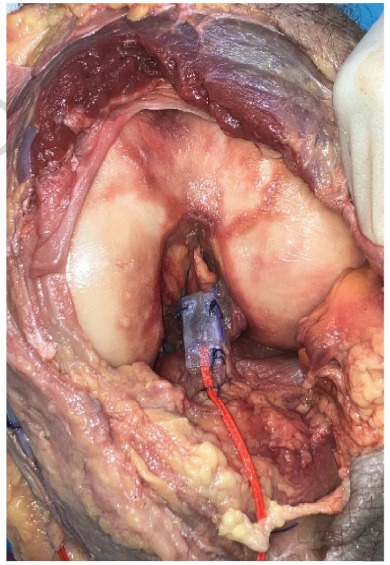
To investigate the strain distribution on PCL, MCL, LCL with an intact and cut ACL.

SingHealth DukeNUS ACADEMIC MEDICAL CENTRE

Methods

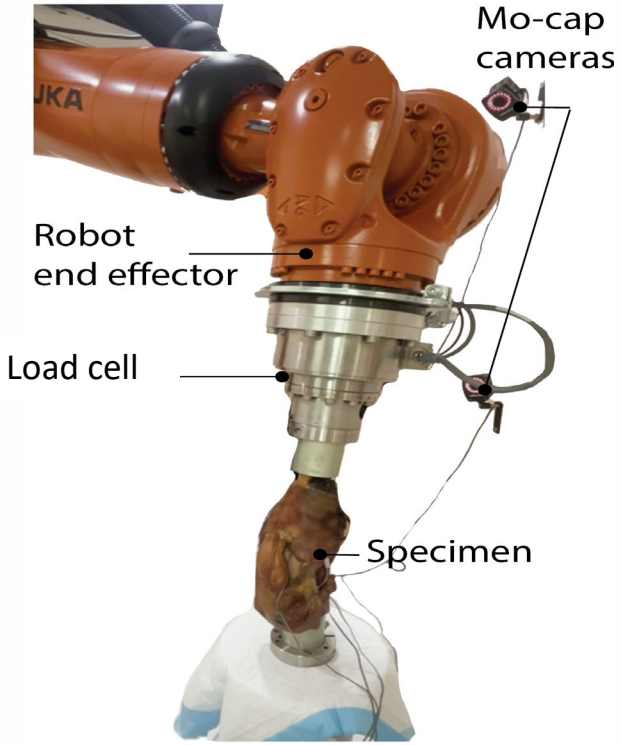
- Six fresh frozen cadavers were used (Males, Mean age: 64 years, range: 58 to 71 years).
- Both femur and tibia cut 20 cm from the joint line.
- Medial parapatellar approach to assess the intra-articular cruciate ligaments.
- Uniaxial strain gauges were sutured into
  - Anteromedial bundle of ACL
  - Posteromedial bundle of PCL
  - Mid-substance of MCL and LCL





SingHealth DukeNUS ACADEMIC MEDICAL CENTRE

Methods

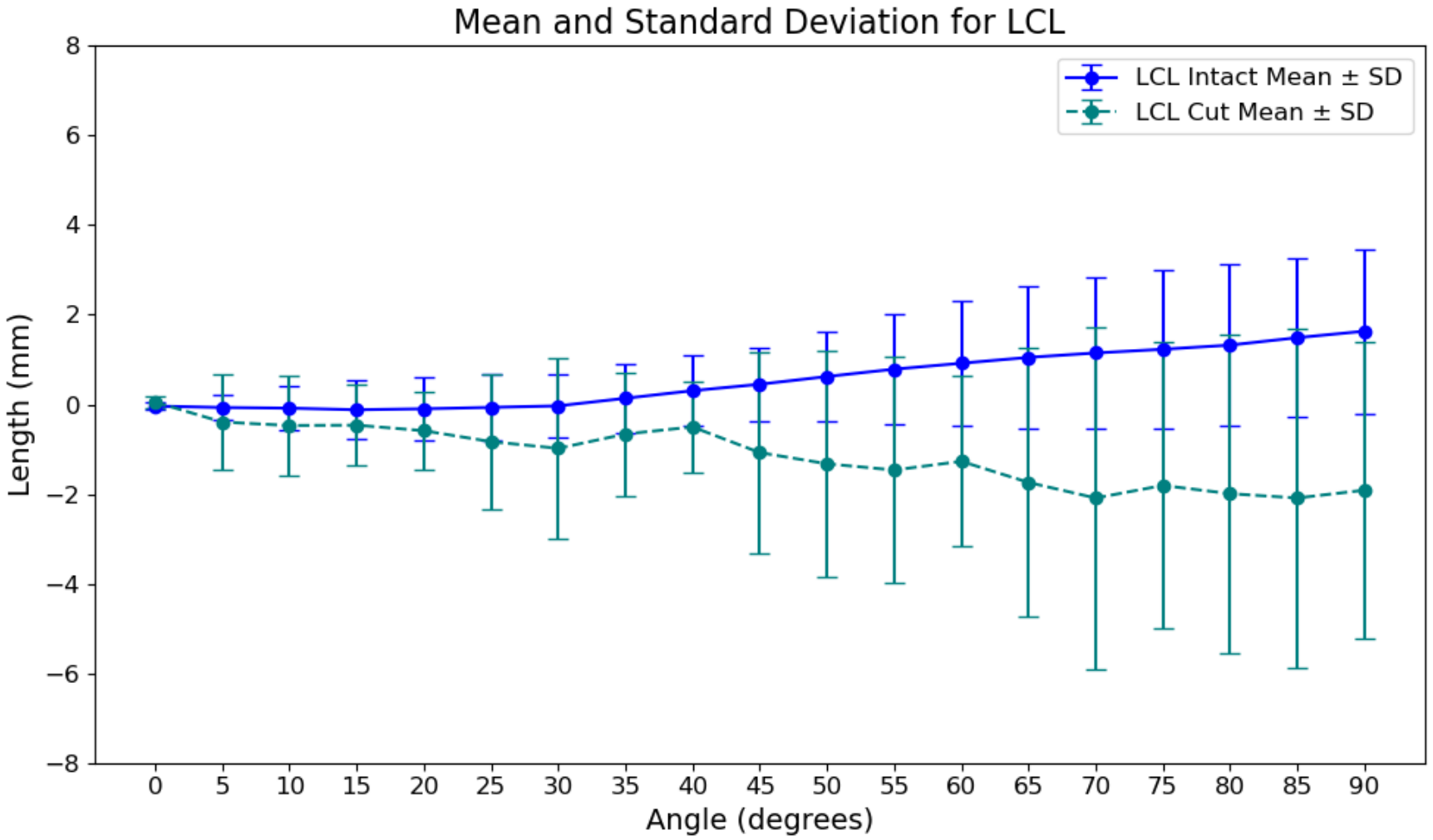


(1) tibia is fixed to the moving arm
(2) femur is secured in a fixed mount on the base,
(3) MO-cap cameras are use to digitize the robot, femur and tibia to track knee kinematics

- Specimens are flexed from 0° to 90° using a 6 DOF robotic simulator.
- Specimens tested with an intact ACL.
- Subsequently, ACL is resected and specimens tested again
- Strain data of the MCL, LCL and PCL are recorded and converted to length change.

SingHealth DukeNUS ACADEMIC MEDICAL CENTRE

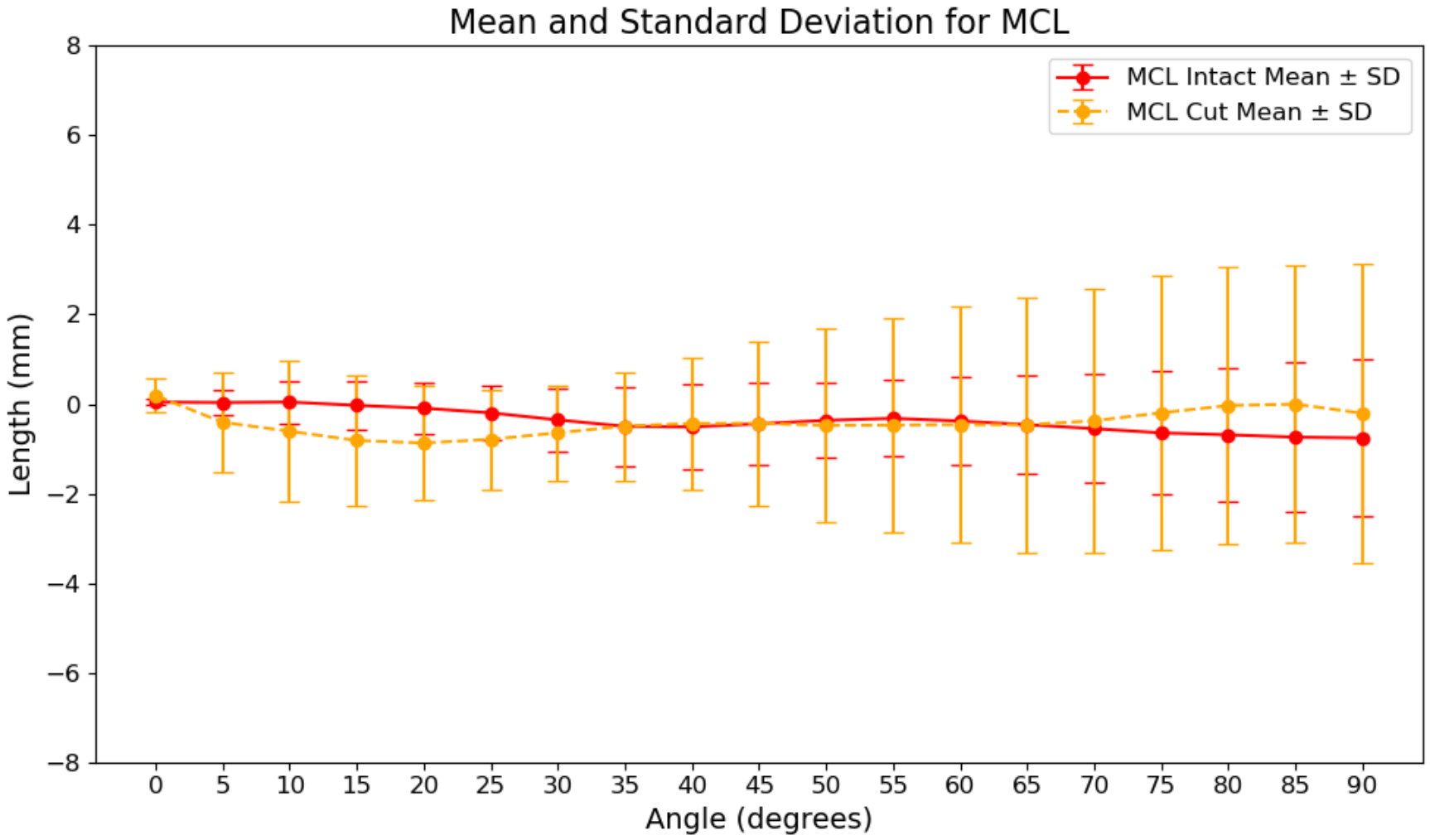
Results



LCL demonstrated negative change in length (slack) throughout flexion suggesting that it may have lost some of its ability to control valgus rotation

SingHealth DukeNUS ACADEMIC MEDICAL CENTRE

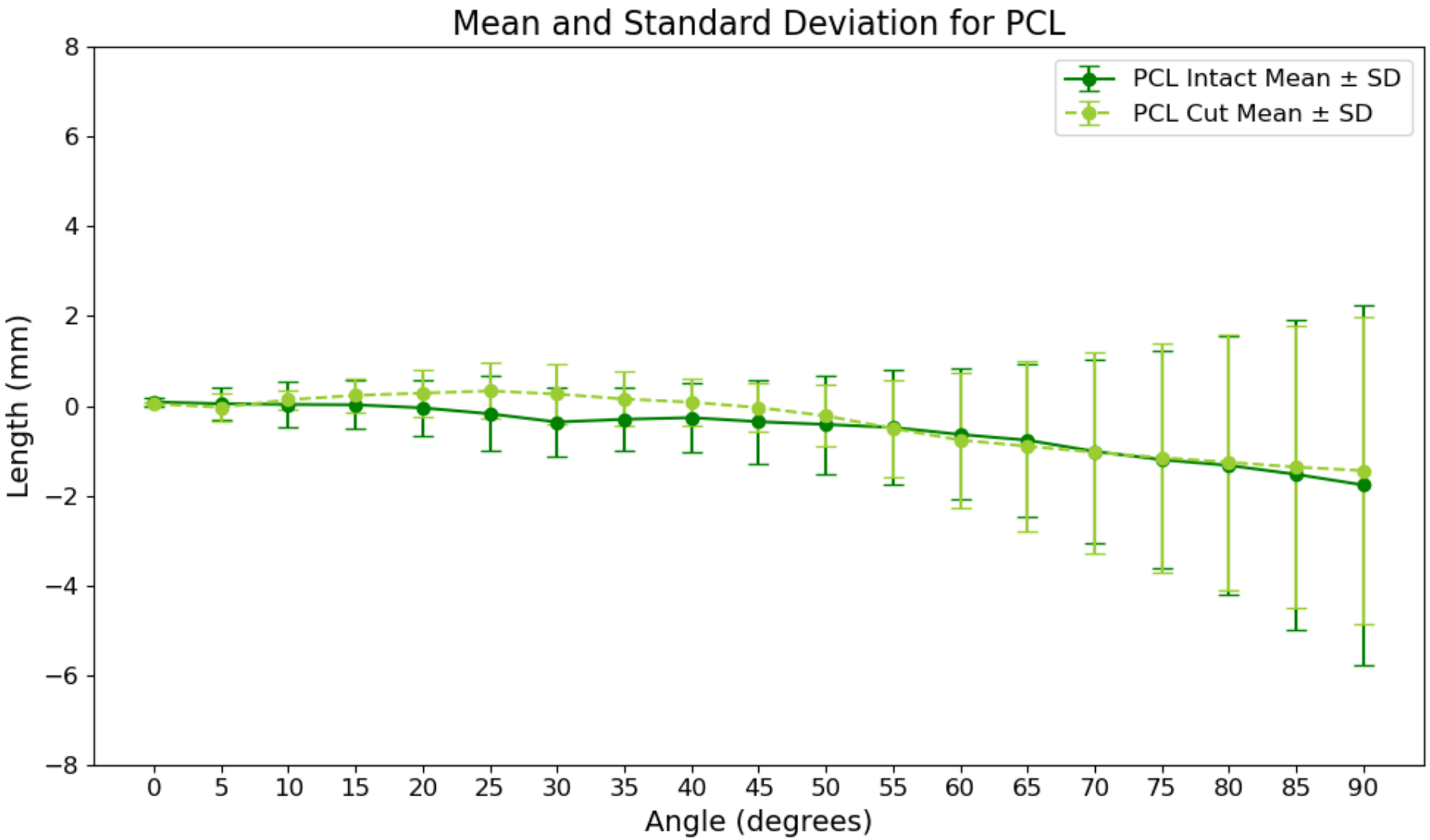
Results



- **From 5° to 25° flexion, the knee is internally rotated, MCL experienced negative length change (slack), suggesting that more internal rotation has occurred as compared to an intact ACL state**
- **From 30° to 65°, MCL was functioning effectively as an external rotation restraint**
- **Beyond 70°, MCL lengthen, indicating a possible loss in its ability to restrain external rotation as the knee flexion continues**

SingHealth DukeNUS ACADEMIC MEDICAL CENTRE

Results



PCL lengthening between 15° and 45° flexion suggest some loss in restraining posterior translation

SingHealth DukeNUS ACADEMIC MEDICAL CENTRE

Discussion

- In an ACL rupture, the LCL, MCL and PCL will exhibit changes.
- In an open chain movement (i.e. tibia flexing while femur remains stationary)
  - LCL loses its ability to restrict valgus rotation throughout knee flexion
  - MCL retains most of its ability to control external rotation
  - PCL loses part of its ability to restrain posterior translation during the initial 45° of knee flexion
- After loss of ACL, MCL likely becomes the primary restraint in an ACL deficient knee

SingHealth DukeNUS ACADEMIC MEDICAL CENTRE