ISAKOS CONGRESS 2025 | MUNICH GERMANY June 8–11

A Novel Method for Evaluating the Effect of a Lateral Meniscus Posterior Root Tear on the Loaded Mechanics of a Human Cadaveric Knee's Lateral Compartment

Parth Lodhia, MD FRCSC

Co-Authors: Edward Hoptioncann, Jordan Broberg, Andrew Yung, Kirsten Bale, and David Wilson

University of British Columbia, Vancouver, Canada

THE UNIVERSITY OF BRITISH COLUMBIA

Faculty Disclosure Information

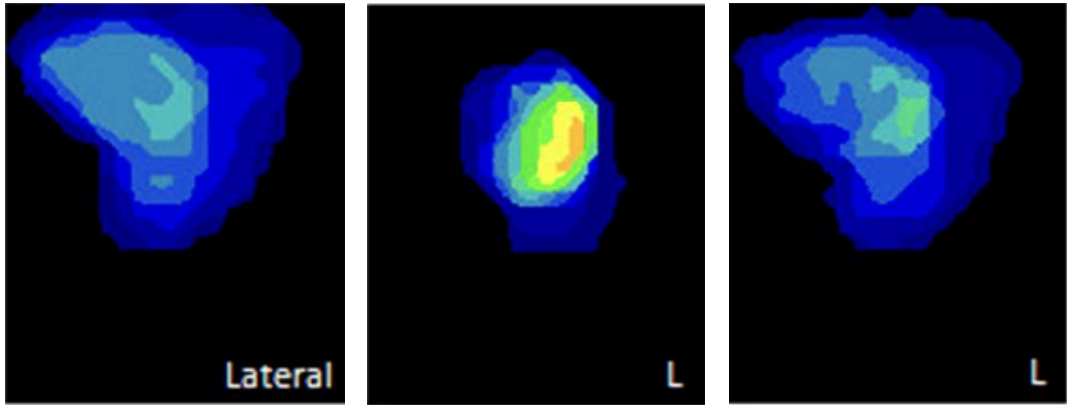
ISAKOS CONGRESS 2025 | MUNICH GERMANY June 8–11

- My disclosures are:
  - Speaker for Arthrex
  - Support received from Ossur
  - Editorial or Governing board of Arthroscopy
  - Board of Directors member for:
    - Canadian Orthopaedic Association
    - International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine
    - International Society of Hip Arthroscopy (ISHA)

LMPRTs Change Knee Mechanics

ISAKOS CONGRESS 2025 | MUNICH GERMANY June 8–11

- Lateral meniscus posterior root tears (LMPRTs) change knee mechanics[1-3]
  - Increases cartilage degeneration and can lead to knee osteoarthritis (OA)
- LMPRT repair can restore contact pressures and areas to intact values[1-3]
  - Demonstrated in multiple biomechanical cadaver studies



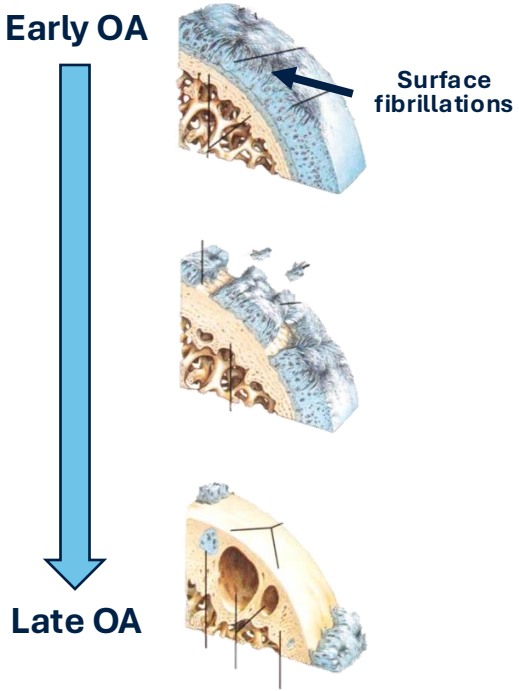
Intact | LMPRT | Repaired

Figures from LaPrade et al (2014) *J Bone Joint Surg Am*

Effect on Specific Tissues?

ISAKOS CONGRESS 2025 | MUNICH GERMANY June 8–11

- **Outstanding Question:** How are the mechanics *within* the joint tissues altered following a LMPRT and subsequent repair?
  - Important to answer because increases in cartilage strain are known to lead to cartilage degeneration and eventual OA[4]
- Measuring cartilage strain together with meniscal mechanics could:
  - Highlight the role of the meniscus in protecting the knee from OA
  - Reveal how LMPRTs disrupt meniscal function and worsen cartilage mechanics
  - Demonstrate the efficacy of LMPRT repair at restoring knee tissue mechanics



Figures from Thompson & Netter, *Netter's Concise Orthopaedic Anatomy* (2nd ed.)

Study Objectives

- **Primary Objective:** To design a novel method for comprehensively investigating tissue mechanics in loaded human cadaver knee lateral compartments
  - Must be able to measure mechanics of femoral cartilage, tibial cartilage, and menisci
  - Needs to be capable of measuring mechanics for specimens with intact, torn, and repaired lateral menisci

- **Future Goal:** To evaluate loaded tissue mechanics in specimens before and after an artificially created LMPRT, and subsequent LMPRT repair

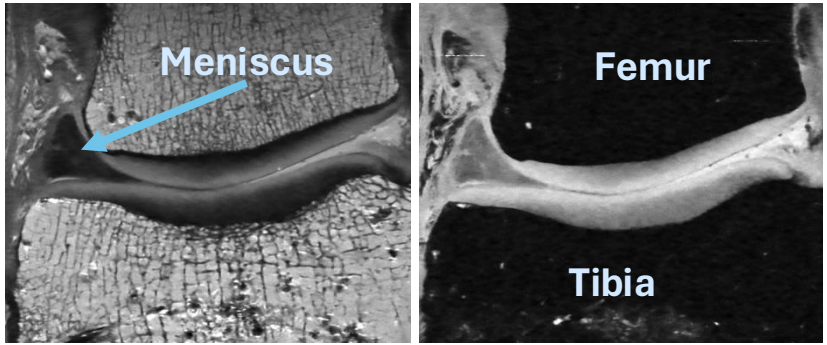
Ultra High Field MRI

ISAKOS CONGRESS 2025 | MUNICH GERMANY June 8–11

- Ultra high field magnetic resonance imaging (MRI) can be used to visualize cartilage and menisci
  - Acquire high enough resolution images to measure cartilage strain, meniscal extrusion, etc.

Specimens placed in this small hole

9.4 Tesla MRI Scanner



Example coronal images of the same knee specimen acquired with 9.4T MRI scanner

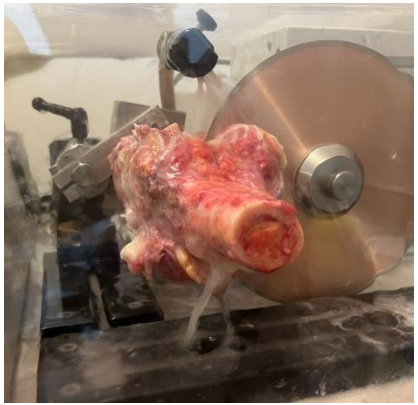
Left figure from UBC MRI Research

Specimen Preparation

ISAKOS CONGRESS 2025 | MUNICH GERMANY June 8–11

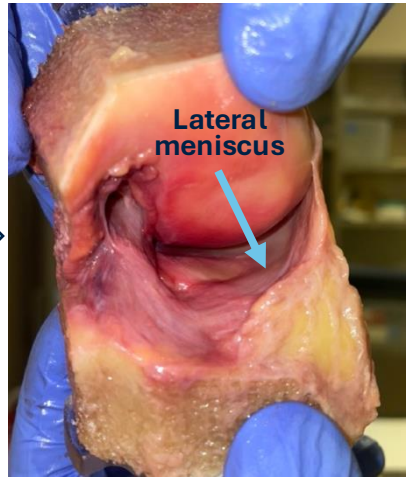
- Lateral compartments were isolated while preserving lateral meniscus roots
  - Had to isolate lateral compartment so specimen could fit in the ultra high field MRI scanner

Collected knee



Parallel sawing

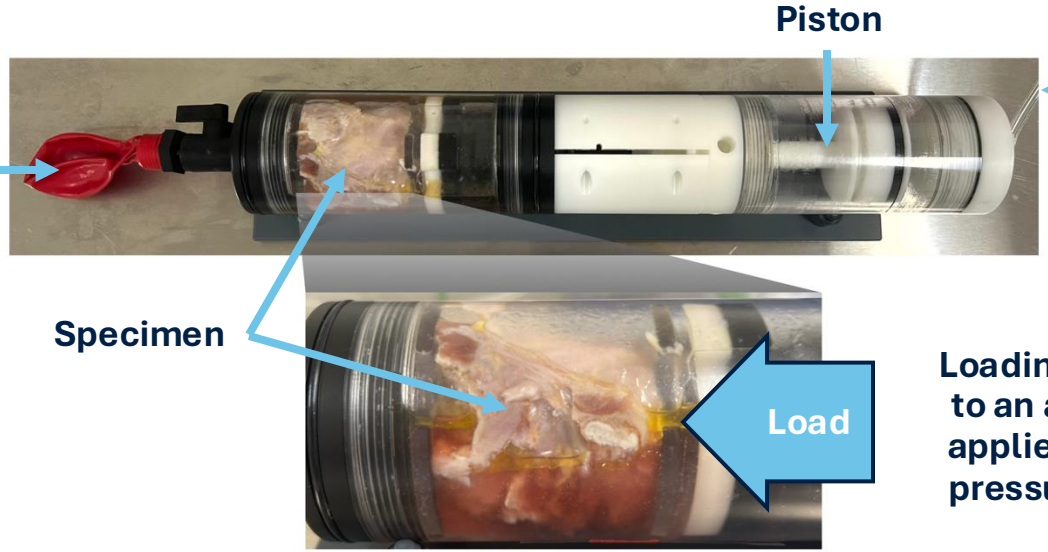
Knee slab from sawing



Final prepared lateral compartment

MRI-Compatible Loading Device

- Compressive load applied to lateral knee compartment by a MRI-compatible pneumatic loading device[5]

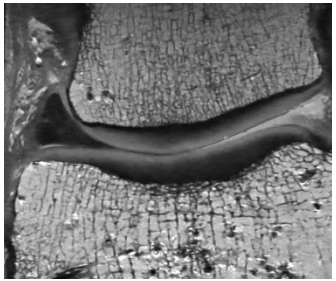


Study Protocol

ISAKOS CONGRESS 2025 | MUNICH GERMANY June 8–11

Intact Meniscus

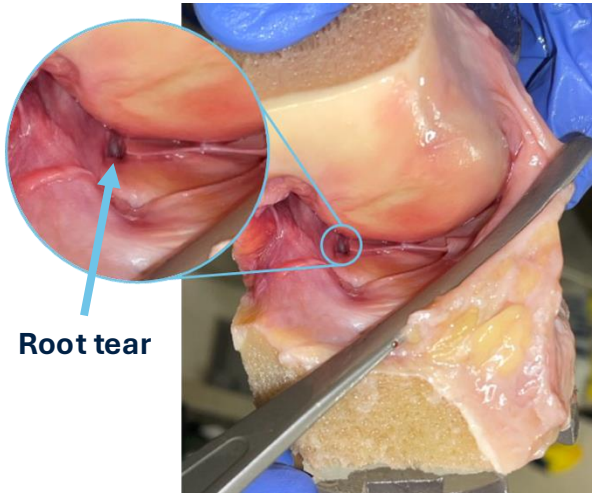
Unloaded



2 hours of loading

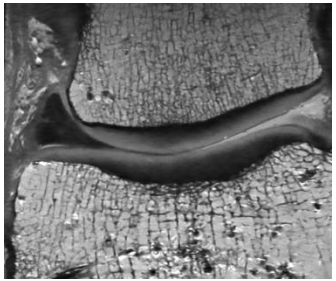
Loaded

Create the LMPRT and image again the following day



LMPRT

Unloaded



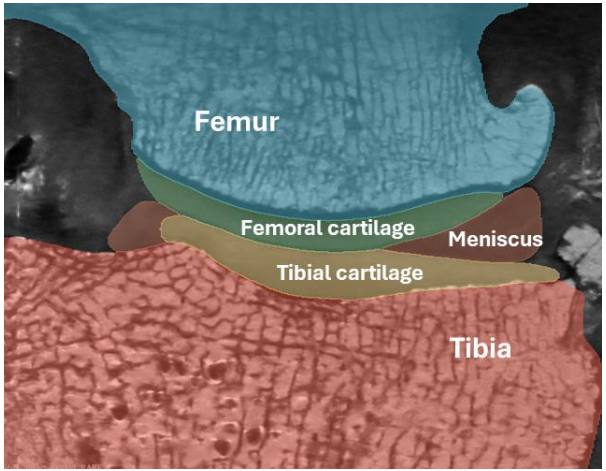
2 hours of loading

Loaded

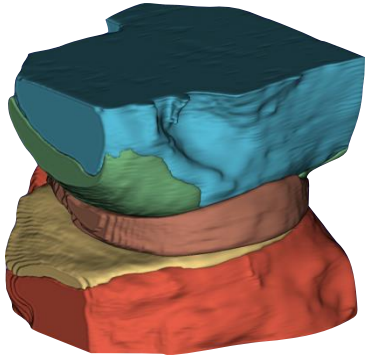
Repair LMPRT and repeat

Image Segmentation

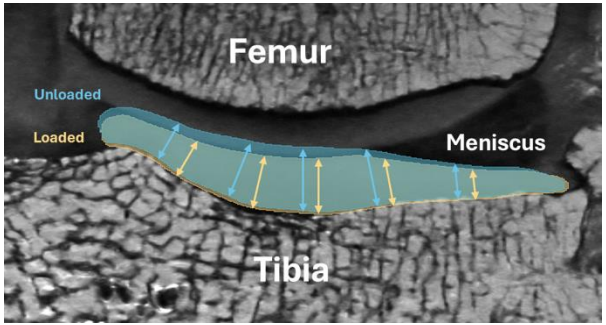
- Joint tissues in acquired images are segmented for evaluating mechanics
  - Ex. Cartilage strain can be measured by comparing unloaded to loaded segmentations



Segmented image

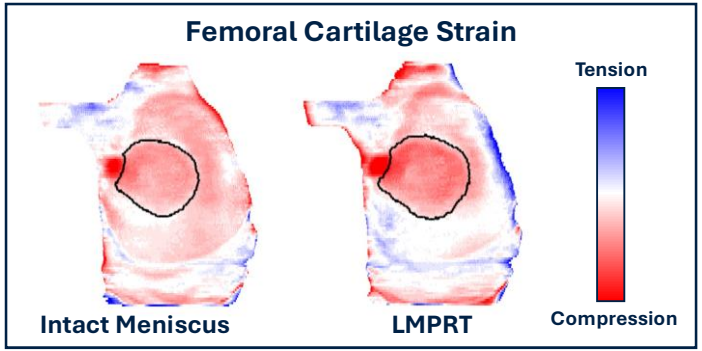


3D reconstruction of knee specimen

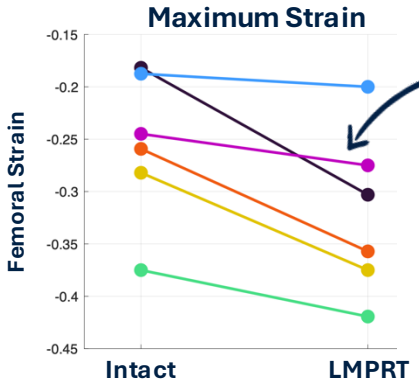


Unloaded and loaded tibial cartilage segmentations for measuring axial strain

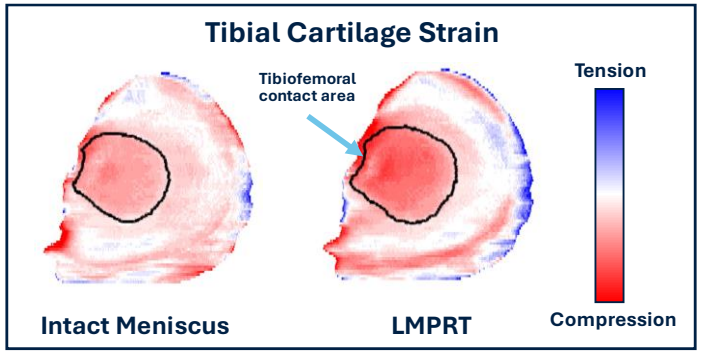
Strain Maps



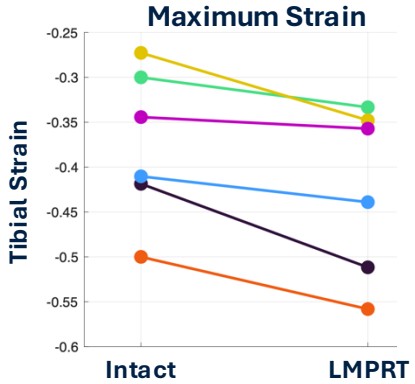
n=6



Decrease = greater compression



n=6



Maximum compressive strain in contact area increases after LMPRT in both:

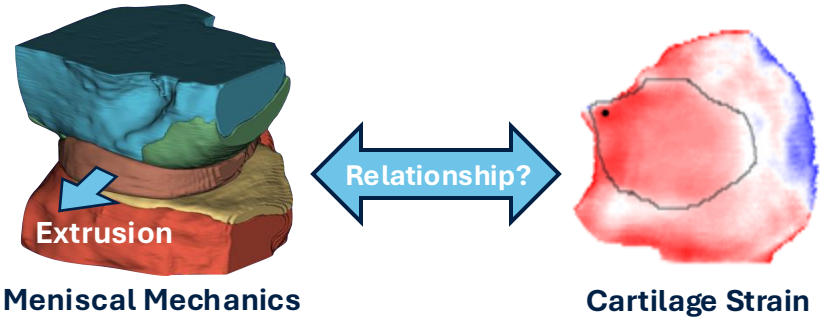
- **Femoral cartilage**
  - **3% increase**
  - **p=0.013**
- **Tibial cartilage**
  - **5% increase**
  - **p=0.010**

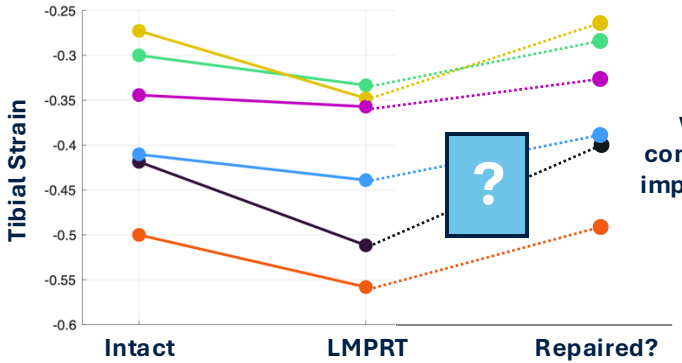
Conclusion

- Developed a method for comprehensively analyzing tissue mechanics in lateral knee
  - Able to assess impact of LMPRTs and repairs on cartilage and meniscal mechanics

Future Goals:

- Evaluate the mechanics of the meniscus[6] (i.e. extrusion)
  - Explore how meniscal mechanics impact cartilage strain
- Perform LMPRT repairs and repeat loaded imaging protocol
  - Determine whether repairs can restore meniscal function and protect cartilage from large focal strains





Will maximum compressive strains improve after repair?

References

1. LaPrade, C. M. *et al*. Altered Tibiofemoral Contact Mechanics Due to Lateral Meniscus Posterior Horn Root Avulsions and Radial Tears Can Be Restored with in Situ Pull-Out Suture Repairs. *JBJS* **96**, 471 (2014).

2. Perez-Blanca, A. *et al*. Comparative Biomechanical Study on Contact Alterations After Lateral Meniscus Posterior Root Avulsion, Transosseous Reinsertion, and Total Meniscectomy. *Arthroscopy* **32**, 624–633 (2016).

3. Forkel, P. *et al*. Biomechanical consequences of a posterior root tear of the lateral meniscus: stabilizing effect of the meniscofemoral ligament. *Arch. Orthop. Trauma Surg.* **133**, 621–626 (2013).

4. Carter, D. R. *et al*. The mechanobiology of articular cartilage development and degeneration. *Clin. Orthop. Rel. Res.* **427**, S69–S77 (2004).

5. Küpper, J. C., Sullivan, E. S., Coope, R. J. N. & Wilson, D. R. Design of a double acting pneumatic cartilage loading device for magnetic resonance imaging. *J. Mech. Behav. Biomed. Mater.* **142**, 105810 (2023).

6. Broberg, J. S. & Wilson, D. R. MR imaging methods to study meniscal position and mechanics. *Osteoarthr. Imaging* **4**, 100222 (2024).