

Mechano-Biology: Understanding the Critical Relationships between Movement, Function and Joint Health

Scott Tashman, PhD
Director, Biomedical Engineering

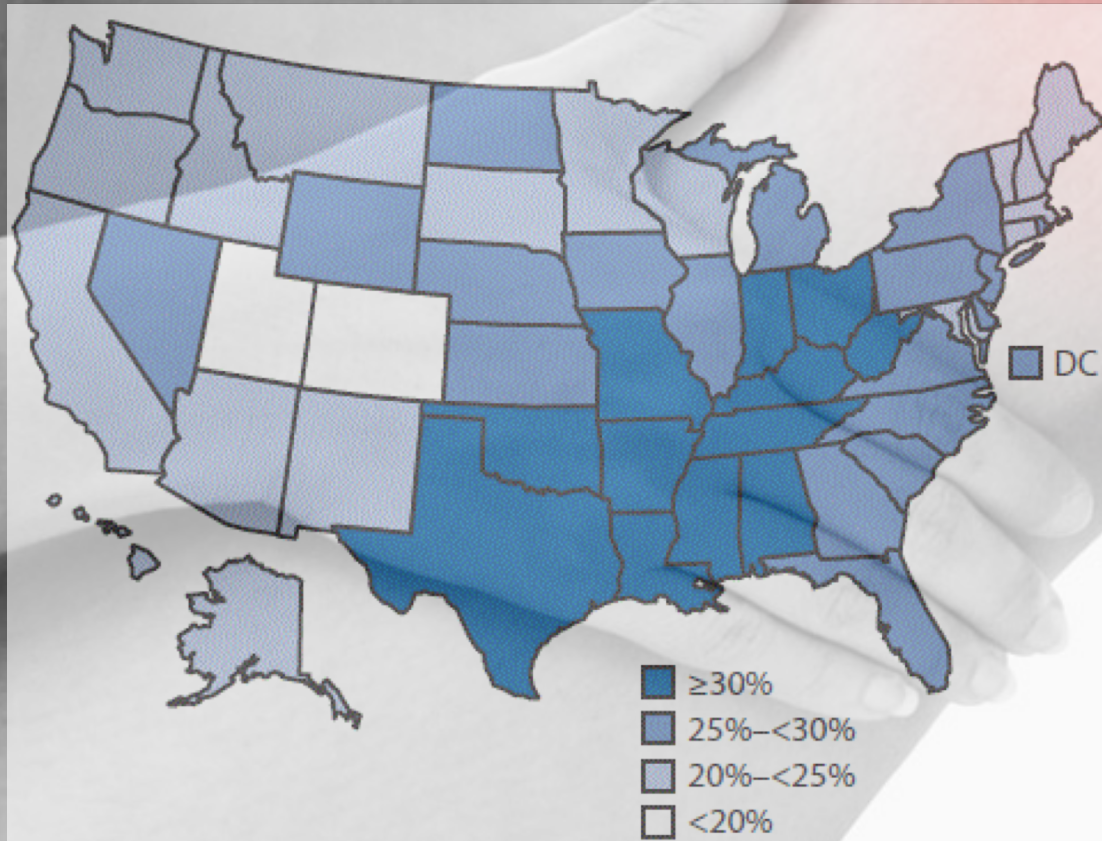
March 21, 2019

Benefits of exercise well known

- Physical activity decreases risk for:
 - Coronary artery disease
 - Type 2 diabetes
 - Hypertension
 - Stroke
 - Breast cancer
 - Colon cancer
 - Sarcopenia (muscle loss)
 - Osteoporosis
 - Loss of cognitive function



Impediments to exercise with aging?



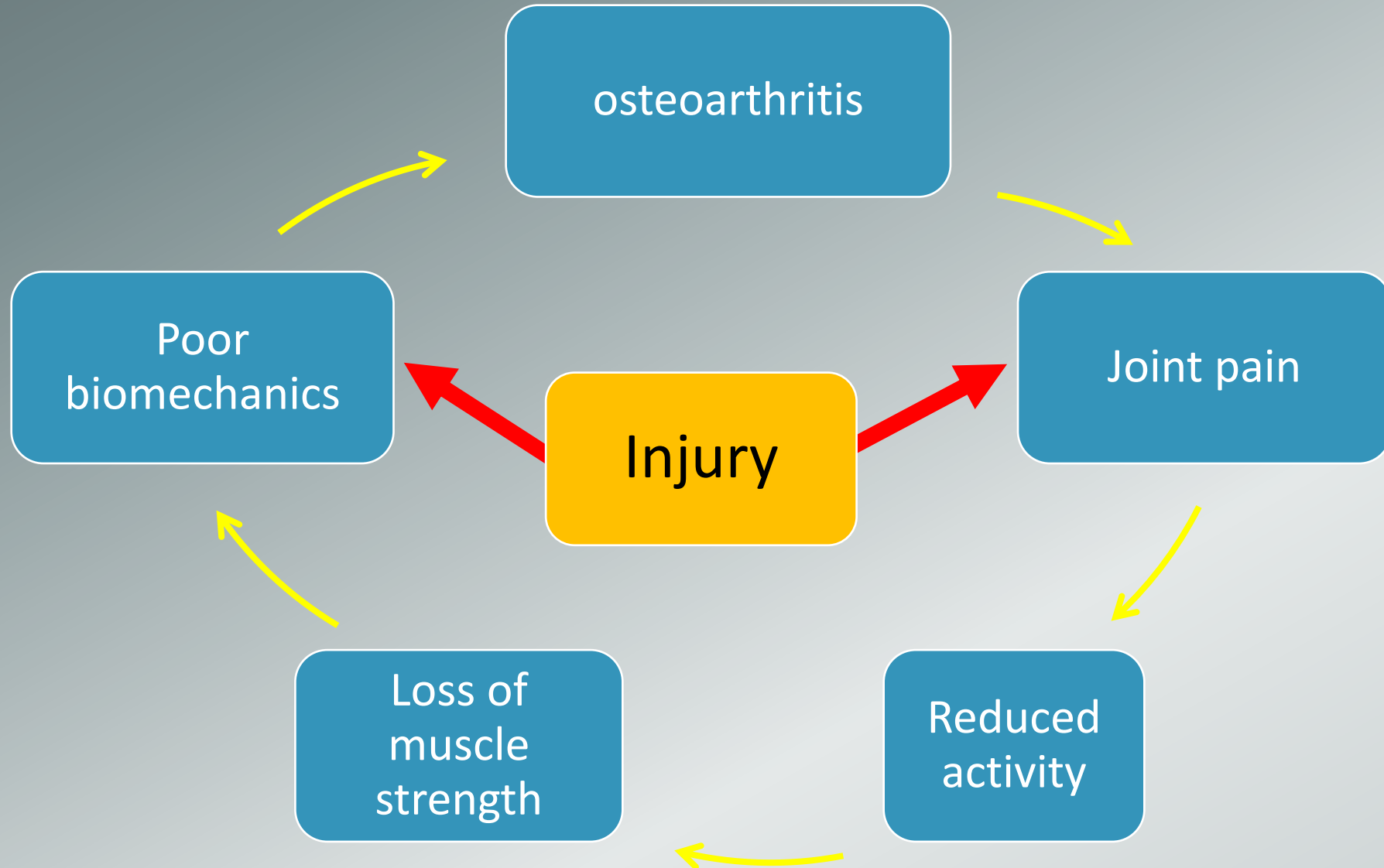
% Physically Inactive Adults > 50 years Old

Joint pain is one of the factors most often cited as a barrier to regular exercise in older adults

Incidence of knee arthritis in US has doubled since 1940, reaching epidemic proportions

One third of individuals over 50 with signs of arthritis are physically inactive

Joint pain and osteoarthritis: a vicious cycle



Osteoarthritis: a major risk factor for dying from cardiovascular disease!

Mortality risk from heart disease increased 15-35% for

Increase in mortality risk



Data from Turkiewicz et al, Osteoarthritis and Cartilage, 2019

SPRI's focus on preserving long-term joint health

A group of older adults, including men and women, are running on a red track. They are wearing various athletic gear, including headbands, watches, and tank tops. The background shows a green wall and a building. The image is overlaid with three semi-transparent dark blue boxes containing white text.

Identifying biomechanical risk factors for osteoarthritis

- Characterize modifiable risk factors
- Develop screening methods to identify individuals at risk
- Design interventions for joint preservation

Optimizing surgical treatment and rehabilitation

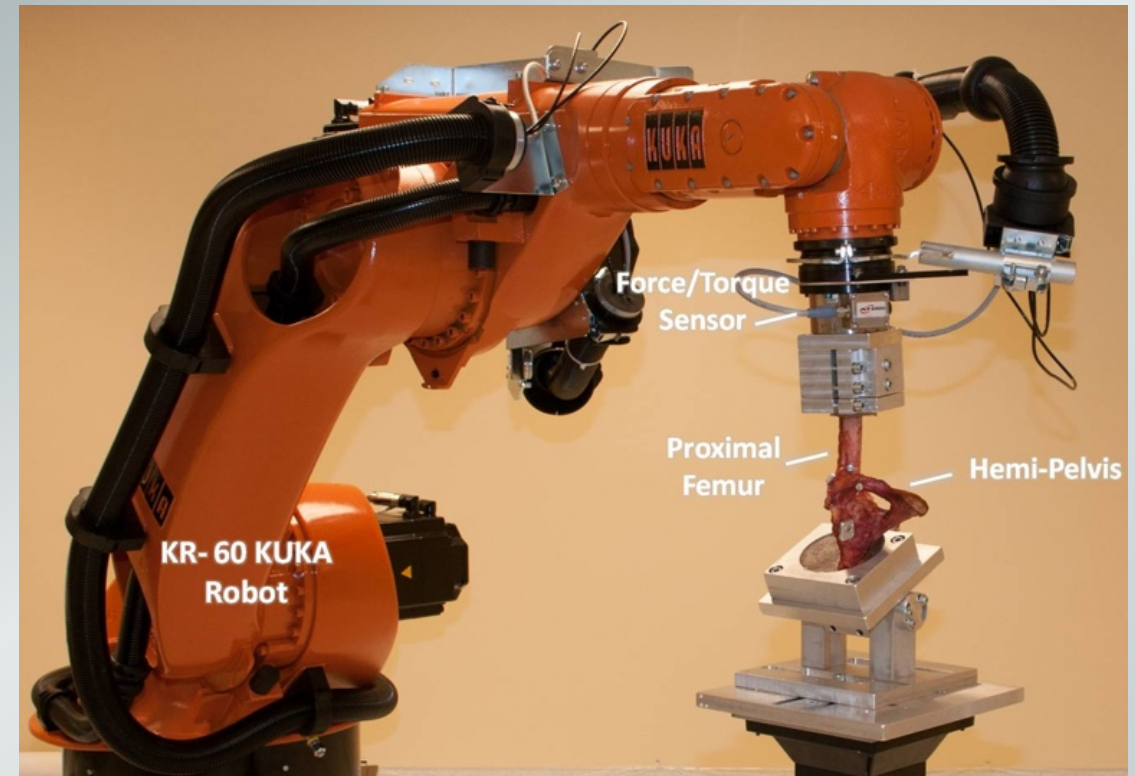
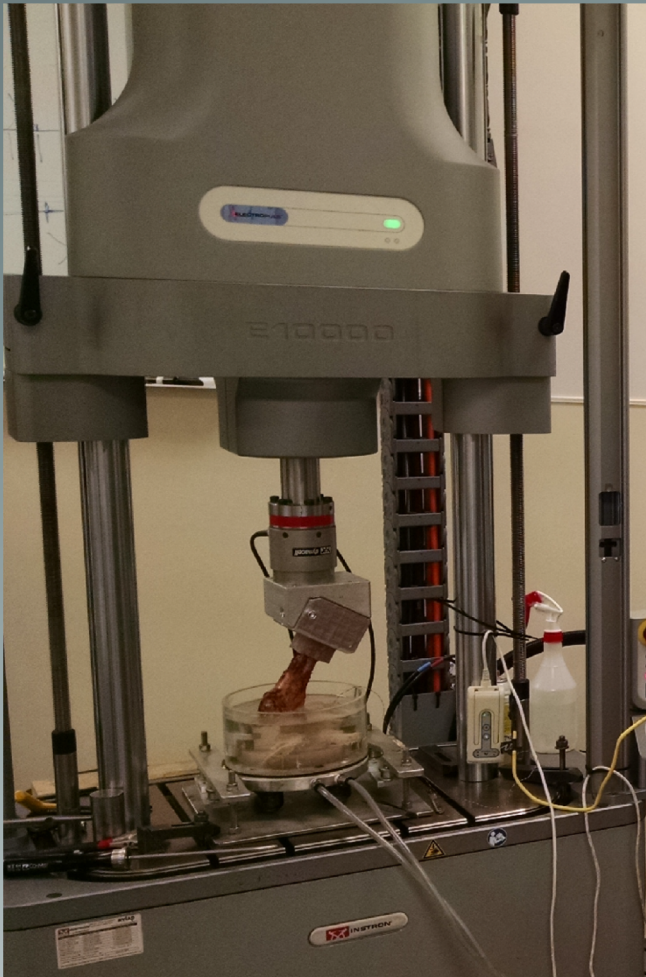
- Developing and evaluating advanced treatments for restoring healthy joint mechanics
- Improving testing and criteria for safe return to play

Reducing or preventing musculoskeletal injuries

- Improved training and techniques
- Equipment modifications

Resources: Biomechanical Robotics Laboratory

- Cutting-edge instrumentation
- Testing of any joint in the body
- Studies of anatomy, normal function, injury, repair
- Development of surgical techniques and devices



SPRI Biomotion Lab: Comprehensive assessment of biomechanical function



20-Camera Video-
Motion Analysis

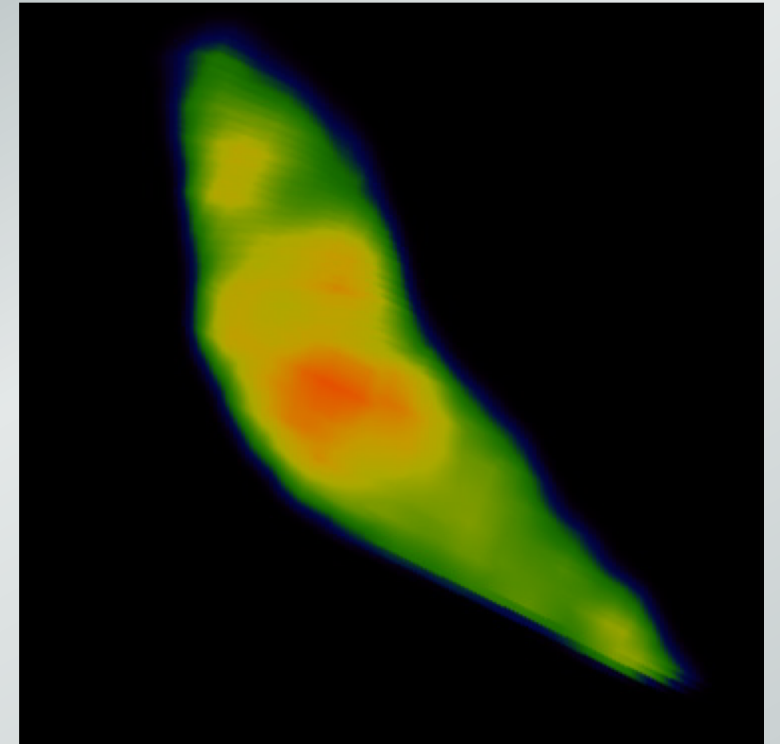
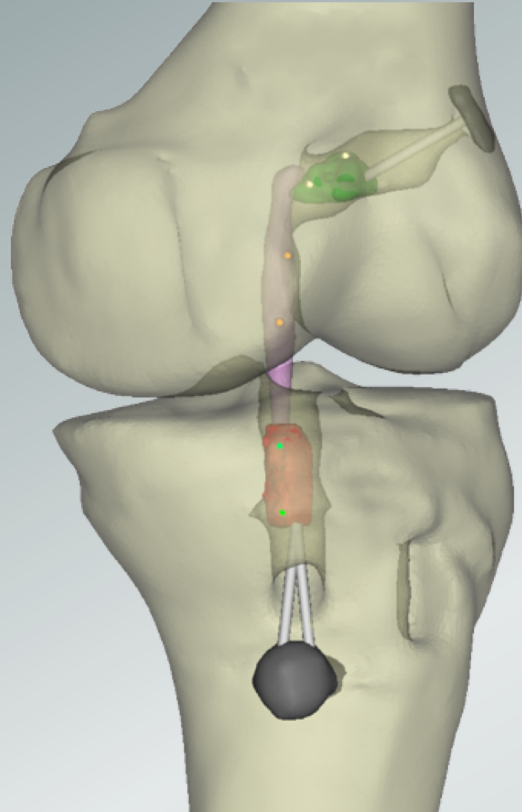
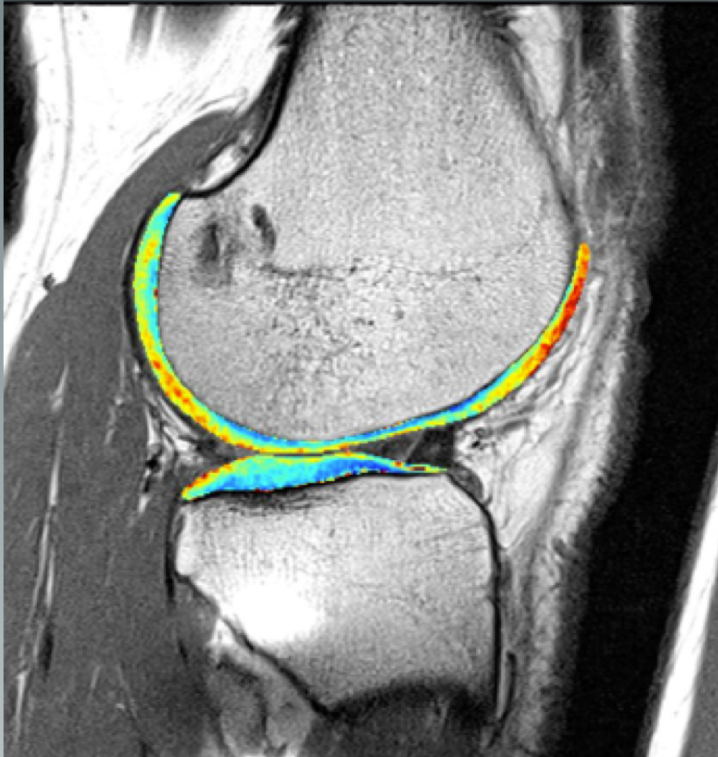


250 frame/sec
Stereo X-Ray

Instrumented
Treadmill

Advanced soft tissue imaging

- Latest-technology 3T MRI and CT
- T2 mapping for assessing cartilage health
- Ultra-short echo (UTE) imaging for evaluating tendon/ligament healing

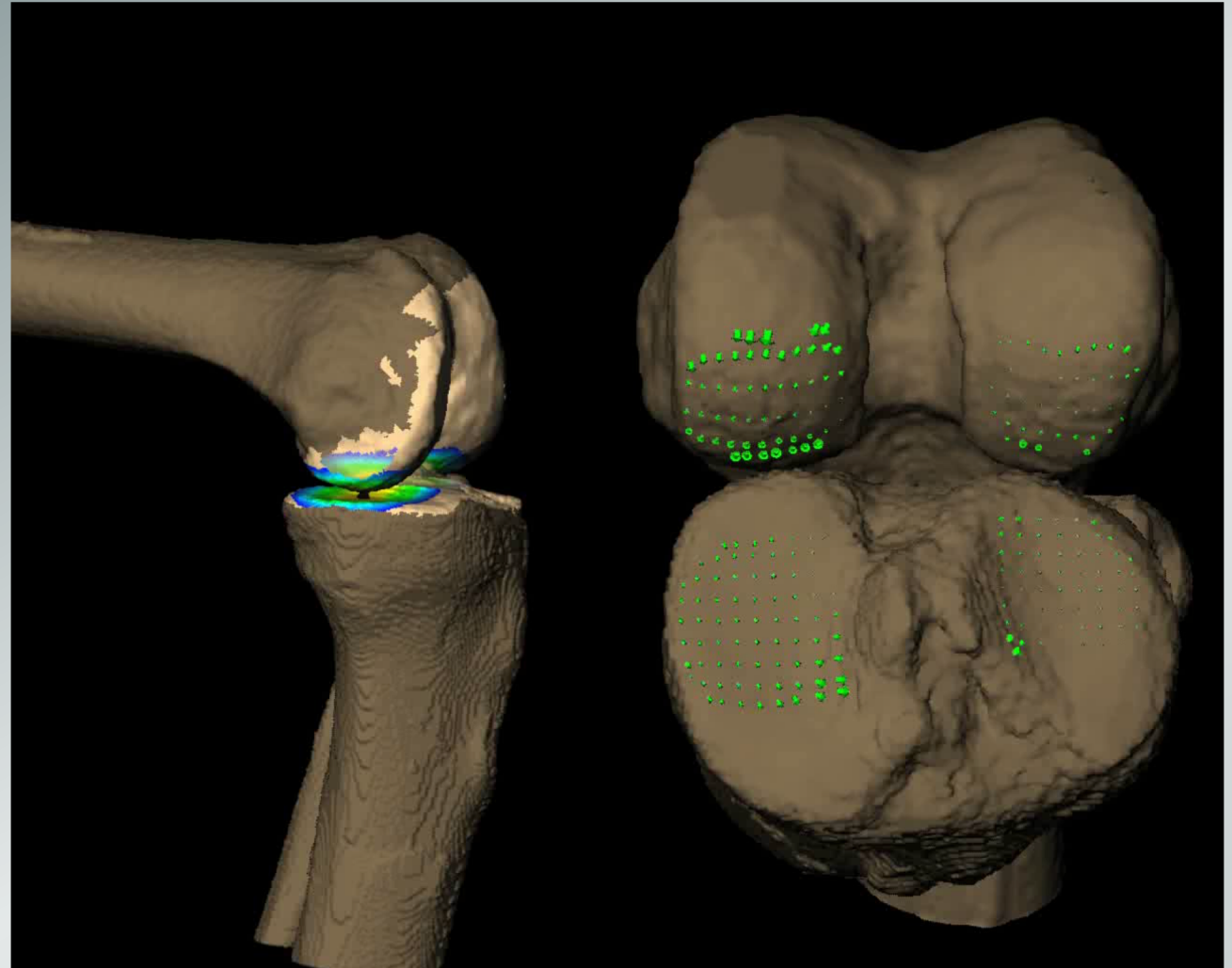


Arthrokinematics: Relative motion of articulating surfaces

Technique for visualizing
abnormal motion between
cartilage surfaces

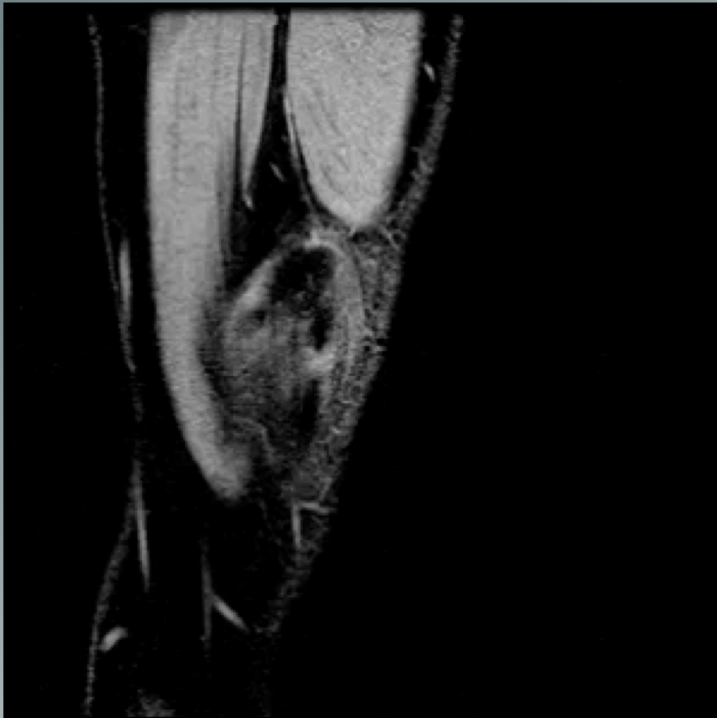
Combines DSX and CT

Ideal for identifying abnormal
cartilage mechanics that can
cause arthritis

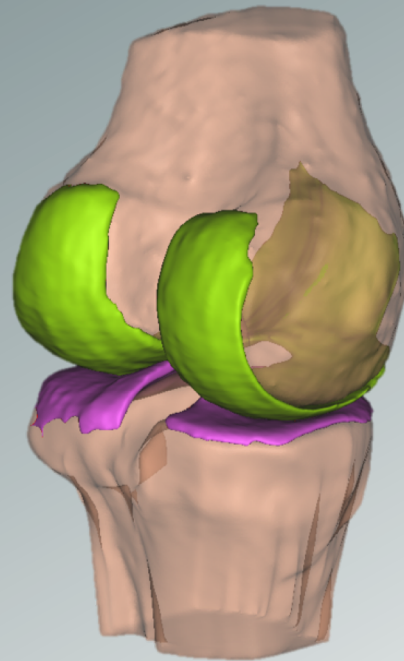


Advanced modeling of cartilage contact

Cartilage modeling

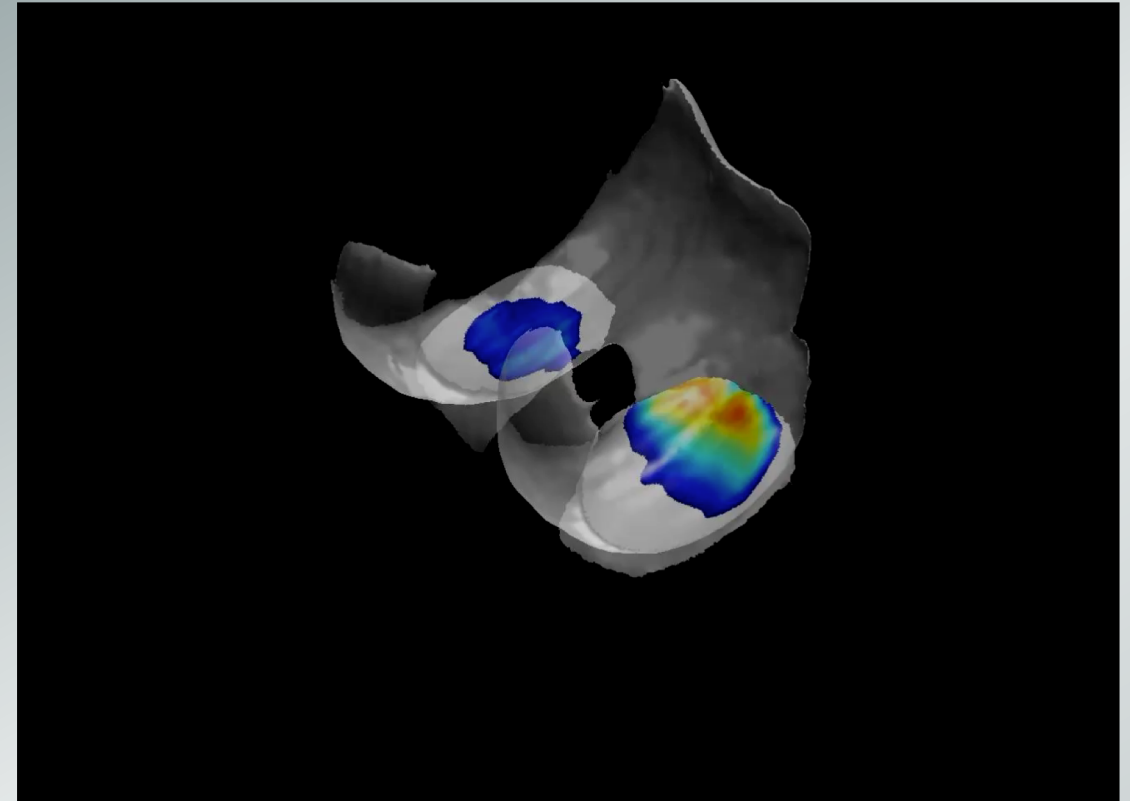


High resolution 3T MRI



Cartilage mapped
to CT bone models

Contact algorithm



Cartilage deformation

Wearable sensor technologies for studies in the field



EMG (muscle function)



IMU (motion)



Force/pressure

Current research



Reducing osteoarthritis risk: Femoro-acetabular impingement (FAI)

- Common deformity
 - 23% of all adults
 - 55% of athletes
- Reduces “safe” range of hip motion
- Major contributor to hip osteoarthritis



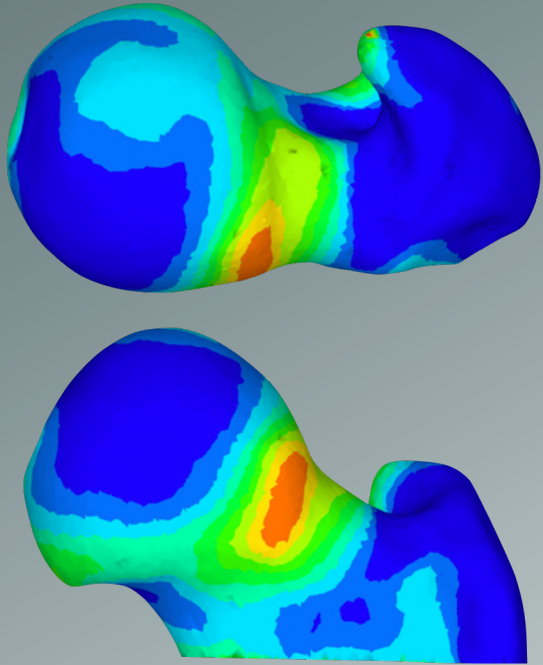
Dr. Philippon is a pioneer and world-renowned expert on the diagnosis and treatment of FAI



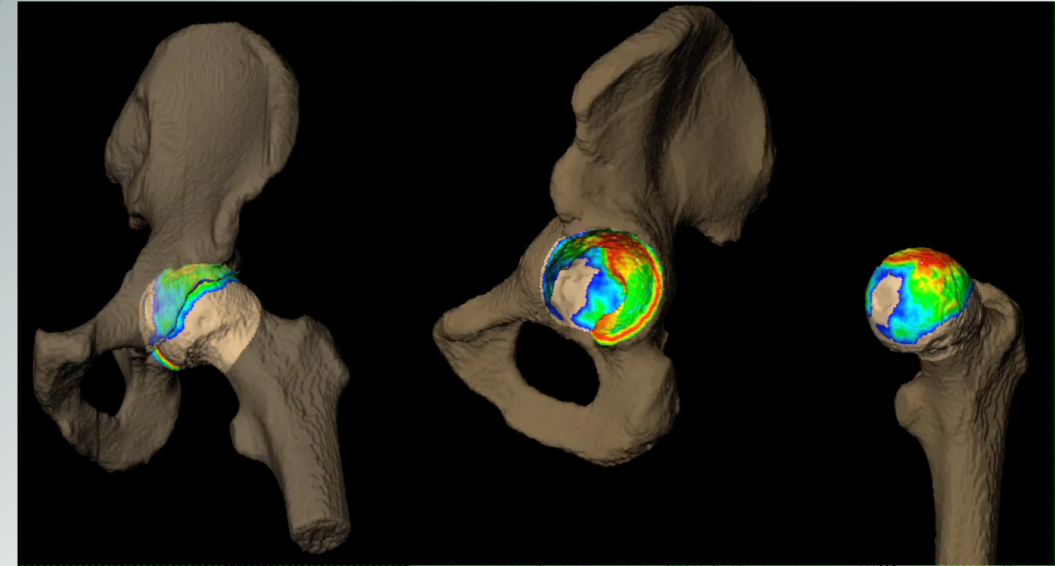
What drives development of FAI?

Pathomorphology
(bone shape)

Arthrokinematics
(joint contact)



Femoroacetabular
Impingement



Pain

Osteoarthritis

Current FAI research at SPRI

- Study of high-risk athletic population to identify factors driving development of symptomatic FAI
- Co-Principal Investigators:
 - Scott Tashman, PhD
 - Marc Philippon, MD

Goals:

- identify high-risk combinations of bone shape and movement
- Develop recommendations for training and activity modification to prevent OA



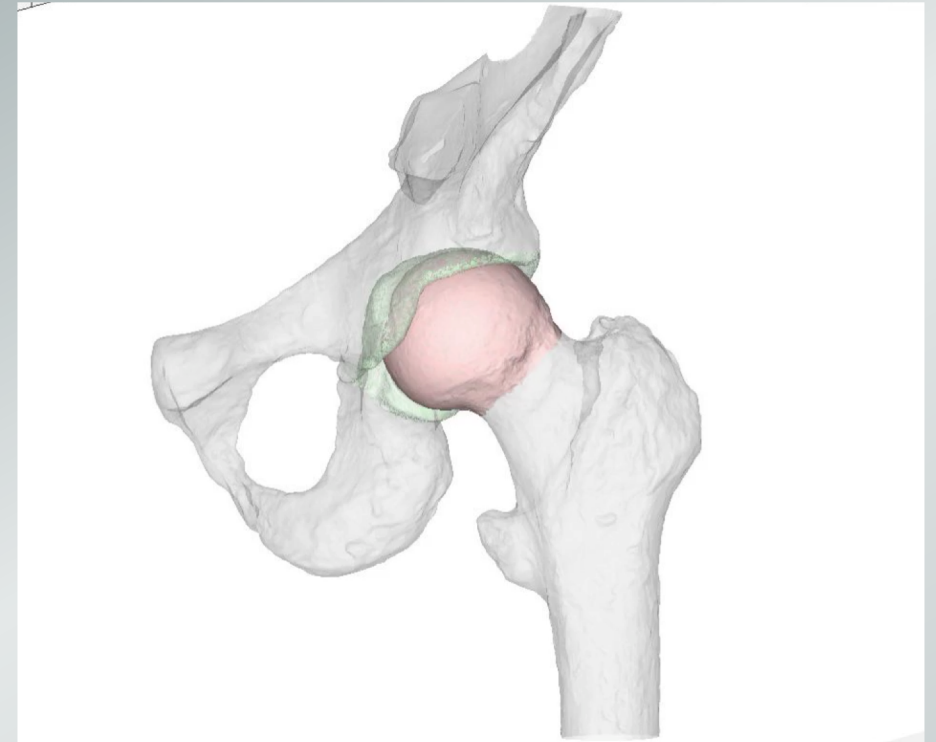
Supported by a gift from Linda and Mitch Hart

Emerging science: Hip micro-instability

- Newly identified condition
- Poorly understood
- Difficult to diagnose
- Linked to hip osteoarthritis

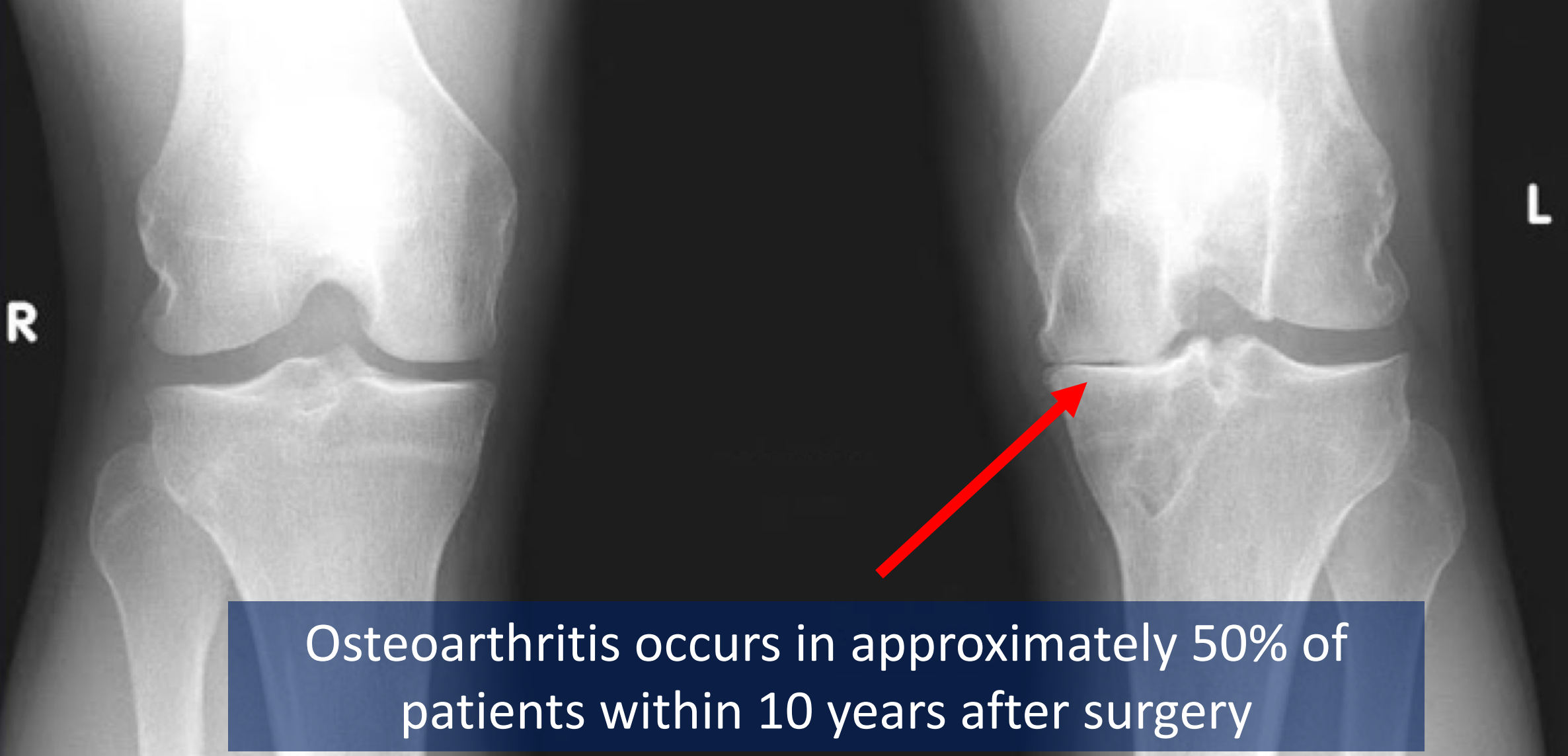


Robotic studies to characterize causes of and evaluate treatments for hip micro-instability



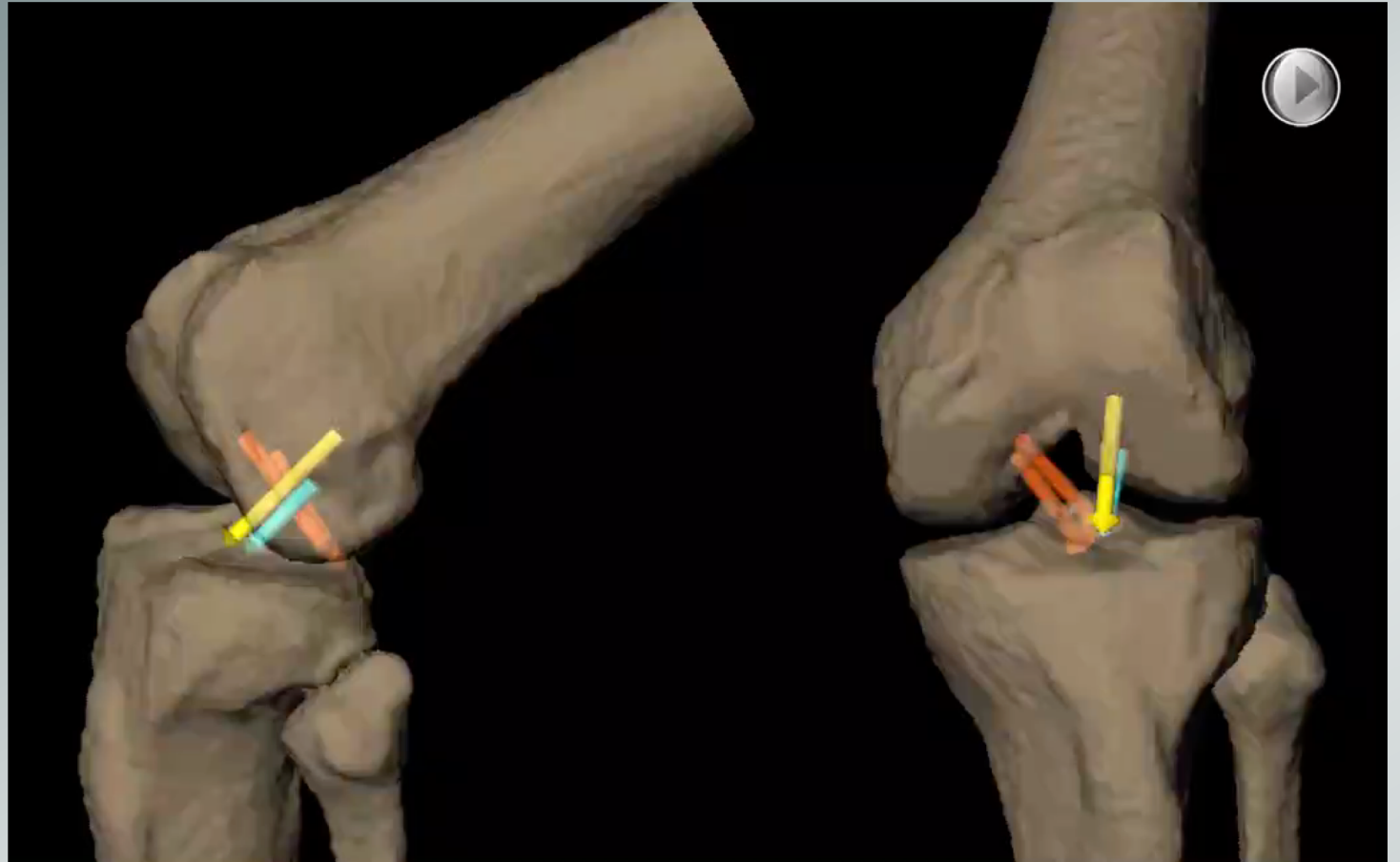
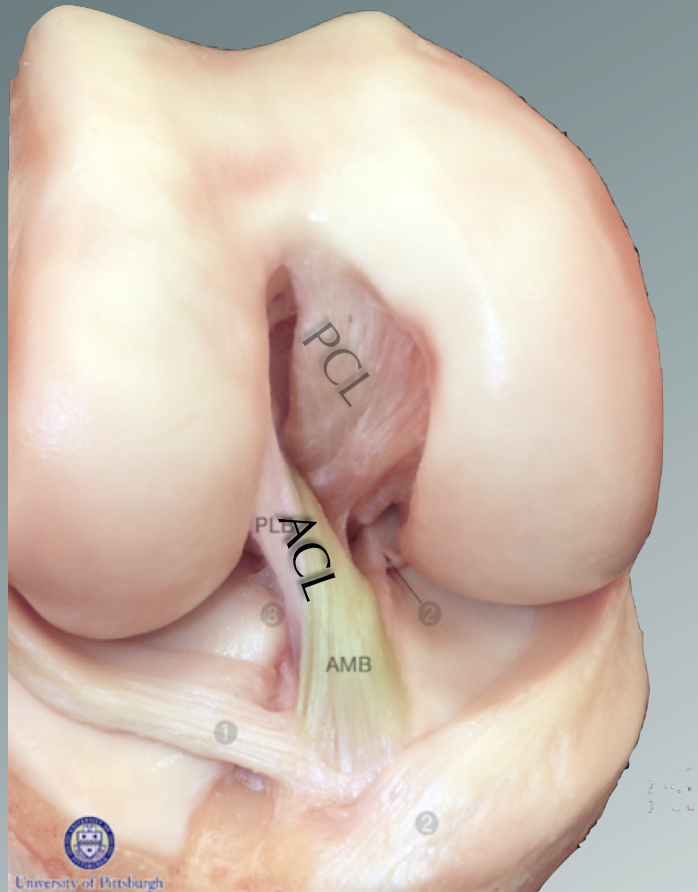
Dynamic imaging of micro-instability

Osteoarthritis after ACL injury



Osteoarthritis occurs in approximately 50% of patients within 10 years after surgery

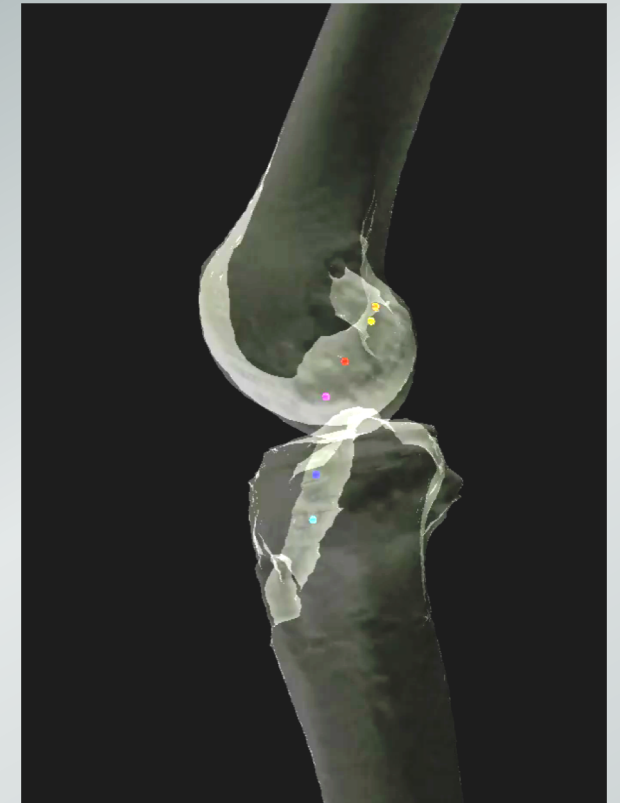
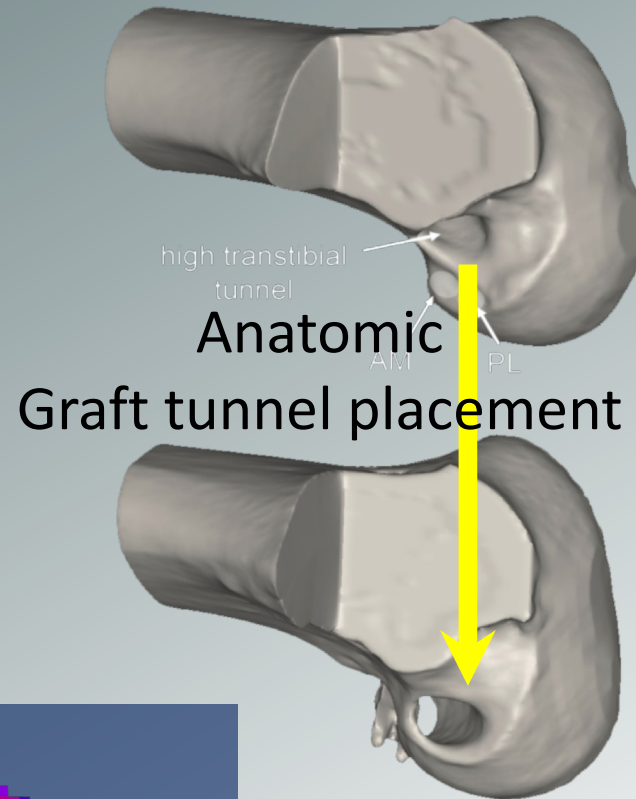
Development and evaluation of more effective surgical techniques



Anterior cruciate ligament (ACL)

Developing & evaluating better treatments

- New surgical techniques
- Optimized rehabilitation
- Biologically enhanced repair



Improved graft fixation



UTE MRI of healing ACL graft



Improving treatment for rotator cuff tears

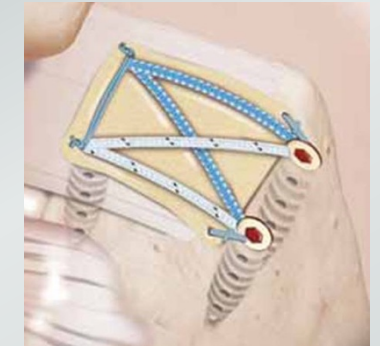
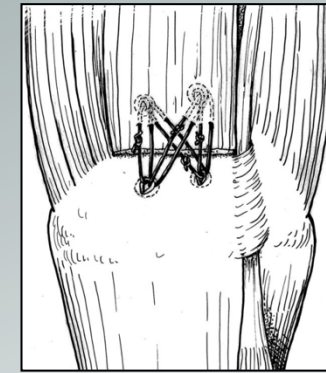
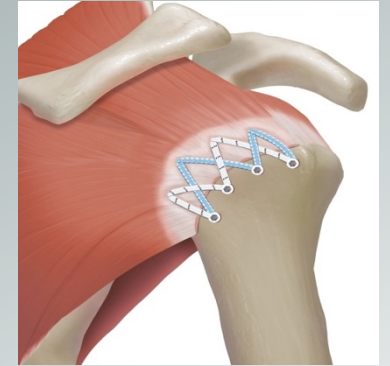
30% of all visits to orthopaedic surgeons are for pathology related to the rotator cuff

50% incidence of bilateral tears in people over the age of 66

Causes pain, disability and activity limitations

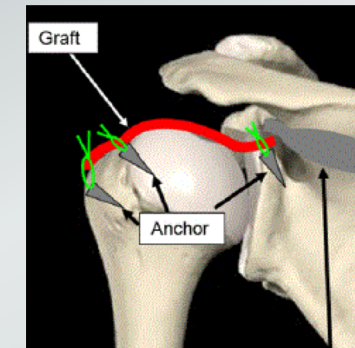
Many treatment options:

- Partial thickness: physical therapy or repair
- Full thickness: various repair options
- Massive, unreparable tears: partial repair, artificial patch/graft repair, tendon transfers, Superior Capsule Reconstruction (SCR), shoulder arthroplasty (joint replacement)

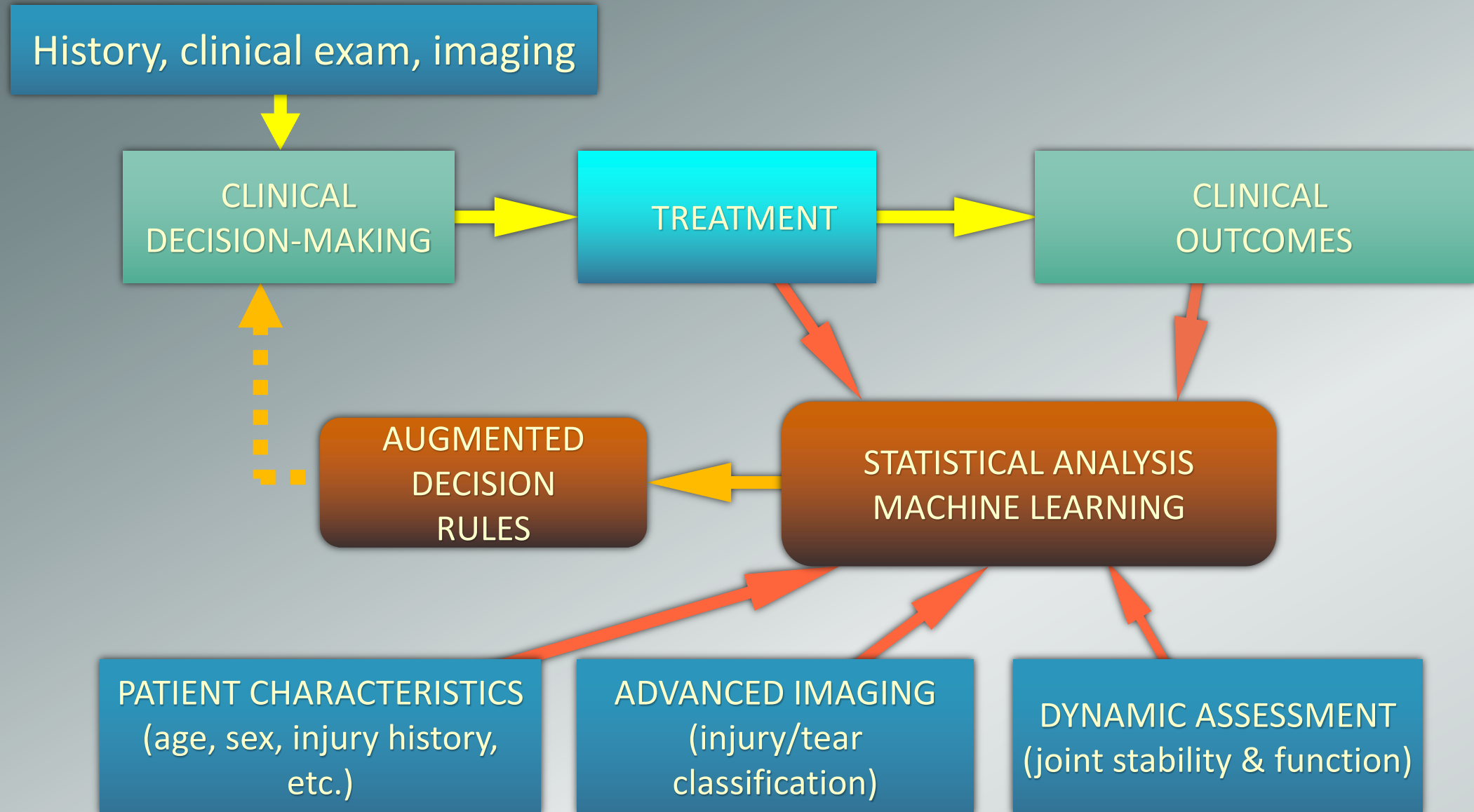


Peter Millett, MD

No clear guidelines for optimal treatment selection!



Precision Medicine: *Optimized treatment selection for every patient*



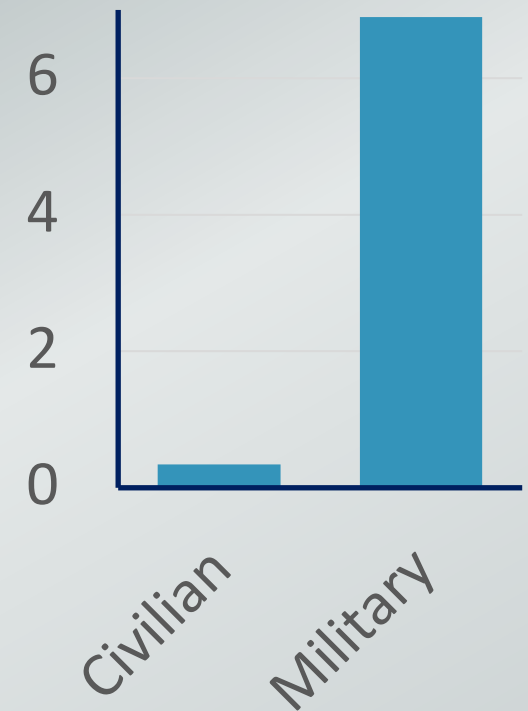
Injury Prevention: Reducing reinjury rates after ACL reconstruction



Matthew T.
Provencher, MD
CAPT MC, USNR

- ACL tears 20X more likely in military personnel than civilians
- 33% of military personnel never return to duty (RTD) after ACL injury
- 30% incidence of a second ACL injury after ACL reconstruction in young, active individuals
- Cost to DOD: \$300M per year

ACL injuries per
1000 person-years



Better RTD testing: Performance in the field

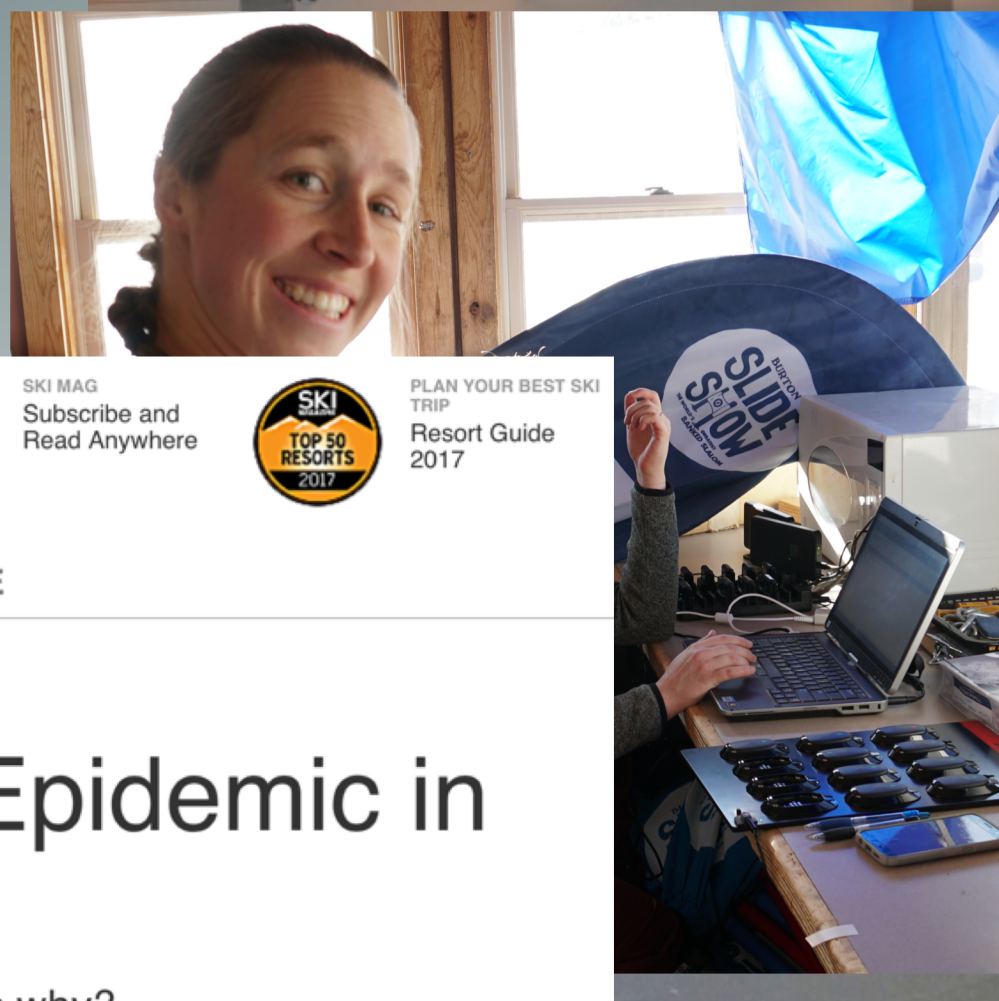
- Common return-to-sports testing not suitable for assessing warfighter readiness
- Advanced wearable technology enables “real-world” testing in rugged terrain



Focus on restoring limb-to-limb symmetry and balance

Ski Injury Reduction Program

- Optimizing boot fitting and alignment to improve skier balance and control
- In-lab tests
- On-mountain



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The confounding ACL Epidemic in Female Skiers

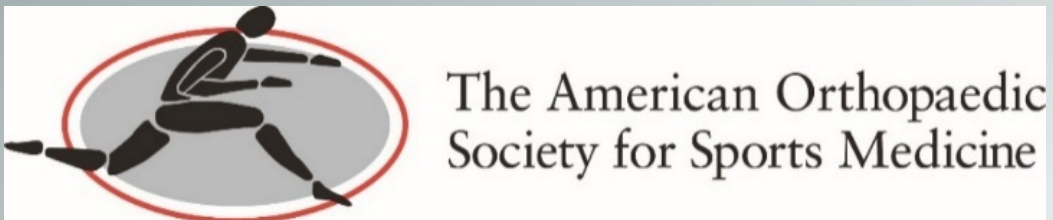
Women account for 60% of ACL injuries. The question is why?

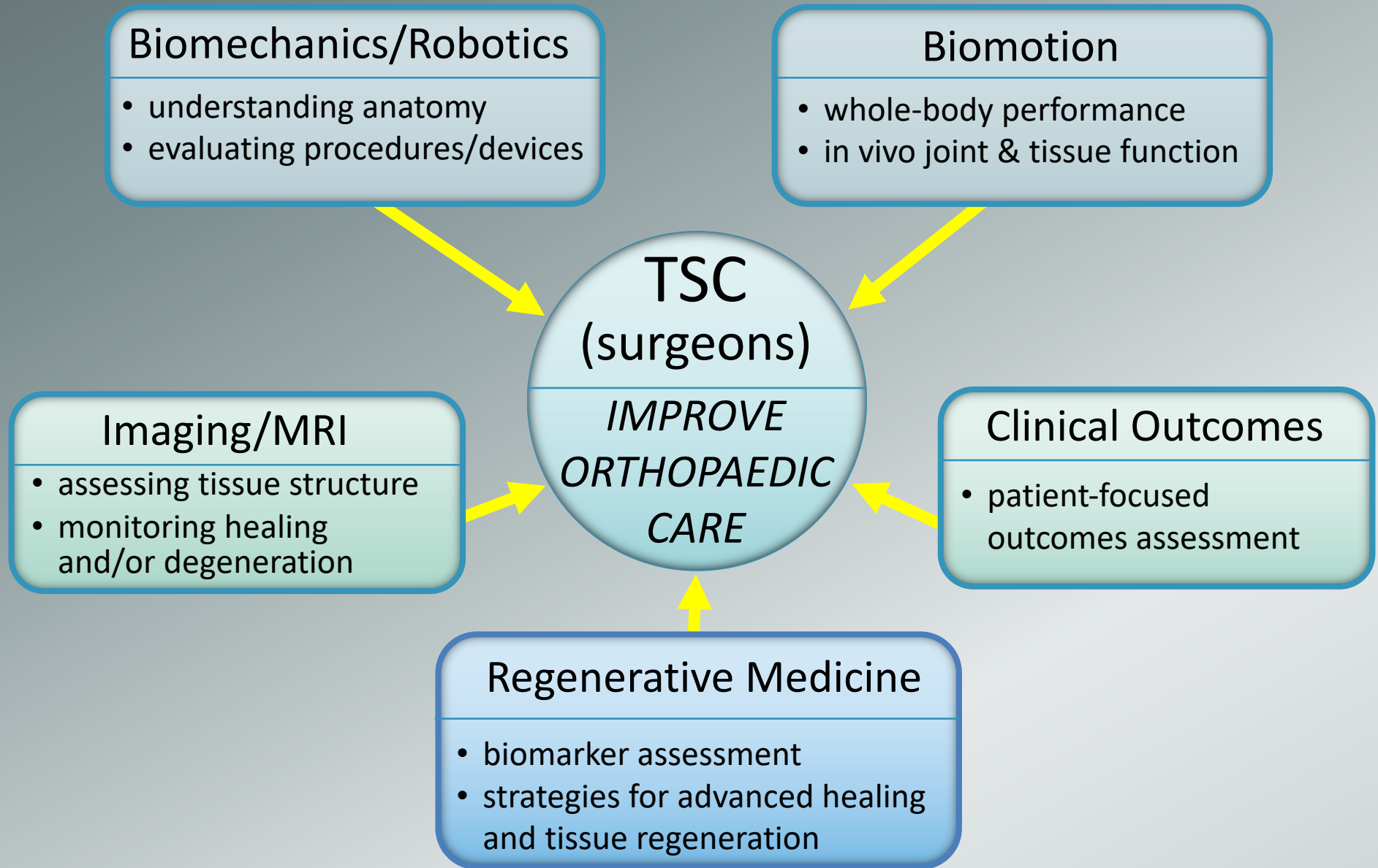
Balance/body positioning
In-boot forces
Muscle function/fatigue



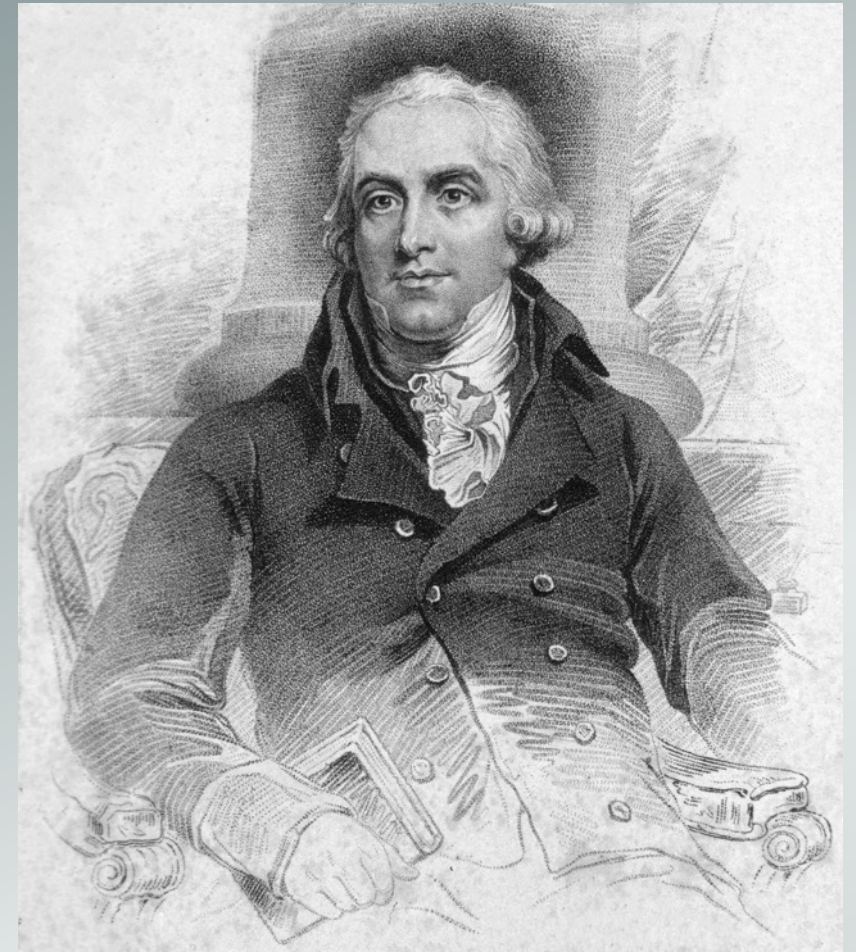
SPRI Bioengineering: Award-winning research

- **2017 Cabaud Memorial Award**
 - Best paper, basic/laboratory research, 2017 AOSSM Annual Meeting
- **2017 ISAKOS Achilles Award**
 - Most outstanding clinical or laboratory sports medicine research
- **2017 Best Scientific Exhibit**
 - Awarded to top 3 scientific exhibits at the 2017 AAOS Annual Meeting
- **2018 William A. Grana Award for Best Original Research**
 - Orthopaedic Journal of Sports Medicine
- **2018 AOSSM Fellow Research Award for Basic Science**
 - American Orthopaedic Society for Sports Medicine





Of all the causes which conspire to render the life of a man short and miserable, none have greater influence than the want of proper exercise.



William Buchan (1729-1805)
18th Century Scottish physician