Innovations in Biomechanics, Imaging and Clinical Engineering

FHS-BME Research Day:

Emily Lalone Ph.D

June 3, 2019

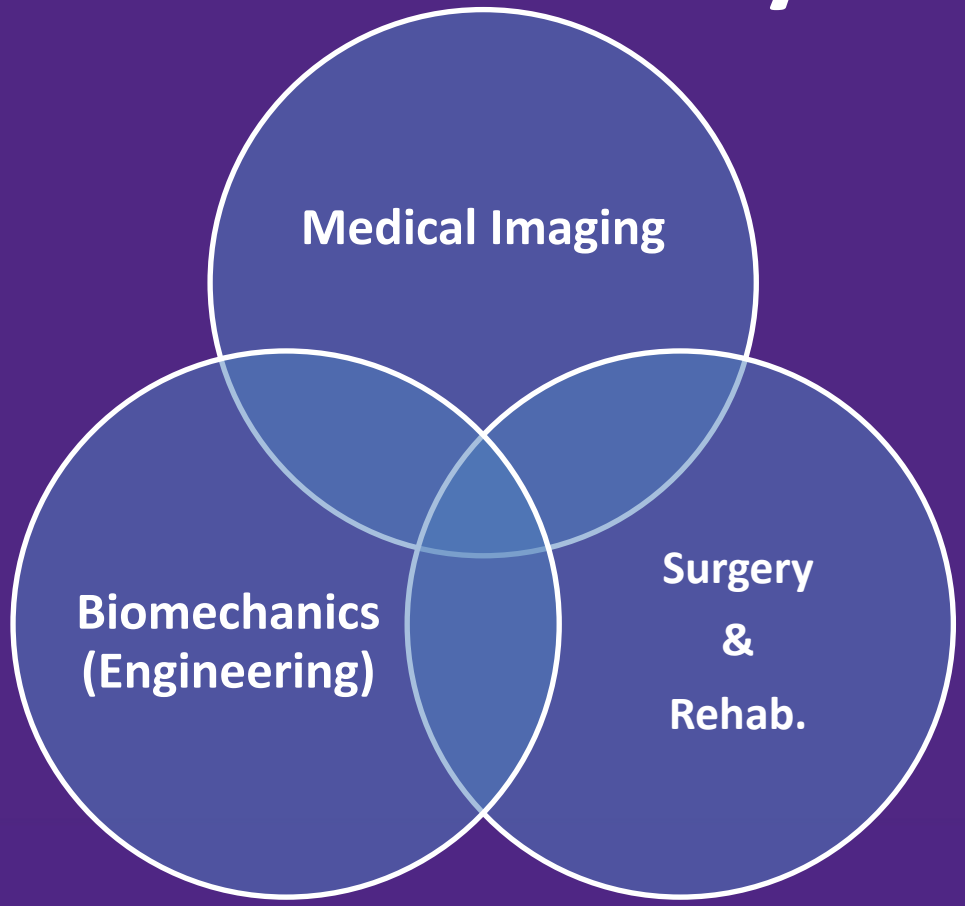
Western Engineering

Overview

- “Innovation in Motion”
- Mobility research: lab to end user-my research program
- My experience working collaboratively with Health Sciences- what I have learned

Human Biomechanics Laboratory

Thompson Engineering Building Room 306



Overview

Western Engineering

robarts RESEARCH

Western Bone and Joint Institute

LAWSON HEALTH RESEARCH INSTITUTE

ROTH | McFARLANE HAND & UPPER LIMB CENTRE

ST. JOSEPH'S HEALTH CARE LONDON

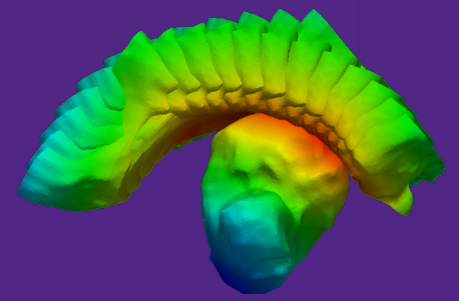
Research Themes

1. Musculoskeletal IMAGING
2. Locomotion and Human MOVEMENT
3. INJURY, surgery and rehabilitation

WHAT IS THE RELATIONSHIP BETWEEN STRUCTURE AND FUNCTION OF JOINTS??

- STRUCTURE
  - Joint Musculature
  - Joint Laxity
  - Joint Alignment
  - Cartilage, Bone, Ligaments
  - Joint Contact Area/Mechanics

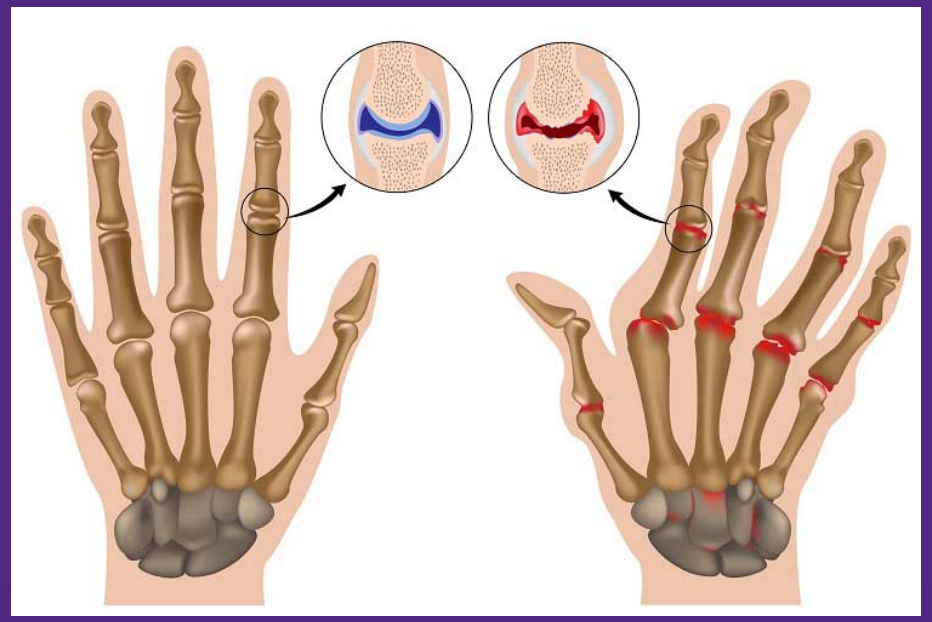
- FUNCTION
  - Kinematics (motion)
  - Joint Forces
  - Joint Contact Mechanics



How does this relationship change with injury and/or disease?

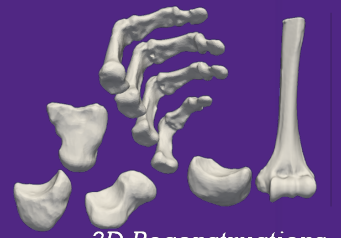
Osteoarthritis

- Dis-entangling factors that determine if mal-alignment is important
- Contributes to knowledge about pathophysiology of degenerative joint diseases
- Identify modifiable factors to provide insight into therapeutic options

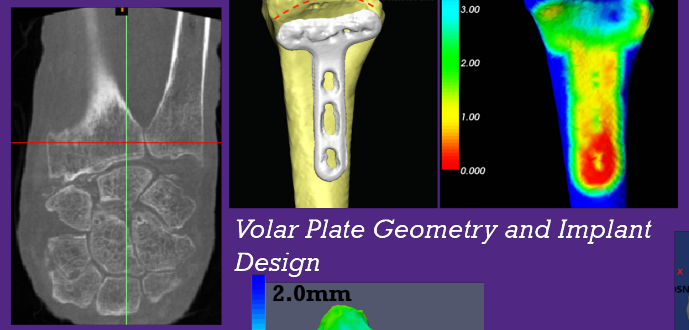


Imaging

Integrating Imaging Innovations to Understand Joint Structure, and Orthopedic Interventions

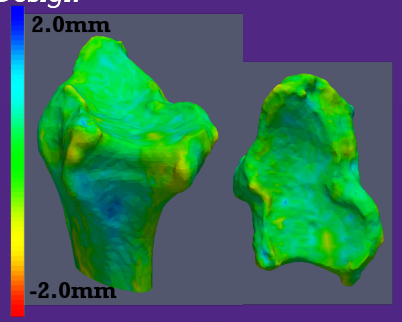


3D Reconstructions

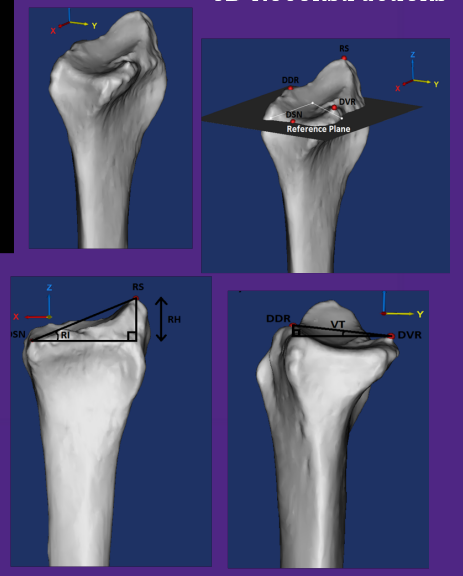


Volar Plate Geometry and Implant Design

2D Computed Tomography Slice



Deviation Maps Examining Symmetry



Anthropometric Shape of 3D Models

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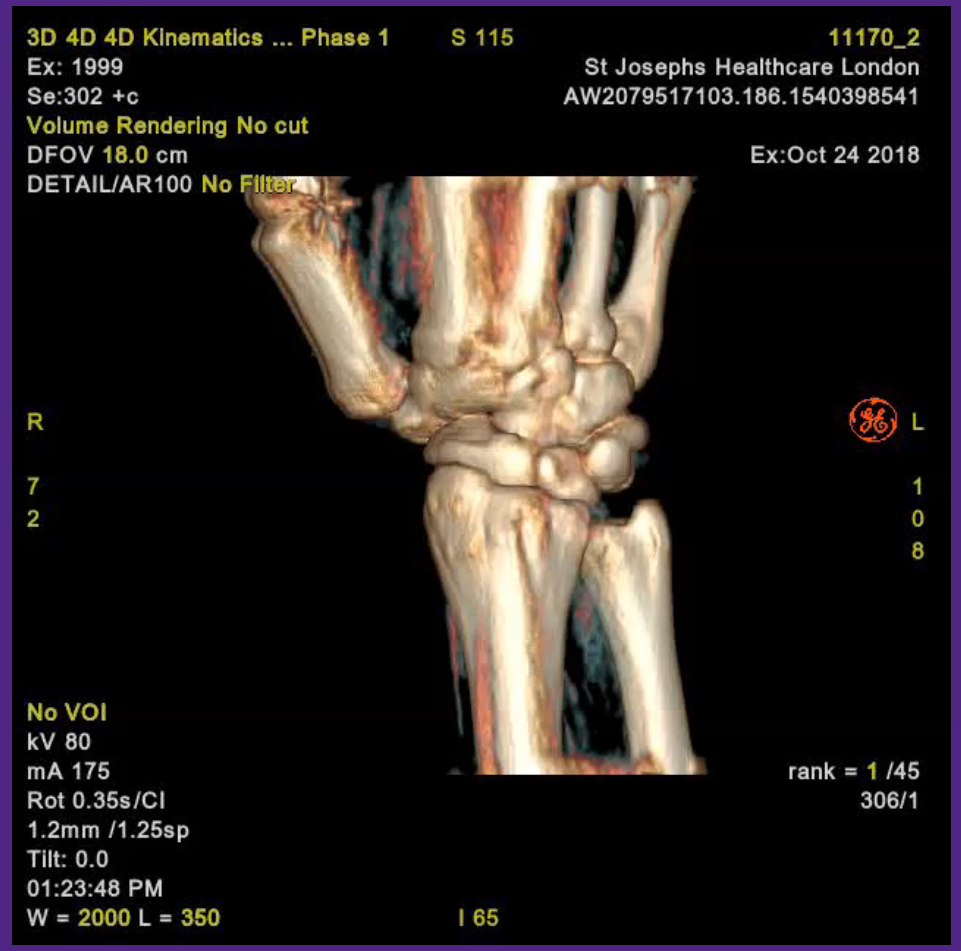
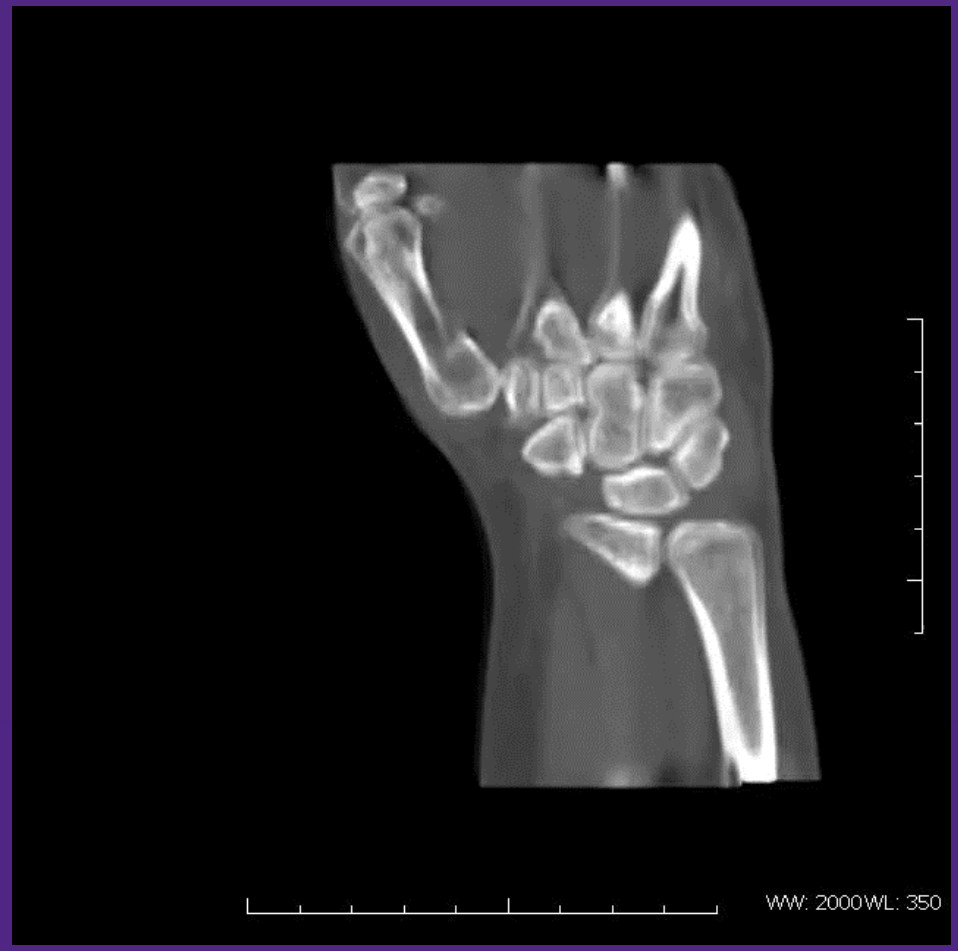
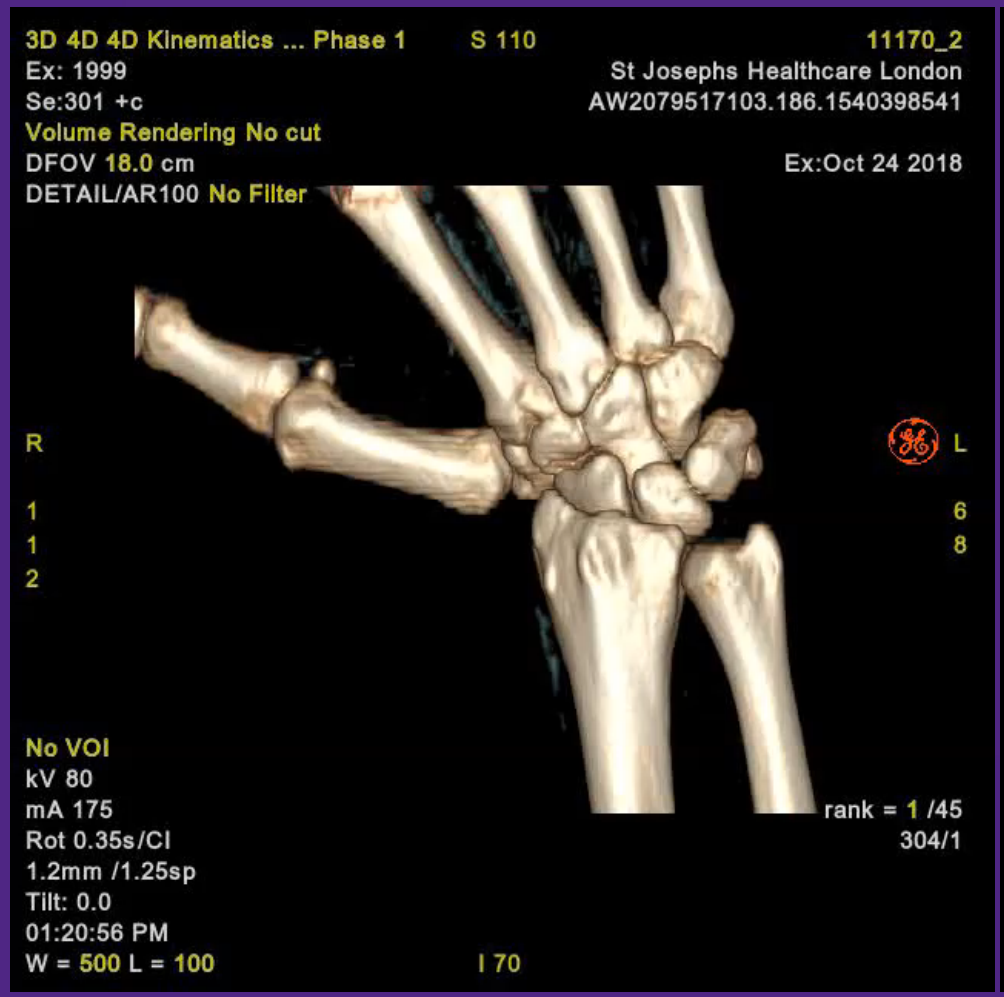
Supination/Pronation



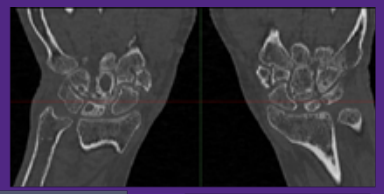


Wrist Flexion/Extension

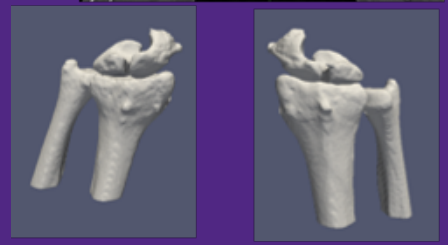
Radial/Ulnar Deviation



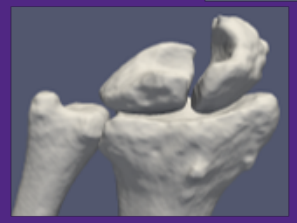
Joint Contact Mechanics



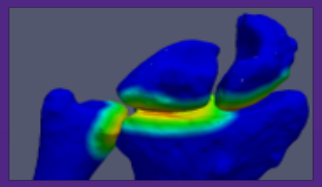
Bilateral CT
Scans



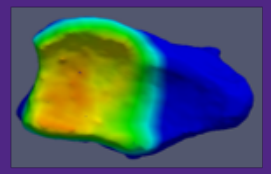
3D
Reconstructions



Measure Joint
Inter-bone Space

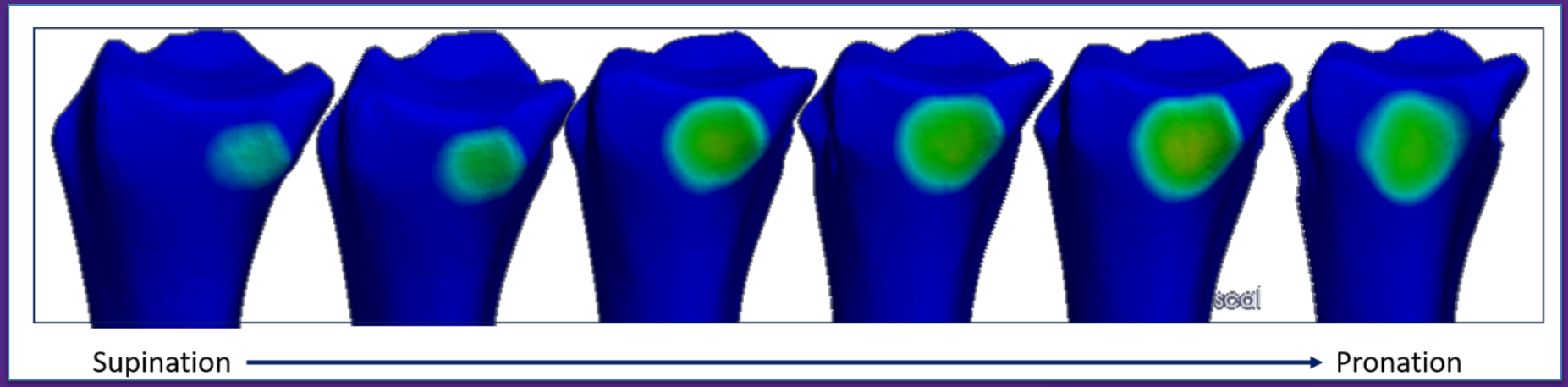


Create Colour-map to
Visualize Joint Inter-bone
Distances

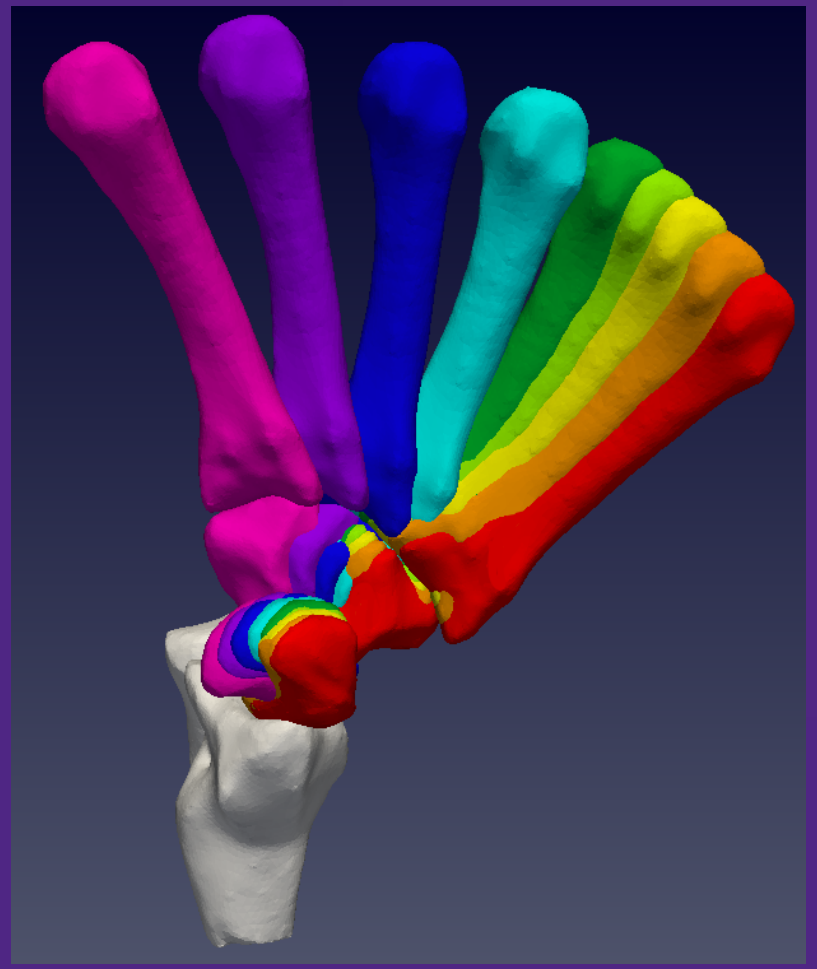


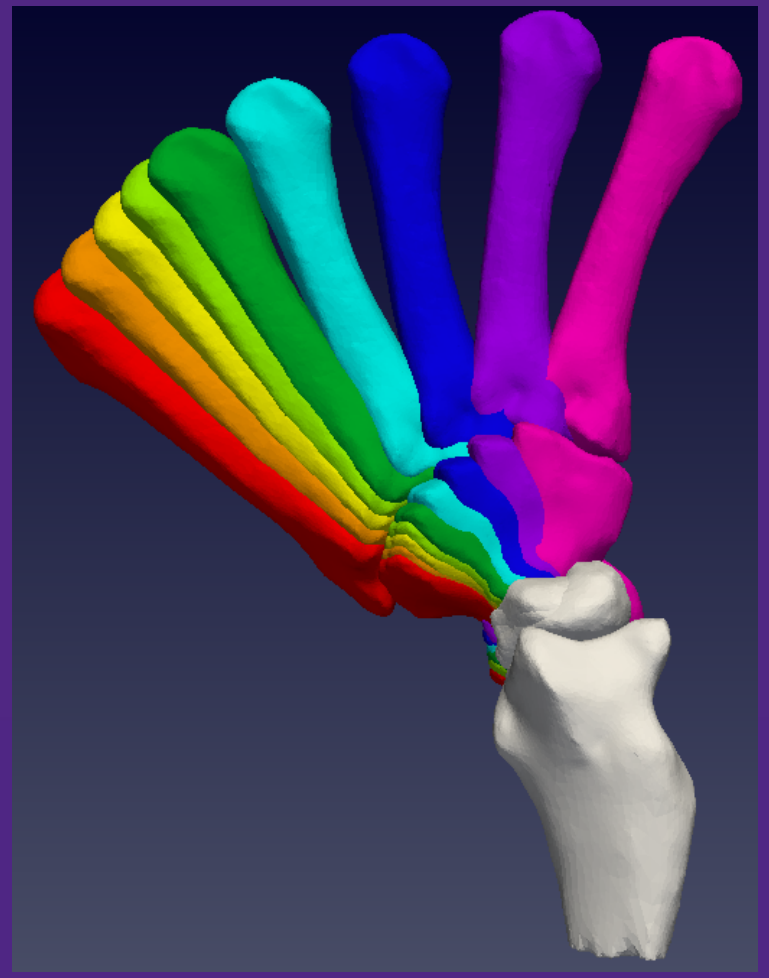
Calculate Joint Inter-bone Spacing
Area and Centroid Location (DRUJ)

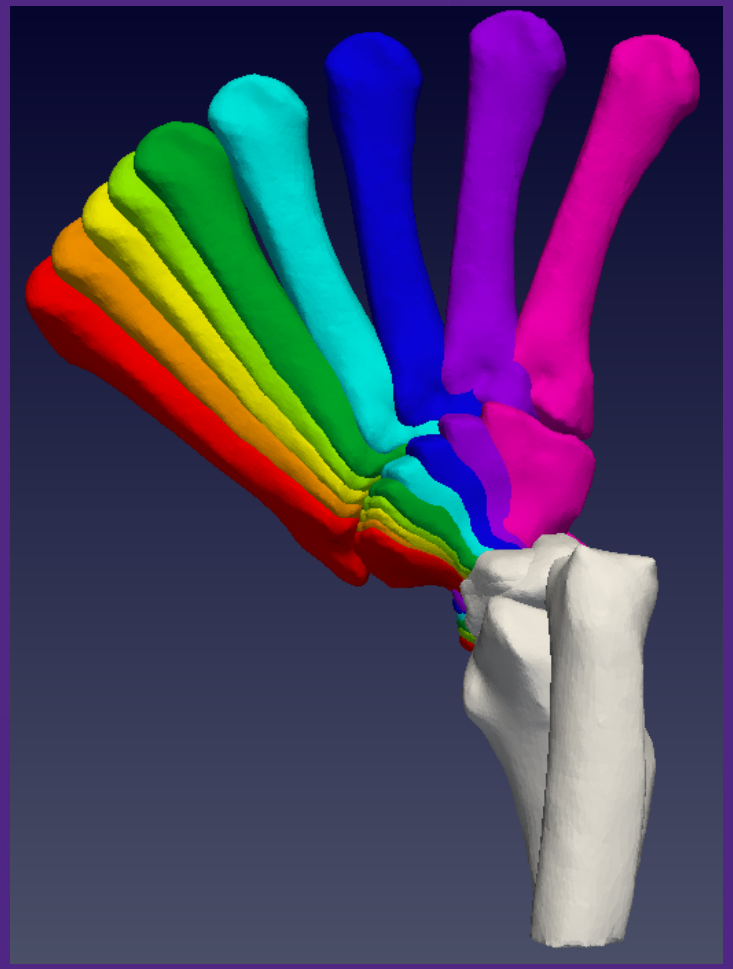
Arthrokinematics



Joint Motion

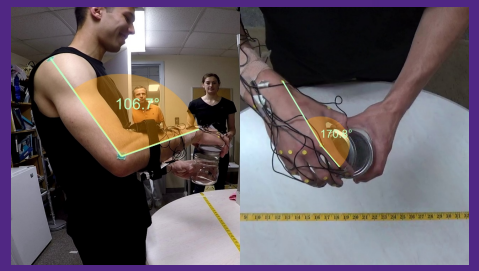






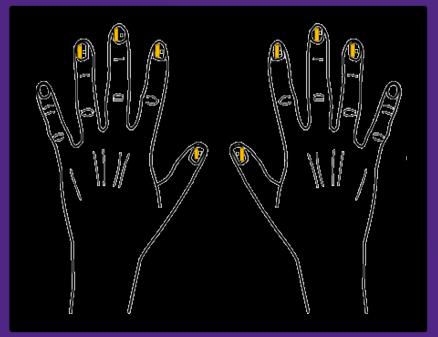
Movement

Examination of Functional Performance of Joints during Standard and Complex Tasks

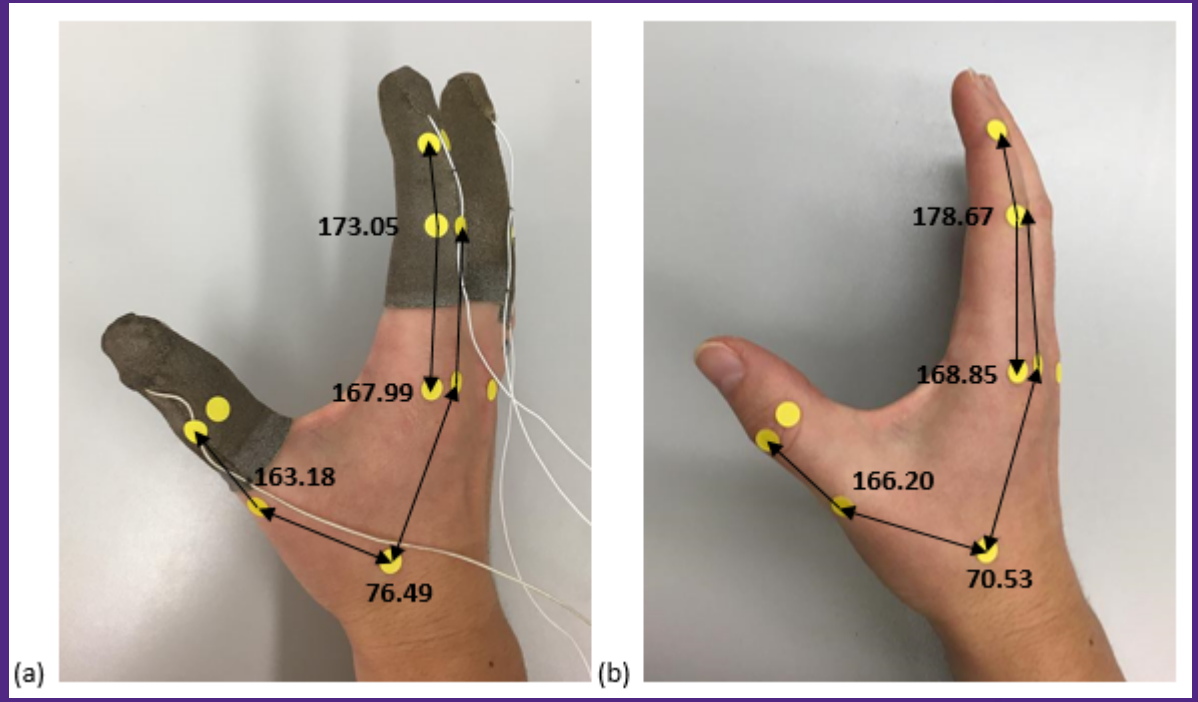


Functional Activities involving the Hand and Wrist

Video-Based Motion Capture during Activities of Daily Living and During Recreation.



Grip Configuration



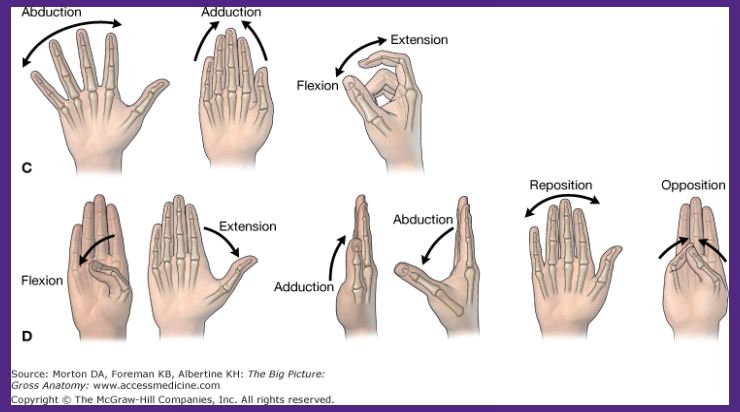
$$Maximum\ Extension: \left[\frac{\beta_1}{\alpha_{max-flex1}} + \frac{\beta_2}{\alpha_{max-flex2}} + \frac{\beta_3}{\alpha_{max-flex3}} + \frac{\beta_4}{\alpha_{max-flex4}}\right]\left[\frac{100\%}{4}\right] = X_E + 100$$

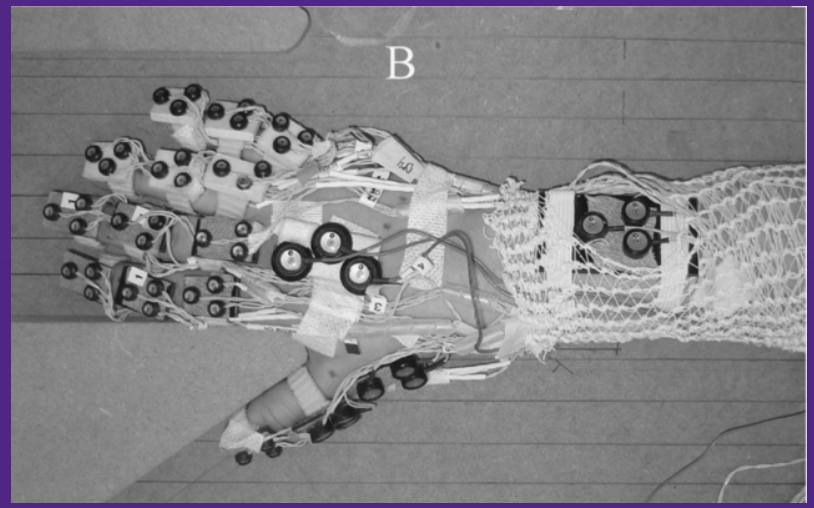
$$\left[\frac{163.18}{141.67} + \frac{76.49}{73.25} + \frac{167.99}{102.00} + \frac{173.05}{67.30}\right]\left[\frac{100\%}{4}\right] - 100 = X_E$$

$$X_E = 60.36\%$$

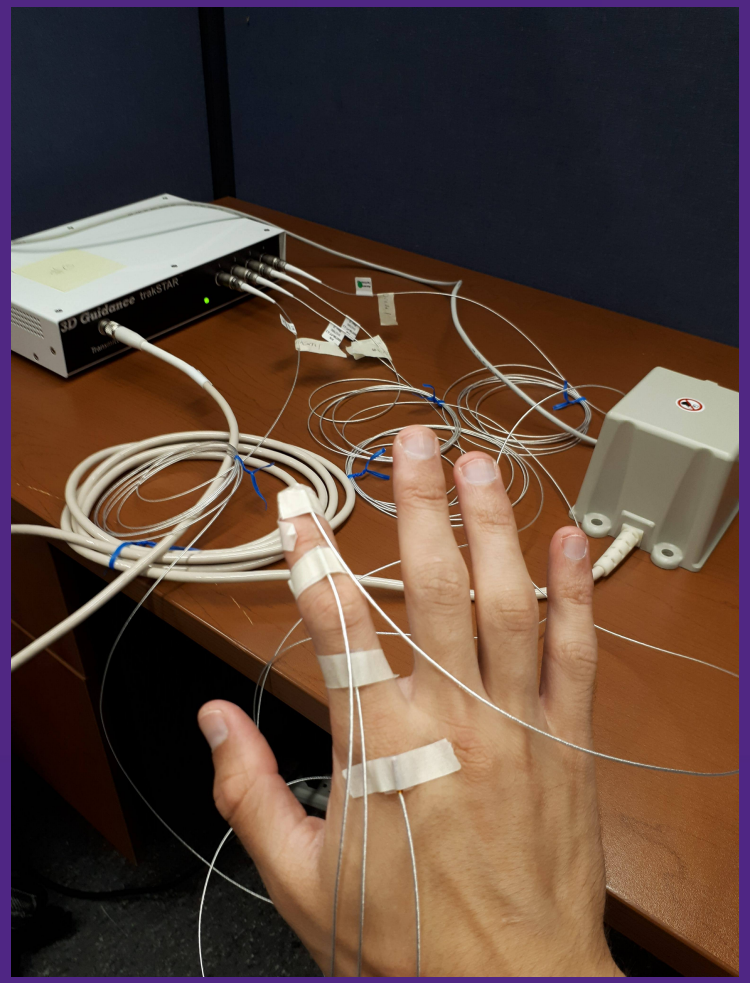
Finger Kinematics

- Complexity of motion pathways
- No universal CS definition
- Current standard: optical tracking

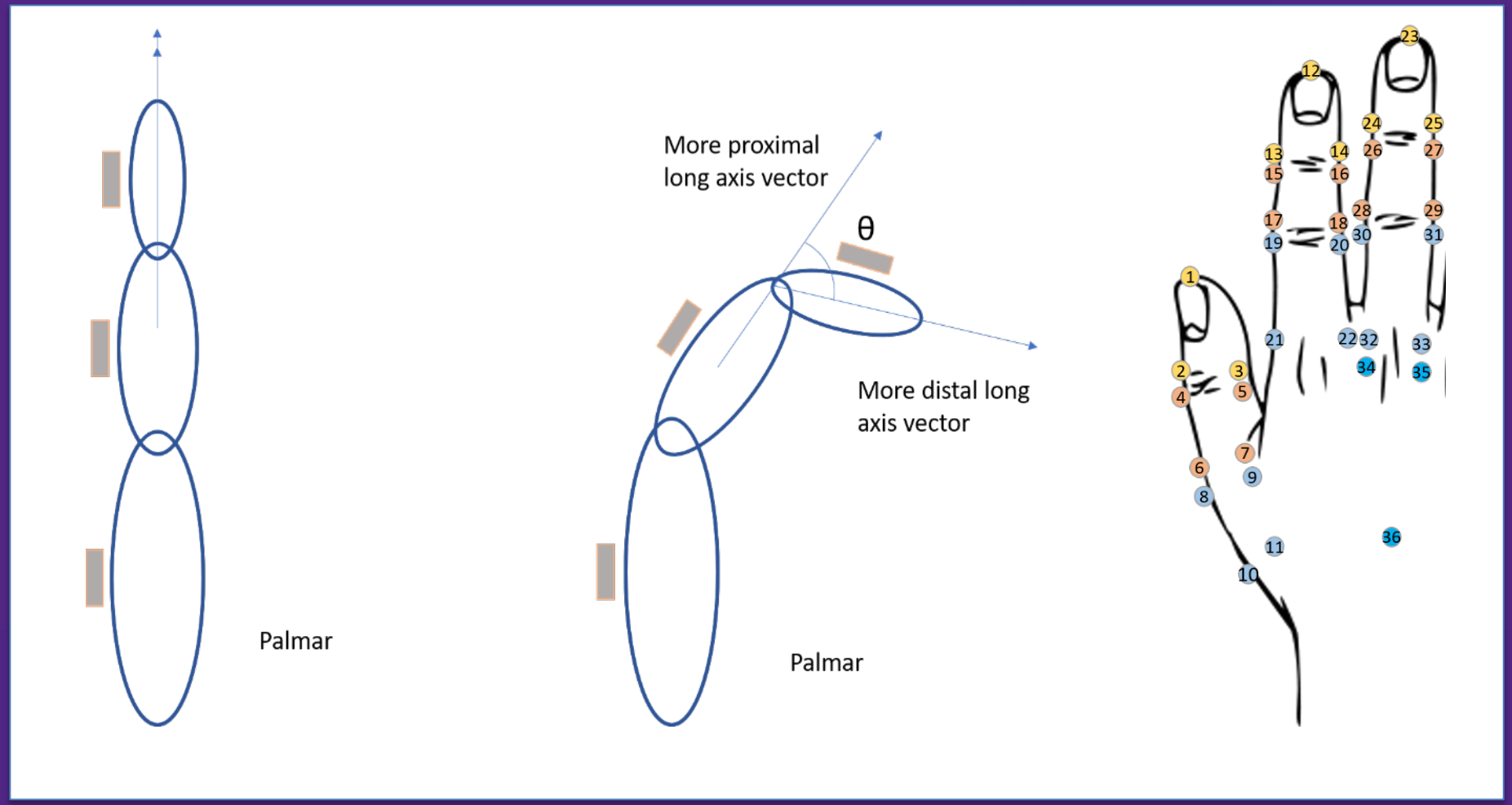




Motion Capture

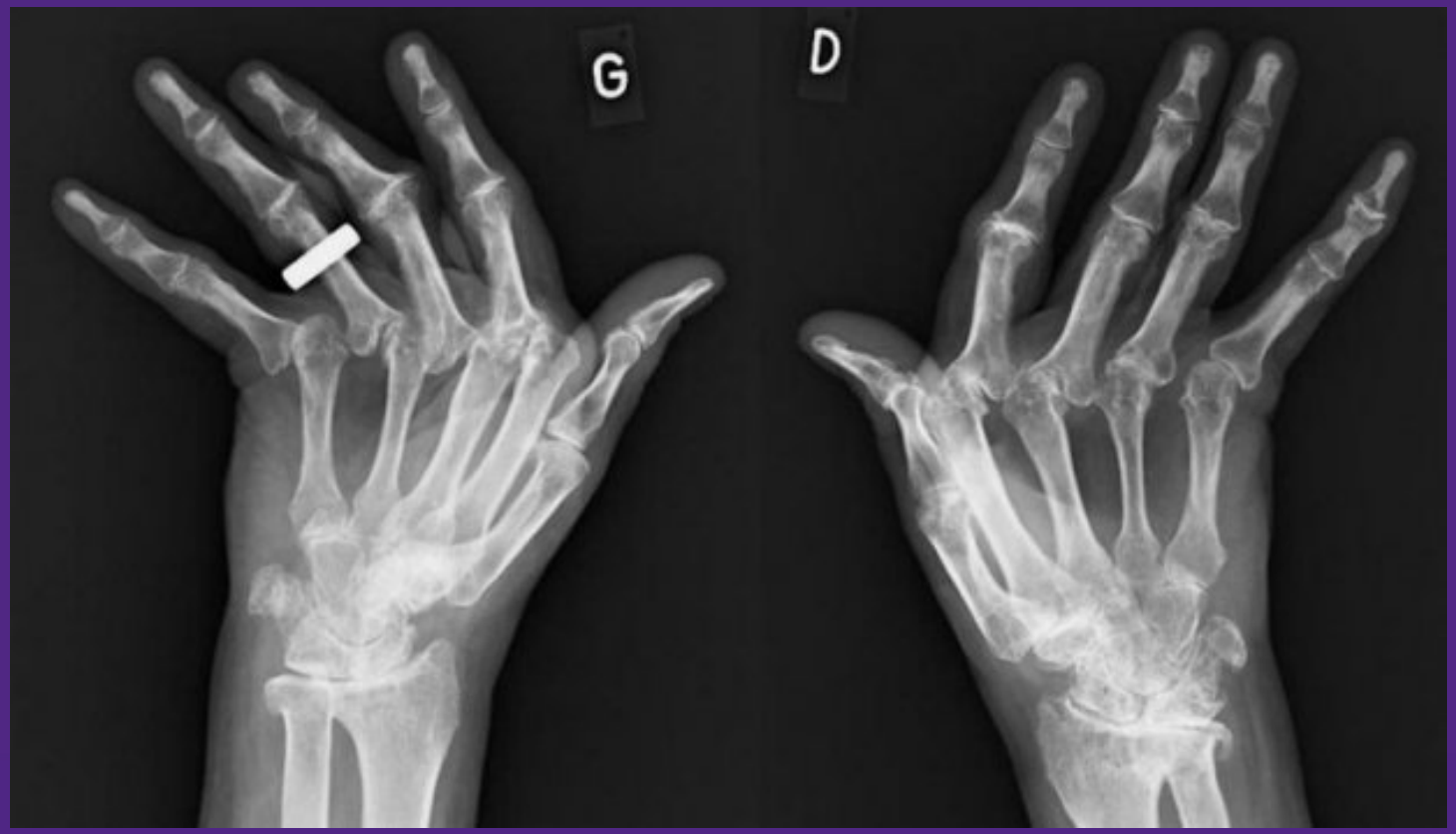


Finger Kinematics



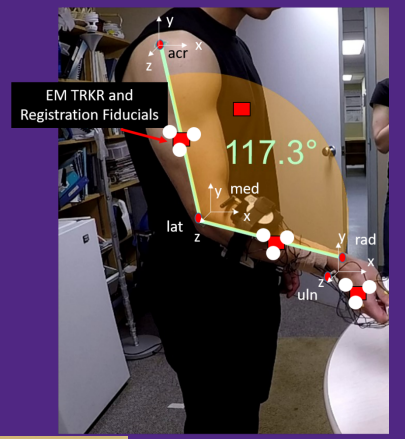
Activities of Daily Living

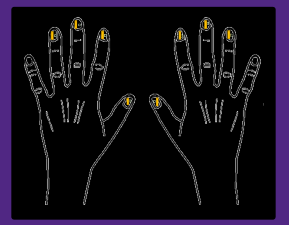
Finger Laxity and Deformity



Injury

Engineering in Clinical Setting (Interventions for Primary Prevention of MSK disorders and Solutions for Self-Care Strategies for Patients)





Finger Force Sensors and kinematic tracking to Examine Current Joint Protection Programs

Osteoarthritis

- Pain and stiffness
- No cure-single most unmet need in Rheumatology

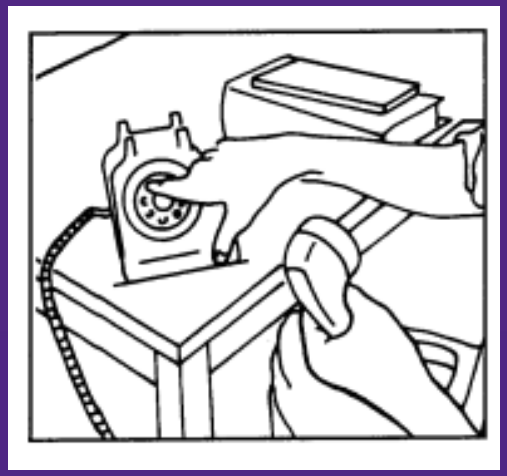
Joint Protection

Self-Management Strategy

- Alternative Movement
- Assistive Devices

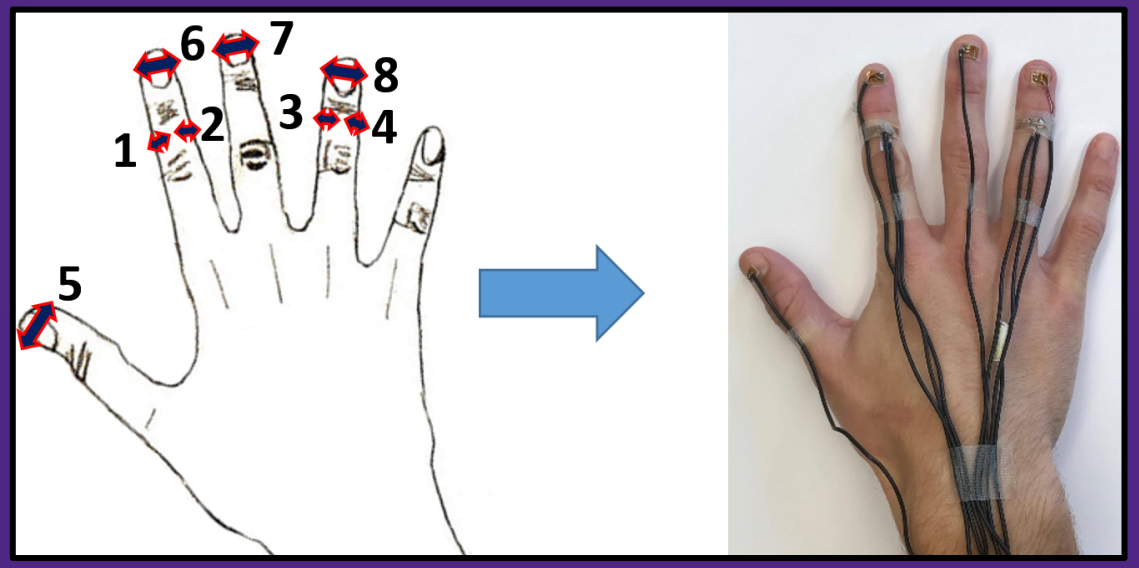
Current Limitations with JPP

- Outdated recommendations
- Insufficient evidence
- Not definitively described in literature
- Compliance

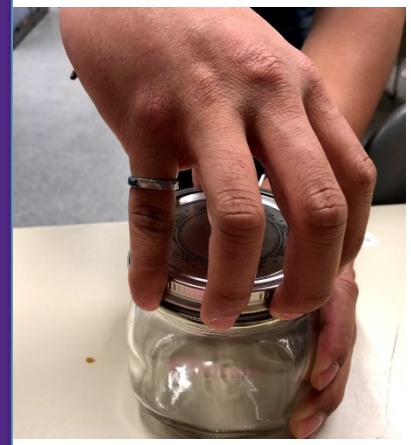


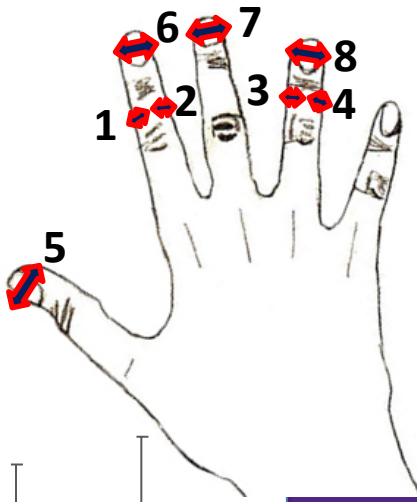
Force Sensors

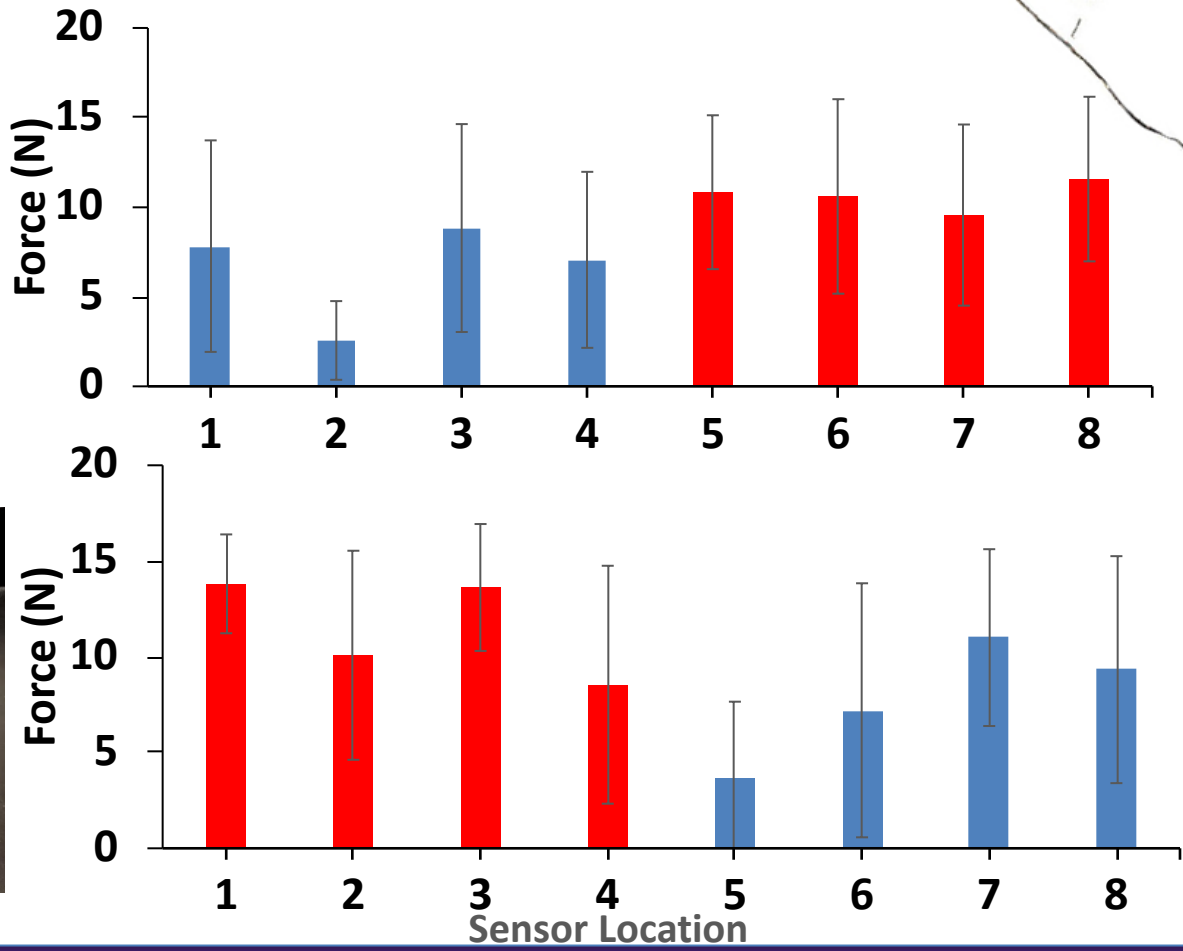
To develop a testing procedure to evaluate finger kinematics to examine joint deformity associated with hand OA during activities of daily living (Ferreira)



Results




6
7
8
2
3
4
1
5


Force (N)
20
15
10
5
0
1
2
3
4
5
6
7
8
Force (N)
20
15
10
5
0
1
2
3
4
5
6
7
8
Sensor Location

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Discipline Differences

<0.5°

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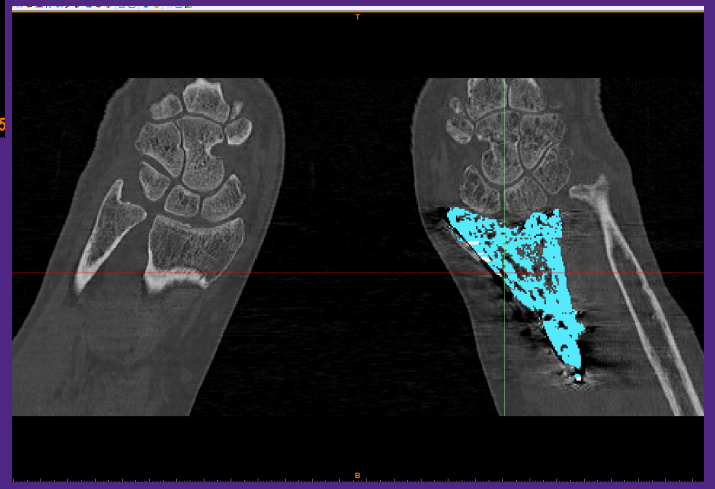
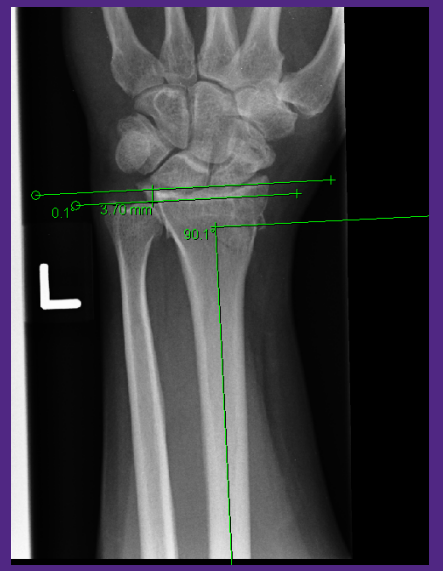
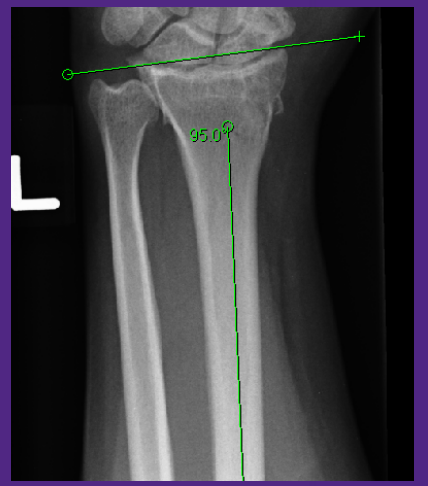
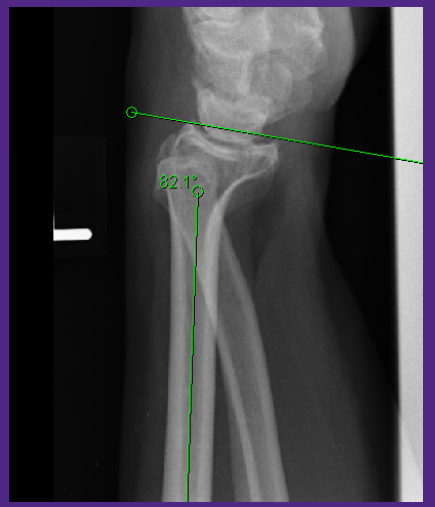
Watch and Observe

- What data is available clinically?







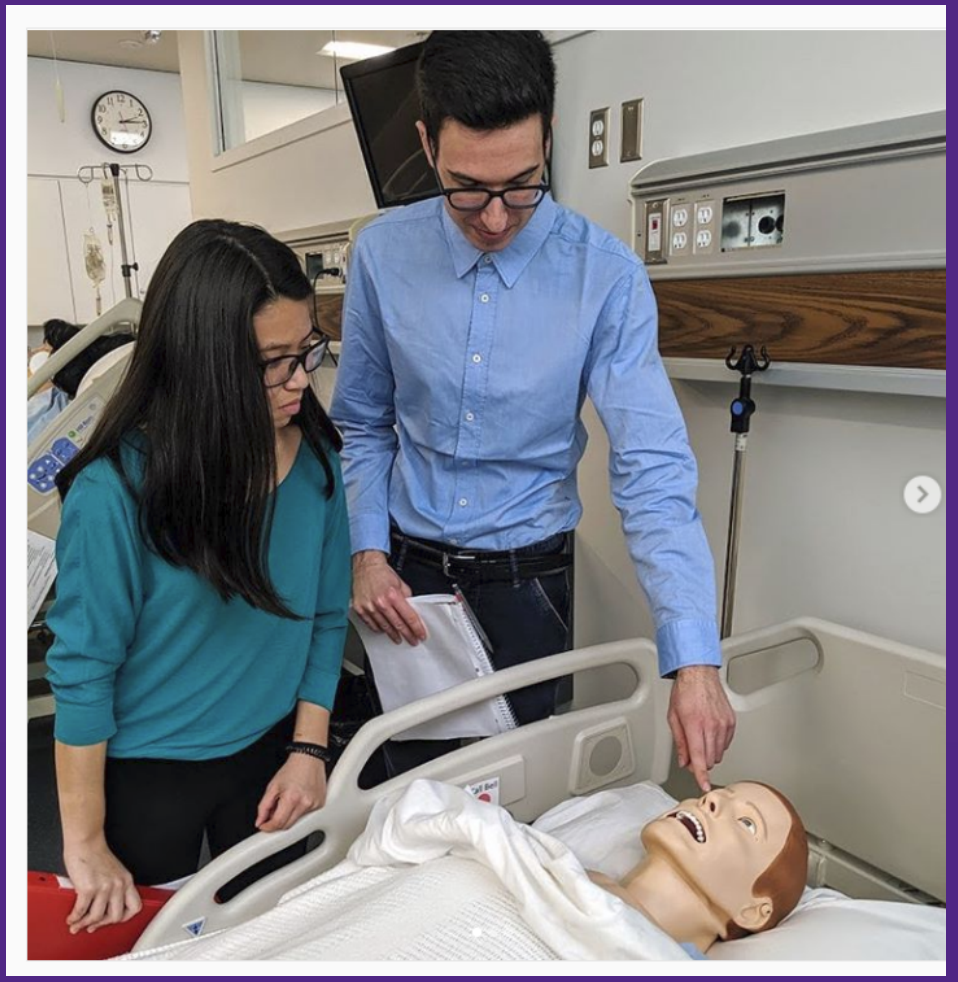


Push vs. Pull Design

Collaborative (PULL)

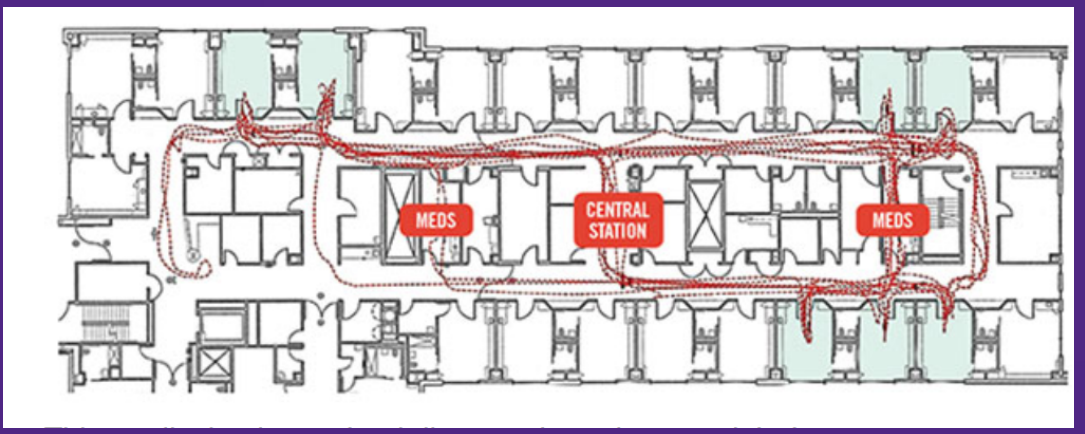
- This is a team-oriented style where the influencer aims to involve others who will offer views and ideas about the issue. This style is most appropriate when:
  - You require commitment from others.
  - You want innovative ideas from others.
  - Your issue has no clear answer.

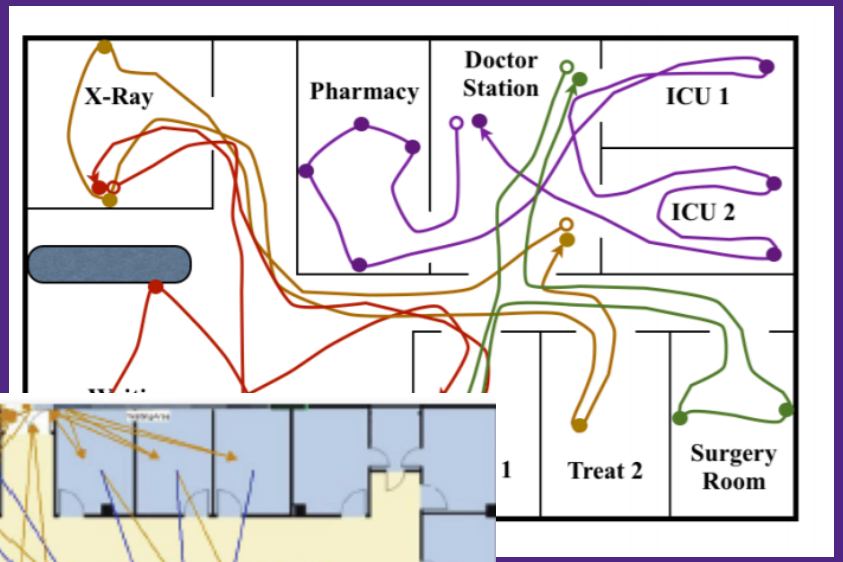
Design Something that Solves a Problem



Don’t Disrupt the Clinical Workflow

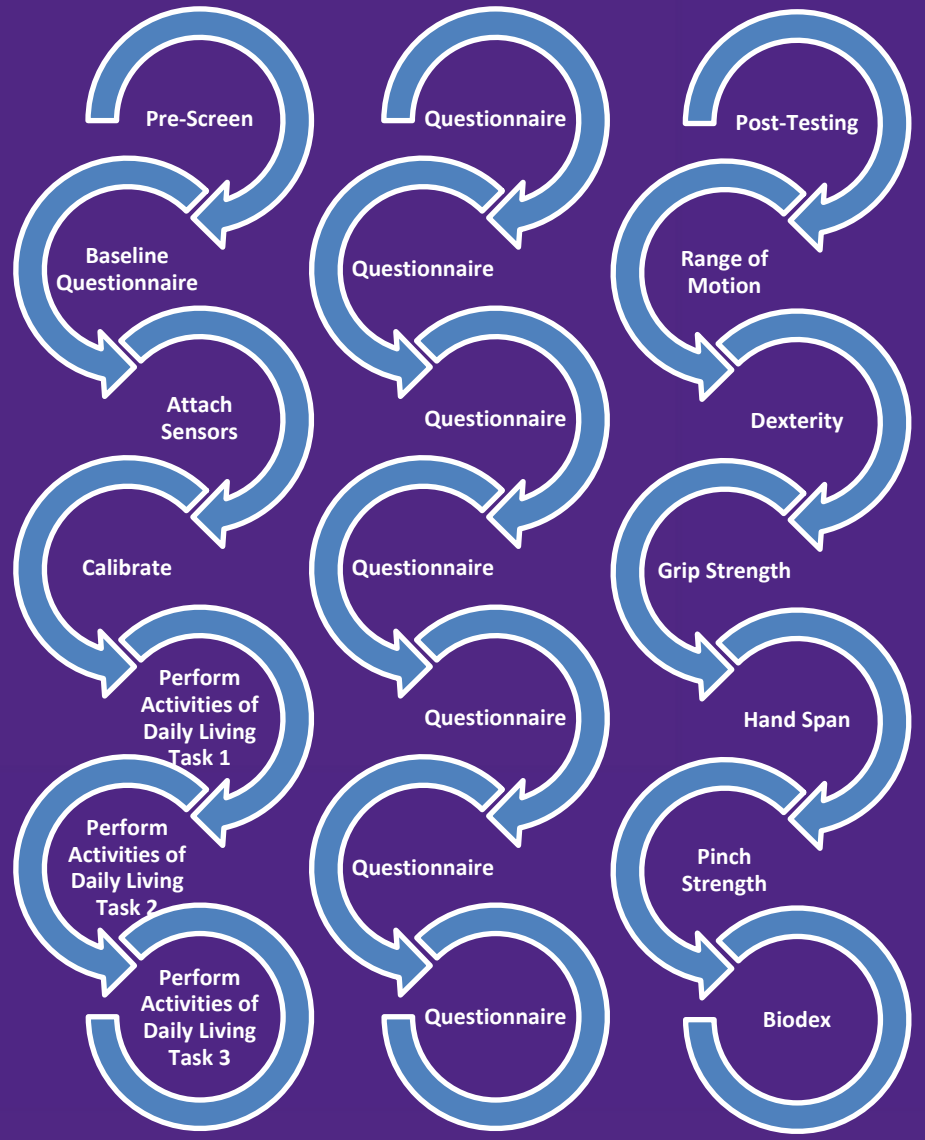
- Its your job to fit in with the pace and flow of the clinic
- Communication is key!



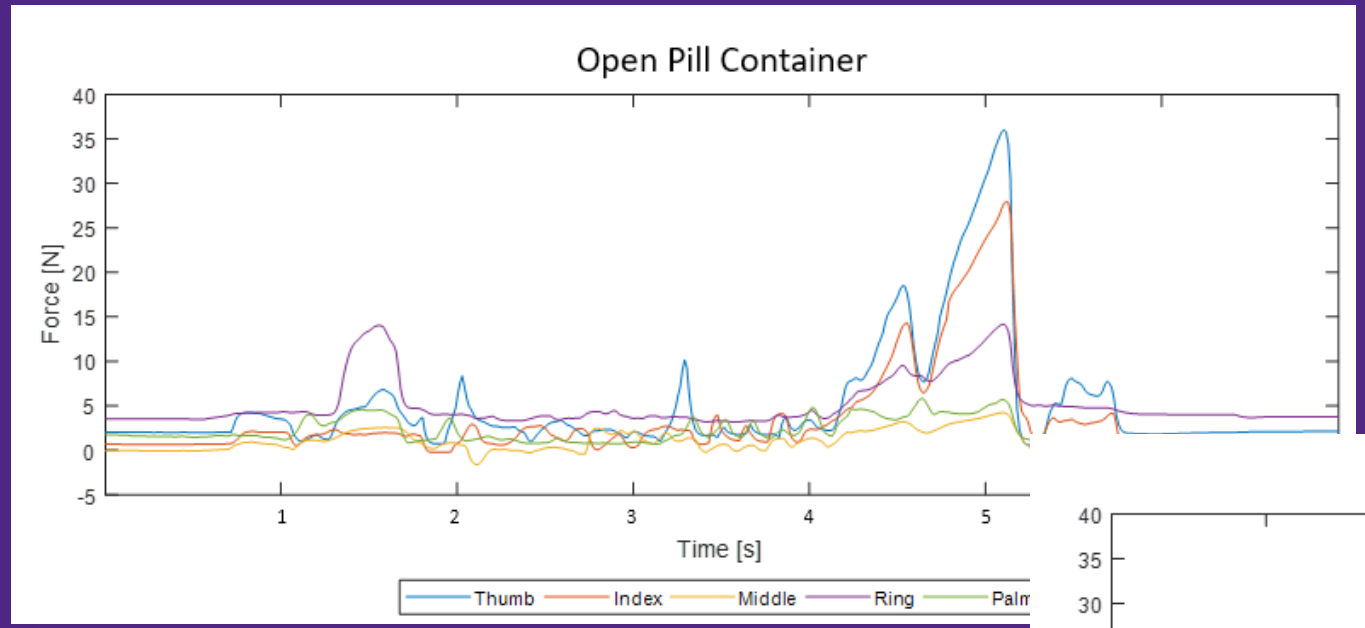


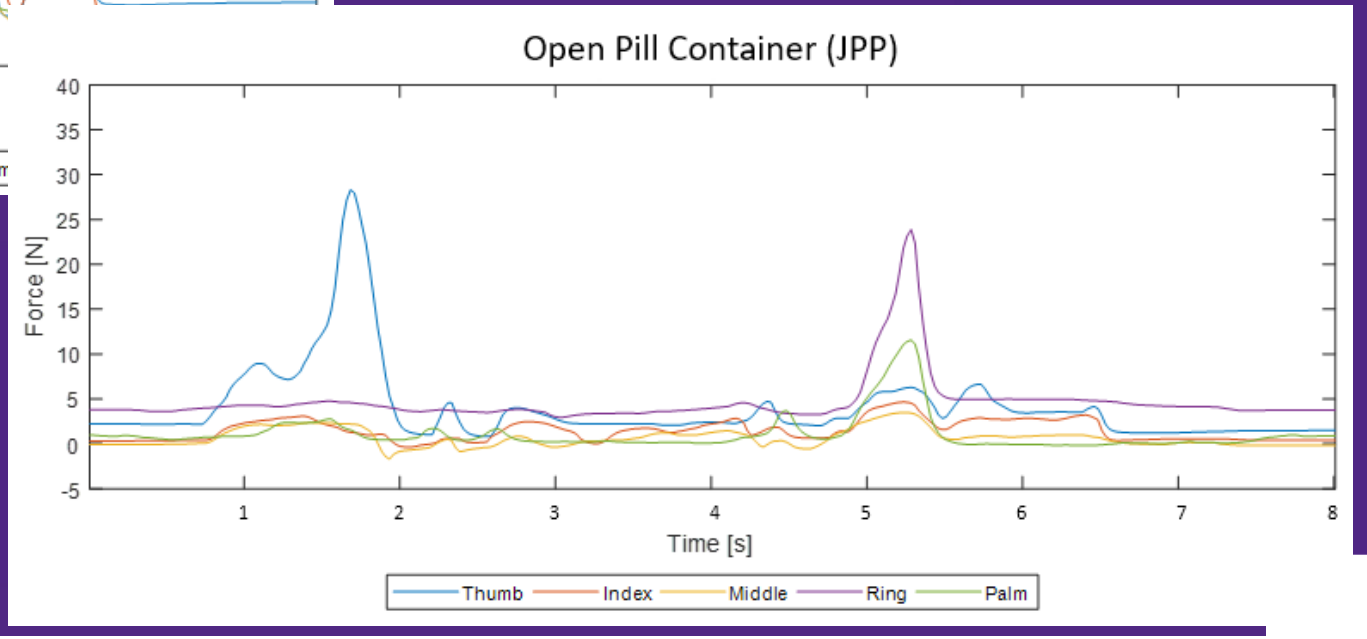
Don’t Burn Out Your Patient Participants!

Protocol burden and the importance of a patient consumer on your team!



Provide the Type and Amount of Data that is Useful not Epic





stern Engineering

Who is going to Pay for your Device? And Who is Responsible for Prescribing the Device?

Strategies

- Go to conferences that your clinician collaborators go to!
- Get to know your stakeholders
- Learn each others language so you can communicate
- Read and Publish in journals that your clinicians read and targeted you technical notes accordingly

Regular Check-ins

Are we answering the right questions and providing the right tools/devices/data??

Acknowledgements:

Graduate Students:
Sara Holland
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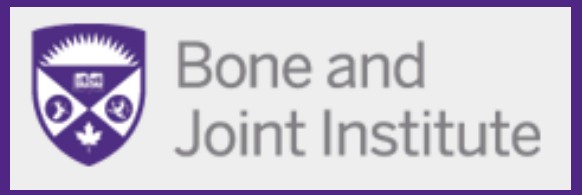
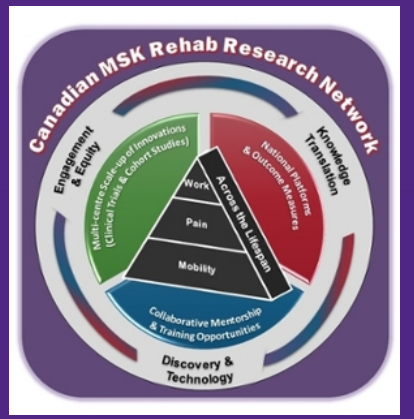
Andrea Kassay
Puneet Ranota
Madeline Perrin
Sydney Robinson

Undergraduate Students:
Paulo Catumbela
Pobe Tran
Shaemus Tracey
Lauren Straatman
Karam Albakri
Baraa Daher





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