Benefits of SlicerAutoscoperM Hierarchical 3D Registration Module over Traditional Research Methods

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Agenda

1. Introduction
2. Challenges with Traditional Workflow
3. Benefits of SlicerAutoscoperM Hierarchical 3D Registration Module
4. Examples in the Human Biomechanics Laboratory (University of Western Ontario, Canada)
5. Why is 3DH Module important for research?

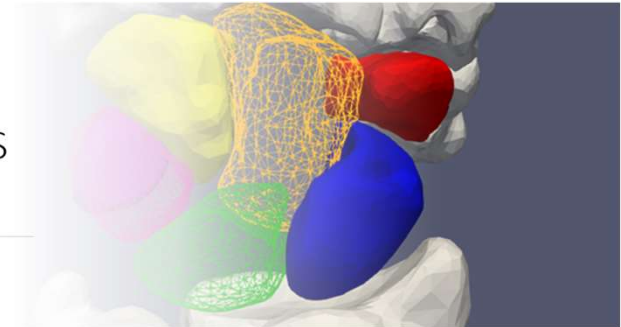# 1. Introduction

1. About Me

- Current candidate for MESc in Biomedical Engineering at Western University (Canada)

- International exchange at **Brown University Health**

- Supported by the **Canadian MSK Rehab Research Network**

1. Lab Resources

ROTH | McFARLANE
HAND & UPPER LIMB CENTRE
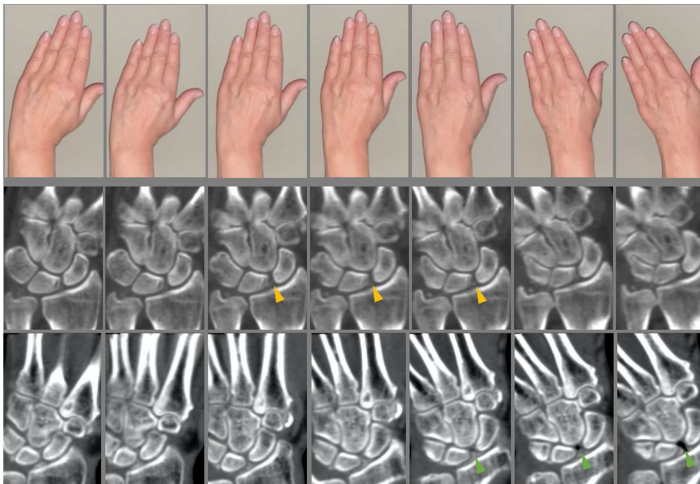ST. JOSEPH'S HEALTH CARE LONDON

HUMAN
BIOMECHANICS
LABORATORY

1. Background of 4DCT

- 4DCT adds another dimension (time) to traditional CT scans

- Analyze motion in **real time**

4DCT Calcium Pyrophosphate Deposition
Disease [1]

4DCT Thoracic Malignancies at The
University of Texas [2]

1. Topic Background

- Carpometacarpal Osteoarthritis (CMC OA) is a **degenerative joint condition**

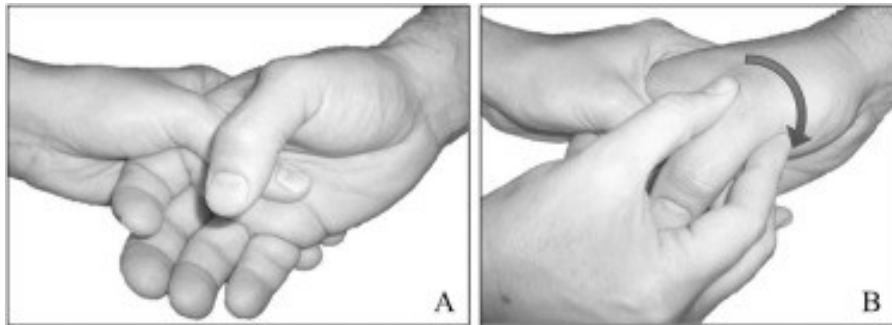- Affects **15% of adults** over 30 years and **66% of women older than 55** [3]

Osteophytes in CMC Joint Radiograph [4]

Joint Subluxation [5]

1. Motivation

- **Mechanical progression** of CMC OA

- **Screw-home mechanism**
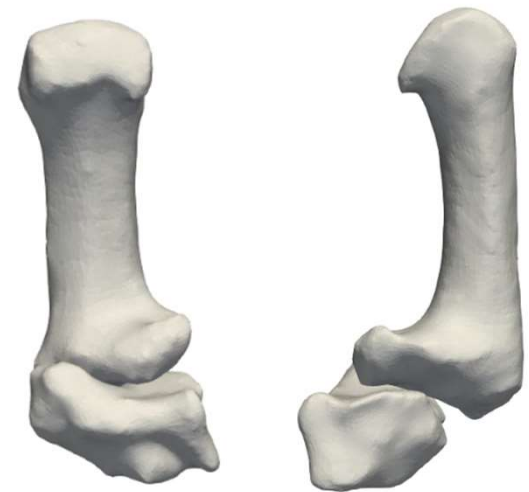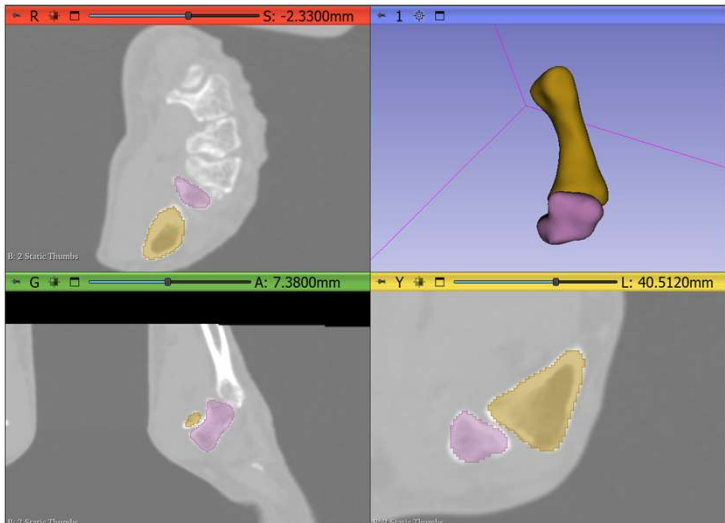
- Kinematic analysis

Screw-home Mechanism [5]

Advanced CMC OA [6]
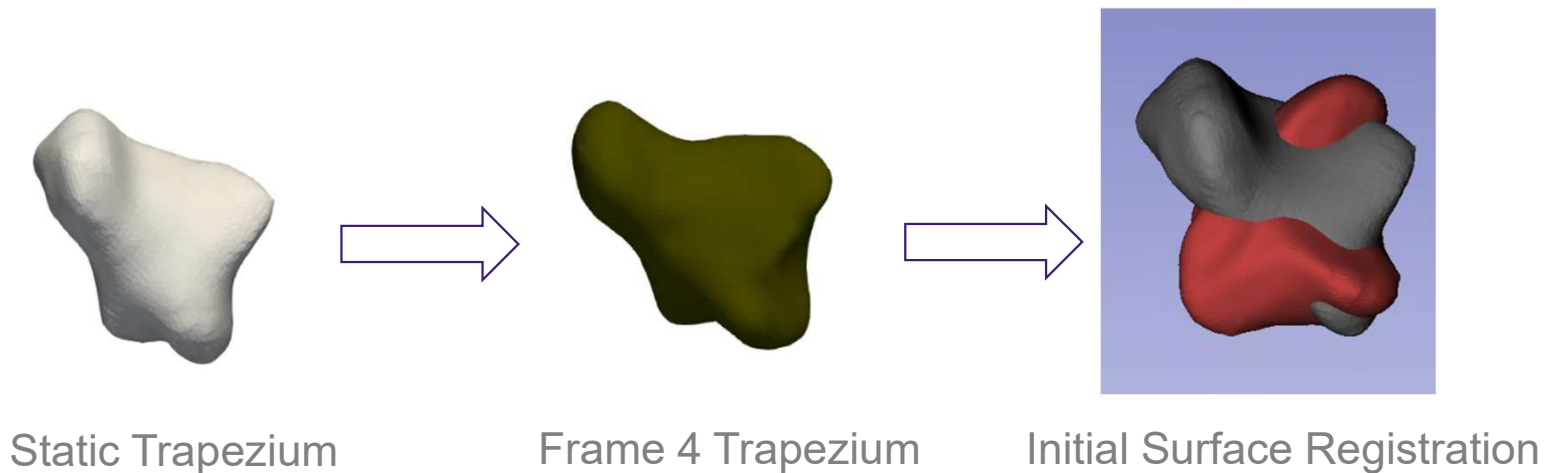
2. Challenges with Traditional Workflow

2. Challenges

- Old Workflow:

Manual Segmentation (24 frames + static) ① ➤ Registration (Python or Slicer) ➤ Helical Axes Calculation

2. Challenges

- Old Workflow:

Manual Segmentation (24 frames + static) → Registration (Python or Slicer) ② → Helical Axes Calculation

Static Trapezium → Frame 4 Trapezium → Initial Surface Registration

2. Challenges

- Old Workflow:

Manual Segmentation (24 frames + static) → **Registration (Python or Slicer)** → **Helical Axes Calculation** ③

Lunate type	Frontal View (z-y axes)		Sagittal View (x-y axes)		Transverse View (x-z axes)	
Lunate 1 (Participant 1)						
Lunate 2 (Participant 5)						

Scaphoid translation comparison between individuals with type one and type two lunates [7]

2. Challenges

Difficult to identify bones due to **morphed geometry**

Increased **artifact** in 4DCT scans

Repeatability concerns

Time consuming (manual segmentation)

3. Benefits of SlicerAutoscoperM Hierarchical 3D Registration Module

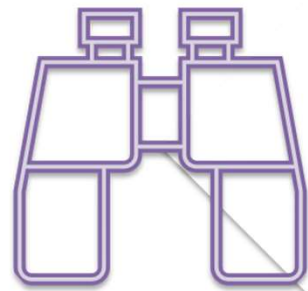# 3. Benefits of the Module

Time Efficient (Semi-automated)

3. Benefits of the Module

- Study includes 3 motions and n=30 participants

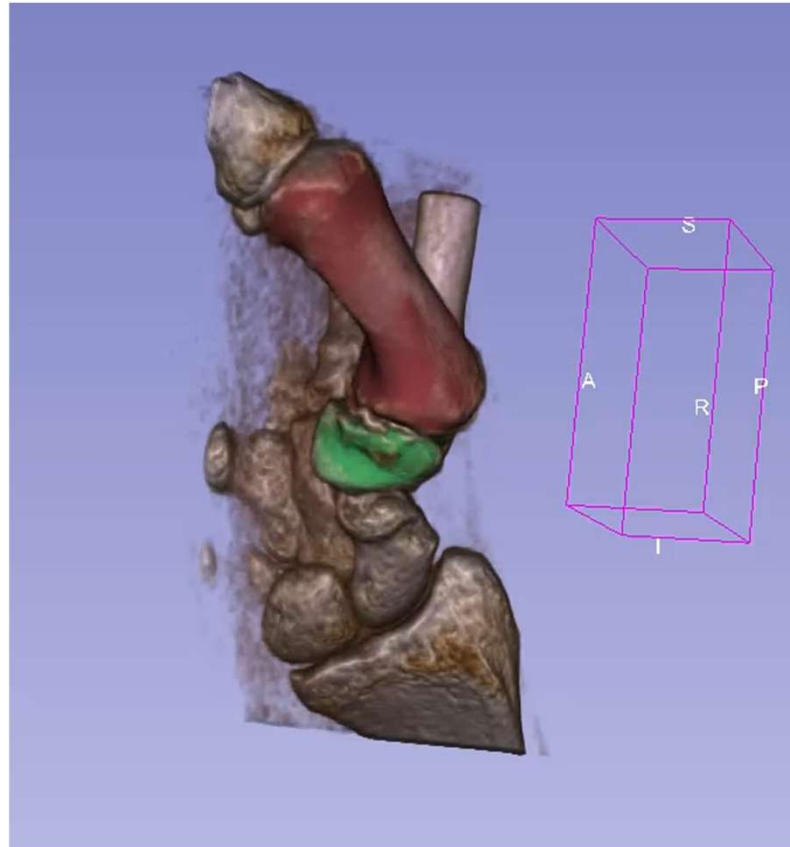|	Old Method	SlicerAutoscoperM Module
Segmentation Time n=1	(0.5 hours*25 frames) (24+static) **12.5 hours**	(static models) **0.5 hours**
Segmentation Time n=30	(12.5 hours*3 motions*30 participants) **1,125 hours**	(0.5 hours* 30 participants) **15 hours**
Registration Time	(0.1 hour* 24 frames *3 motions* 30 participants) **216 hours**	(0.3 hours per motion *3 motions * 30 participants) **27 hours**
Total Analysis: (Registration + Segmentation)	(1,125 + 216) **1,341 hours**	(15+27) **42 hours**

Over **54 days** saved with the SlicerAutoscoperM Hierarchical 3D Registration Module!

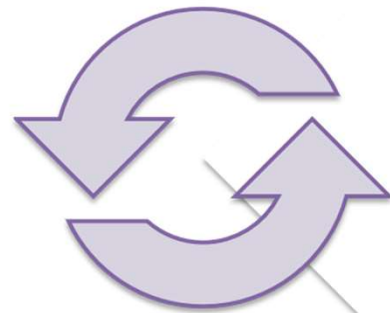# 3. Benefits of the Module

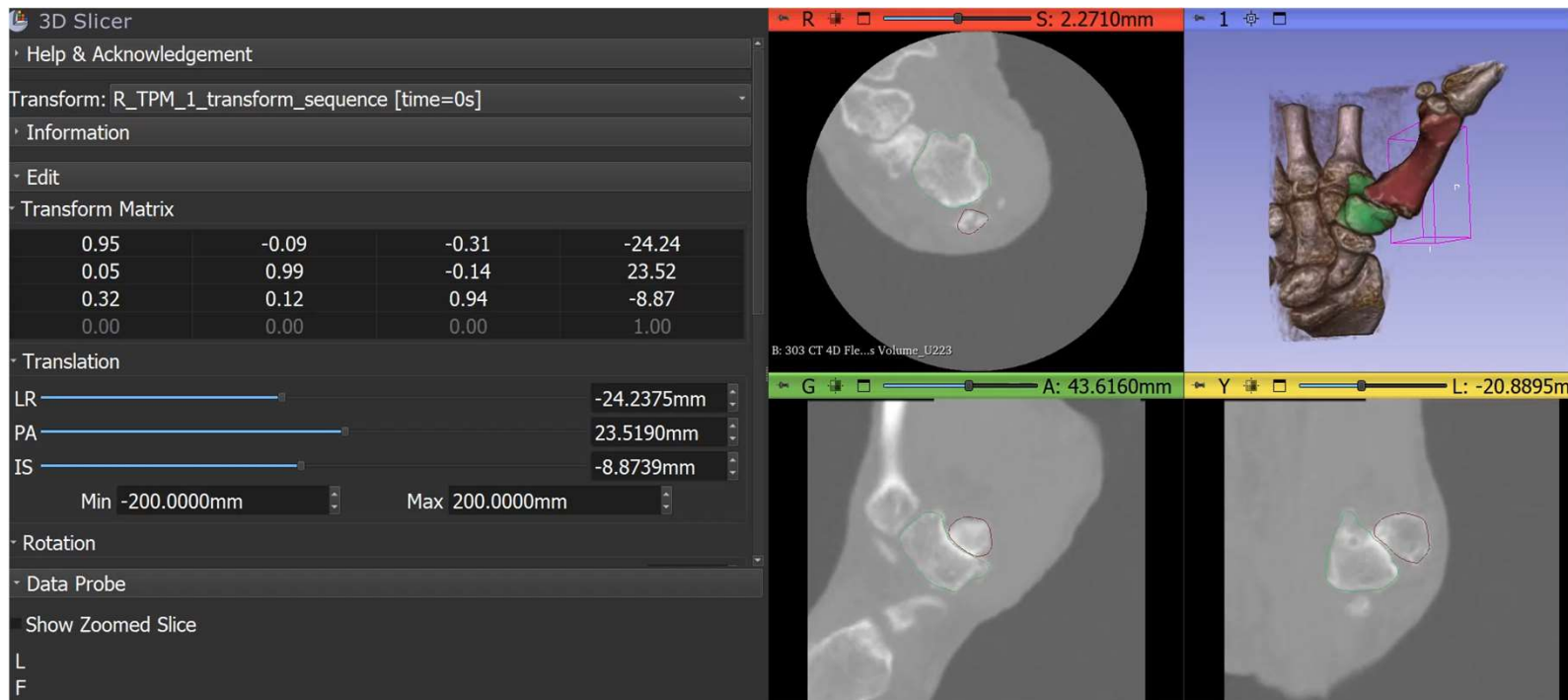Easy to Visualize

3. Benefits of the Module
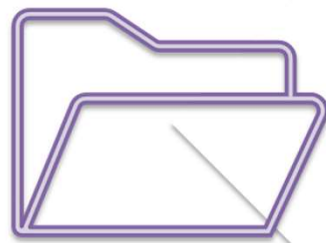
3. Benefits of the Module

Repeatable

3. Benefits of the Module

3. Benefits of the Module
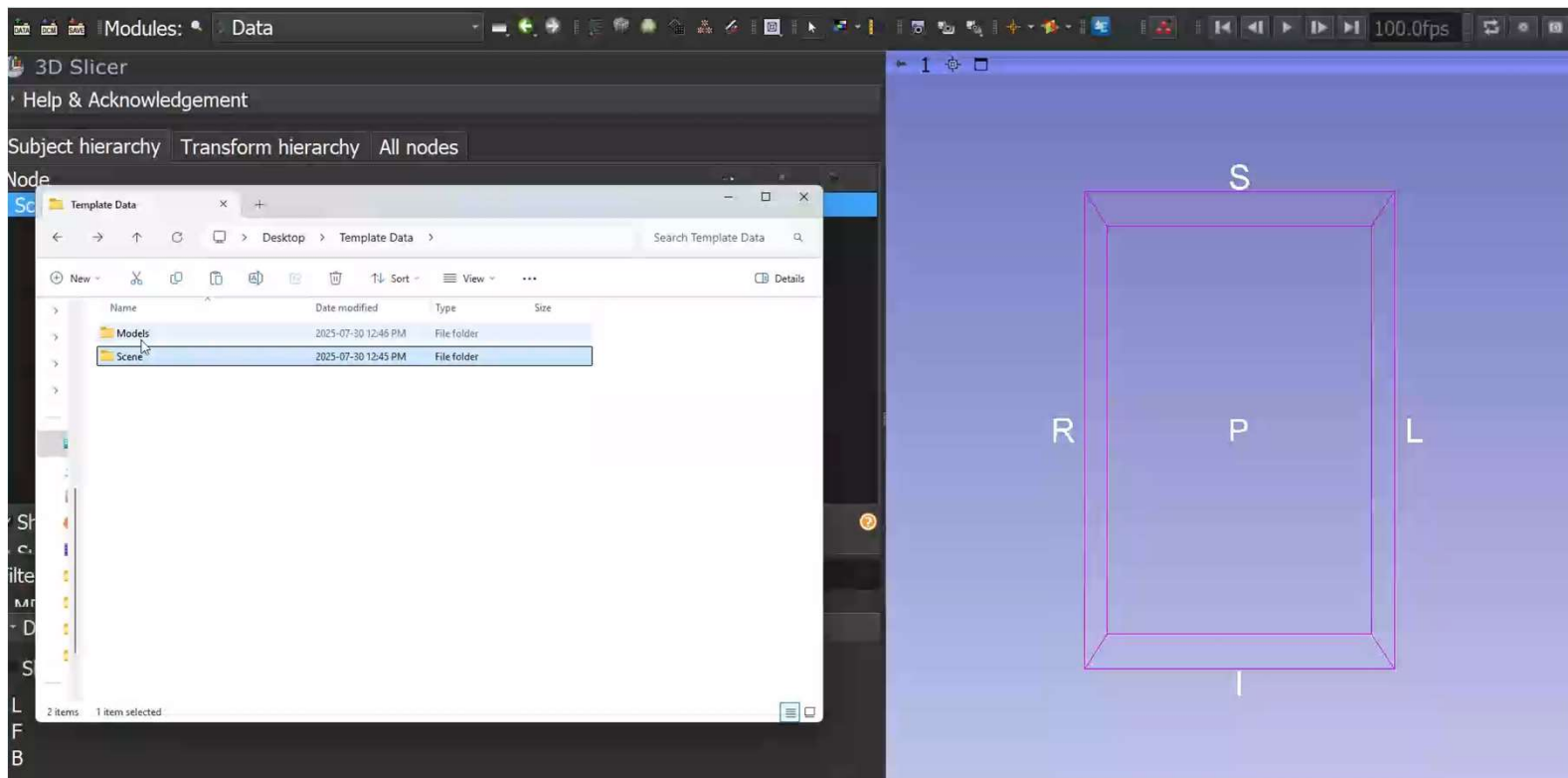
3. Benefits of the Module

- Infinite possibilities of **additional features**

- Online **resources** and support

- **Easily accessible** for all researchers

- Continuous **updates** and system improvements

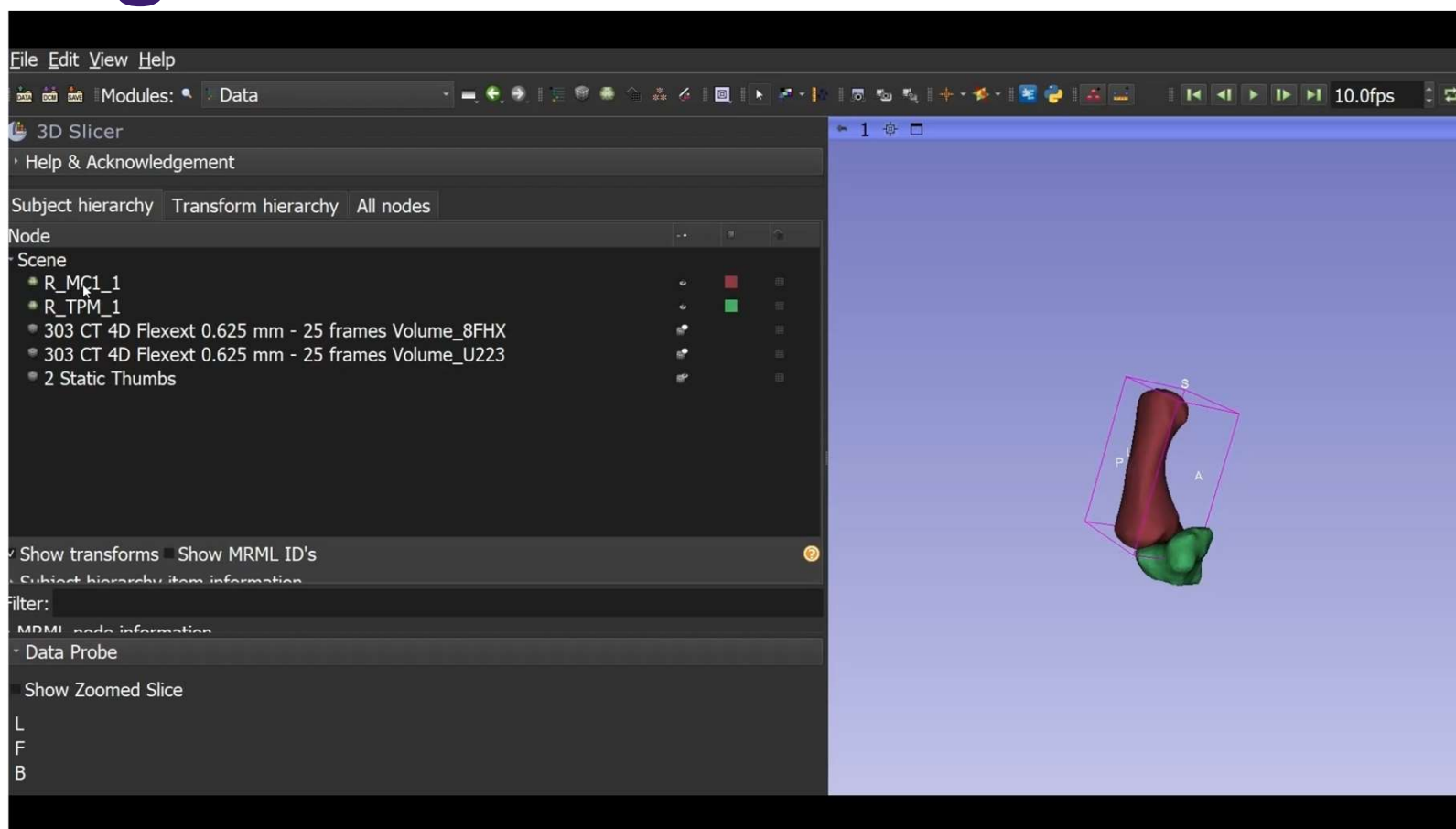# 4. Example Case

4. Initial Set Up

4. Lessons Learned

- Load DICOM files through Slicer and then export them (save) in a specific location
- Ensure you have **proper file formats** (for my workflow):
  - **Static CT-** .nrrd
  - **4DCT-** .seq.nrrd and .nrrd

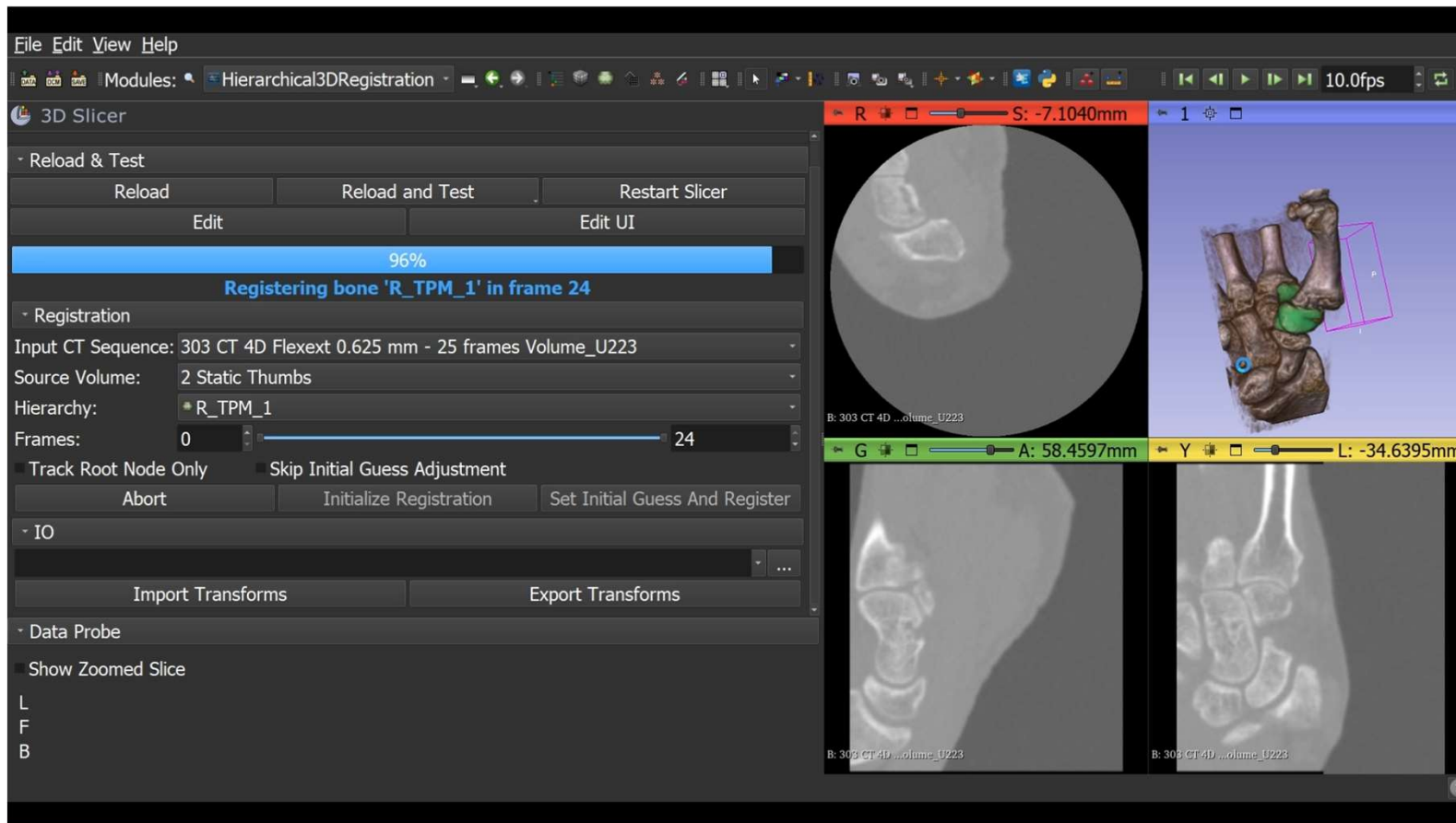**SlicerAutoscoperM Supported File Formats**
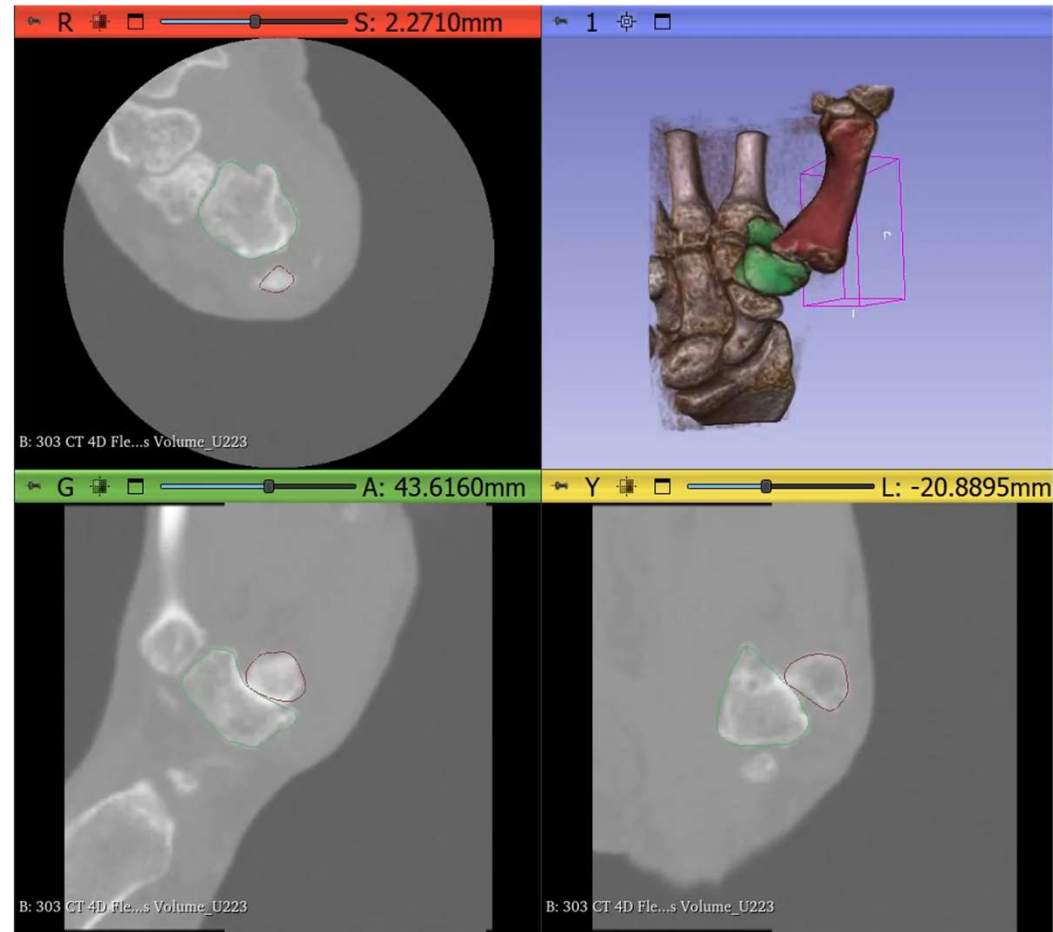
Western

4. Registration

4. Lessons Learned

- Ensure that the **source volume** is your **static CT**
- Utilize all **planes of view** when registering
- If one frame does not register properly, abort registration and try again
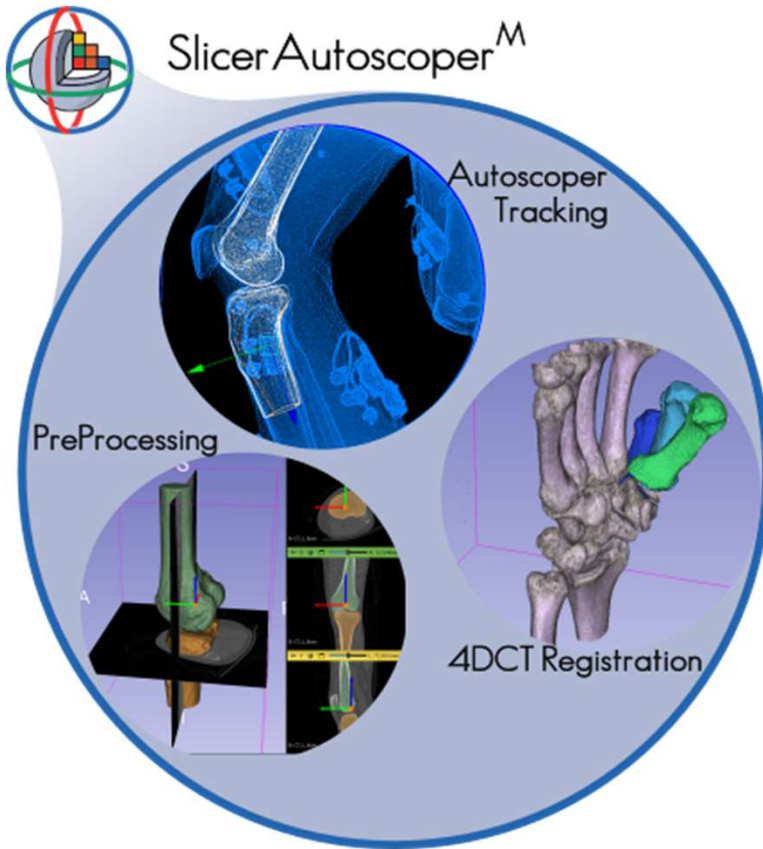
4. Registration

4. Lessons Learned

- When exporting transforms, **select a directory first**

5. Why is 3DH Module important for research?

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5. Impact

SlicerAutoscoperM

Autoscoper Tracking

PreProcessing

4DCT Registration

Handles **challenging OA morphology**

Accelerates speed of analysis for large datasets (hours not days)

Enables **standardized**, reproducible results

Facilitates the integration of future Slicer developments

5. Lessons Learned

File Structure

- Ensure proper format

Registration

- Use all planes of view

Exporting transforms

- Must include a directory for exporting transforms

Acknowledgements

I would like to thank:

- Brown Orthopedics Lab, Dr. Crisco, Amy Morton, and lab members
- My supervisor, Dr. Emily Lalone
- Canadian MSK Rehab Research Network

I look forward to any questions!

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SlicerAutoscoperM Hierarchical 3D
Registration Module

References

[1] S. T. Ulas, L. Pochandke, S. Ohrndorf, T. Diekhoff, and K. Ziegeler, "Four-dimensional computed tomography detects dynamic three-dimensional pathologies of the wrist in patients with calcium pyrophosphate deposition disease," Frontiers, https://www.frontiersin.org/journals/medicine/articles/10.3389/fmed.2023.1231667/full (accessed Aug. 6, 2025).

[2] R. Castillo et al., "A framework for evaluation of deformable image registration spatial accuracy using large landmark point sets," Physics in Medicine and Biology, vol. 54, no. 7, pp. 1849–1870, Mar. 2009. doi:10.1088/0031-9155/54/7/001

[3] M. M. HAARA et al., "Osteoarthritis in the carpometacarpal joint of the thumb," The Journal of Bone and Joint Surgery-American Volume, vol. 86, no. 7, pp. 1452–1457, Jul. 2004. doi:10.2106/00004623-200407000-00013

[4] J. Schreiber, "Thumb arthritis - Raleigh hand surgery," Raleigh Orthopaedic Clinic, https://www.schreibermd.com/thumb-arthritis (accessed Aug. 6, 2025).

[5] "Osteoarthritis, Carpometacarpal (CMC) joint of thumb," OSTEOARTHRITIS, CARPOMETACARPAL (CMC) JOINT OF THUMB | Hand Surgery Resource, https://www.handsurgeryresource.net/osteoarthritis-thumbcmc (accessed Aug. 6, 2025).