

# COMSOL Model of Canine Elbow for Use in Investigating Medial Coronoid Disease

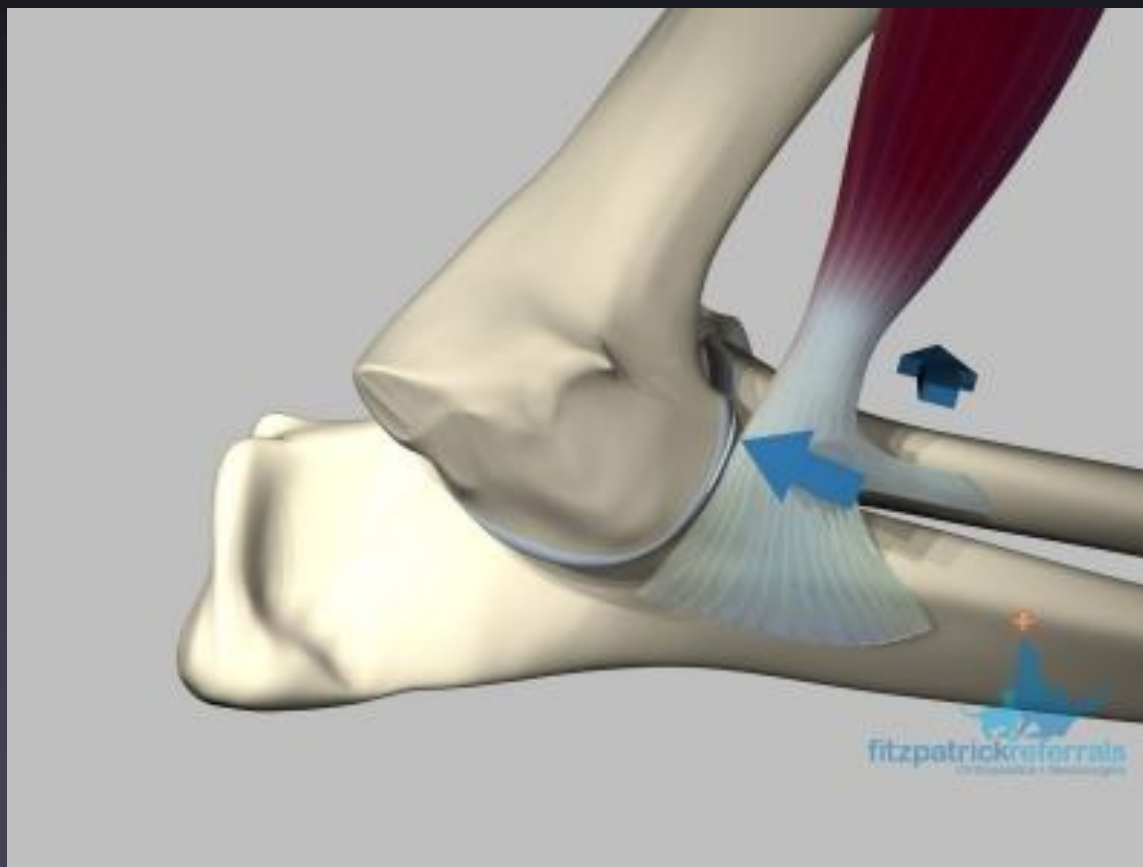
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The Ohio State University  
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# Introduction

- **Canine elbow joint**
  - Complex Interaction of three bones
    - 1) Radius
    - 2) Ulna
    - 3) Humerus



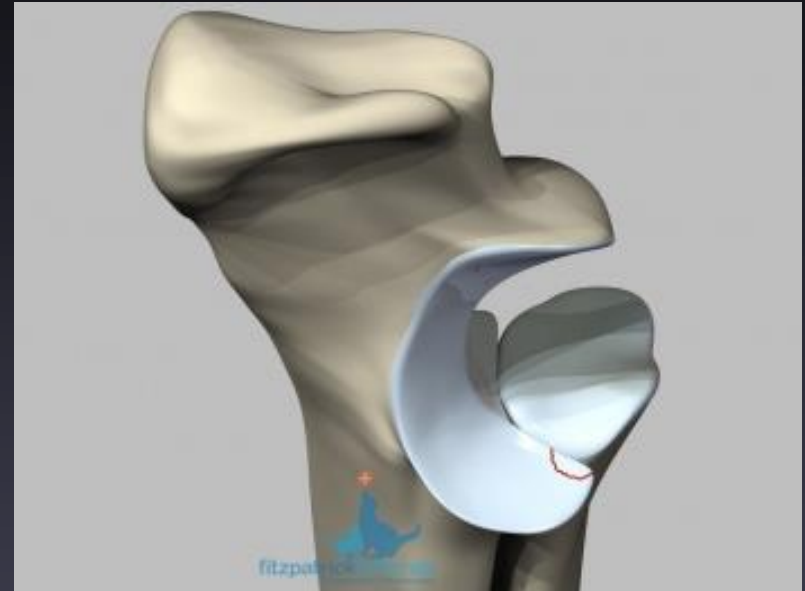
<http://www.fitzpatrickreferrals.co.uk/our-services/surgery/conditions/fore-limb/canine-elbow-dysplasia>

# Introduction

- Canine elbow joint
  - Hinge Articulation
  - Pivot Articulation

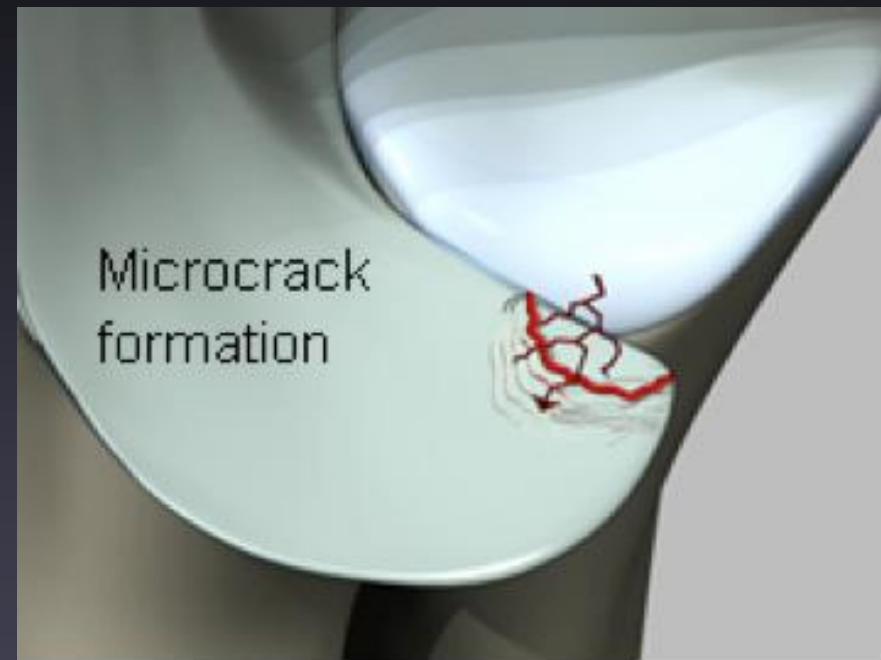
# Introduction

- **Medial Coronoid Process (MCP)**
  - Located on Ulna
  - Normal anatomical landmark
  - The center of articulation
  - Prone to disease



# Introduction

- **Medial Coronoid Disease (MCD)**
  - #1 cause of lameness in dogs
  - Etiology unknown
  - Microcracking of bone
  - Leading to stress fractures
  - Fragmenting coronoid process



<http://www.fitzpatrickreferrals.co.uk/our-services/surgery/conditions/fore-limb/canine-elbow-dysplasia>

# Hypothesis 1

- **Joint Incongruency: Low Radius Avalanche**
  - Radius shorter than ulna
  - Radius contacts ulna
  - ‘Avalanche’ analogy

# Hypothesis 2

- **Joint Incongruency: Poor Fitted Cogs**
  - Radius does not fit geometry of radial notch on ulna
  - ‘Poor fitted cogs’ analogy

# Objective

- Develop a novel model using CT data to create a functional geometrically valid model in COMSOL to test these hypotheses and derive possible treatment strategies.



# Method Overview

1. CT scan of elbow
2. Import into Simpleware
  - Segment bones
3. Import into Geomagic
  - Smoothing
  - Simplify geometry
4. Import into SolidWorks
  - Repair edges
  - Create boundaries
5. Import into COMSOL using LiveLink

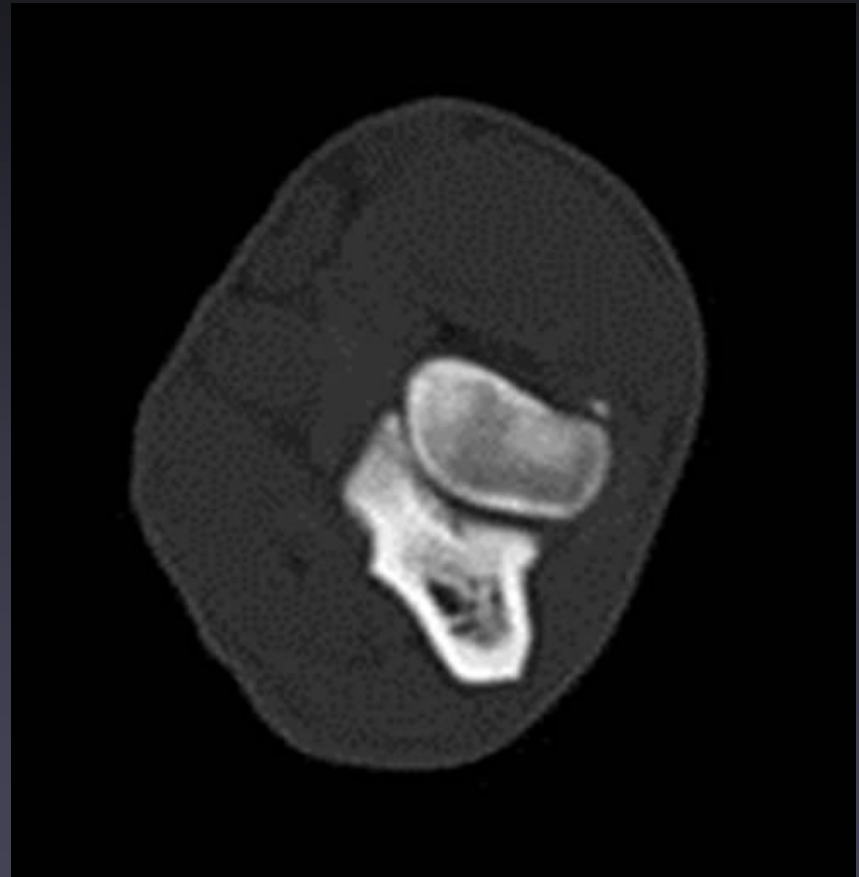
# Methods

## 1. CT scan

- Canine elbow joint



Sagittal plane



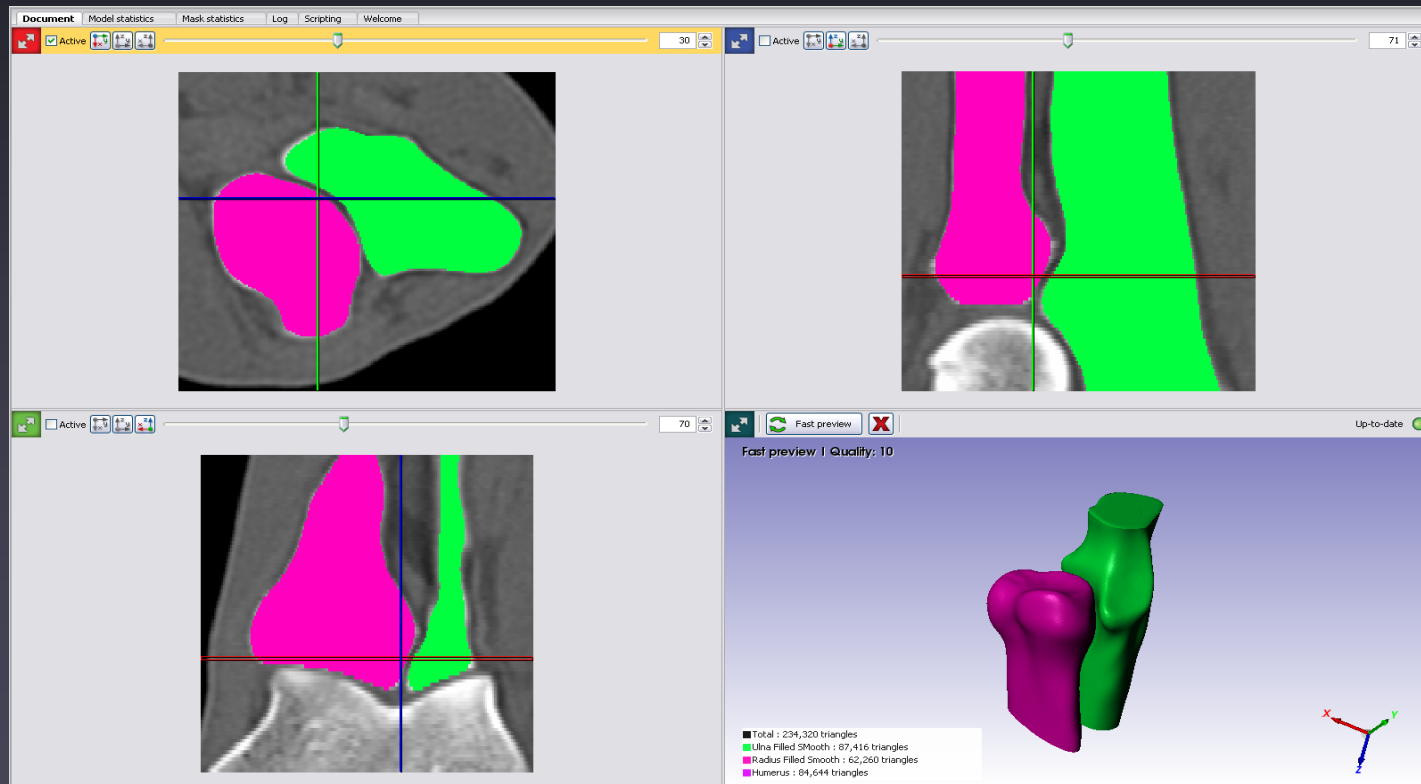
Frontal plane

<http://www.fitzpatrickreferrals.co.uk/our-services/surgery/conditions/fore-limb/canine-elbow-dysplasia>

# Methods

## 2. Simpleware

- Segmented each bone using DICOM slices
- Smoothing
- Export IGES



# Methods

## 3. Geomagic

– Mesh doctor

Dialog Mesh Doctor

OK Cancel Apply

Operation

Type

Action

Analysis

<input checked="" type="checkbox"/> Non-Manifold Edges	0
<input checked="" type="checkbox"/> Self-Intersections	0
<input checked="" type="checkbox"/> Highly Creased Edges	6
<input checked="" type="checkbox"/> Spikes	7
<input checked="" type="checkbox"/> Small Components	0
<input checked="" type="checkbox"/> Small Tunnels	0
<input checked="" type="checkbox"/> Small Holes	0

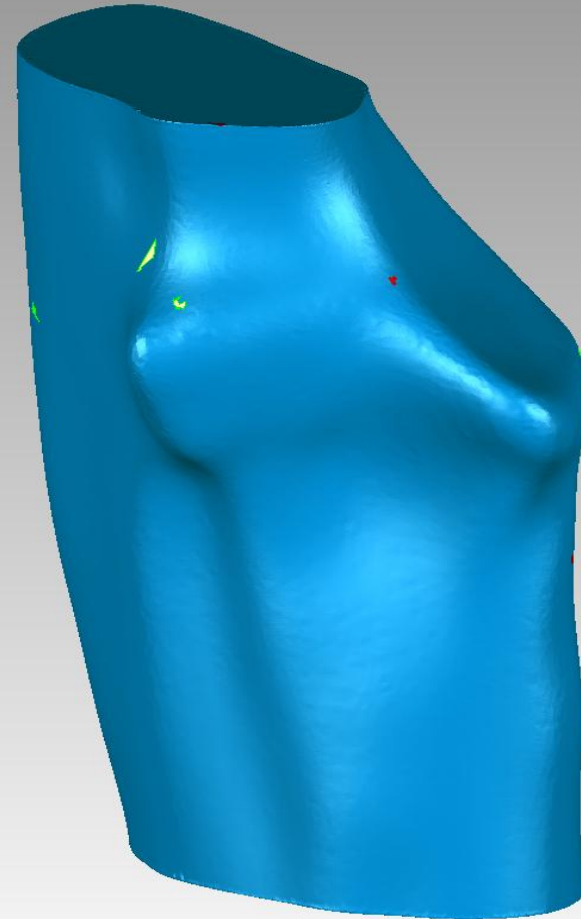
Update

Walkthrough

0/3

Clip Plane

Advanced

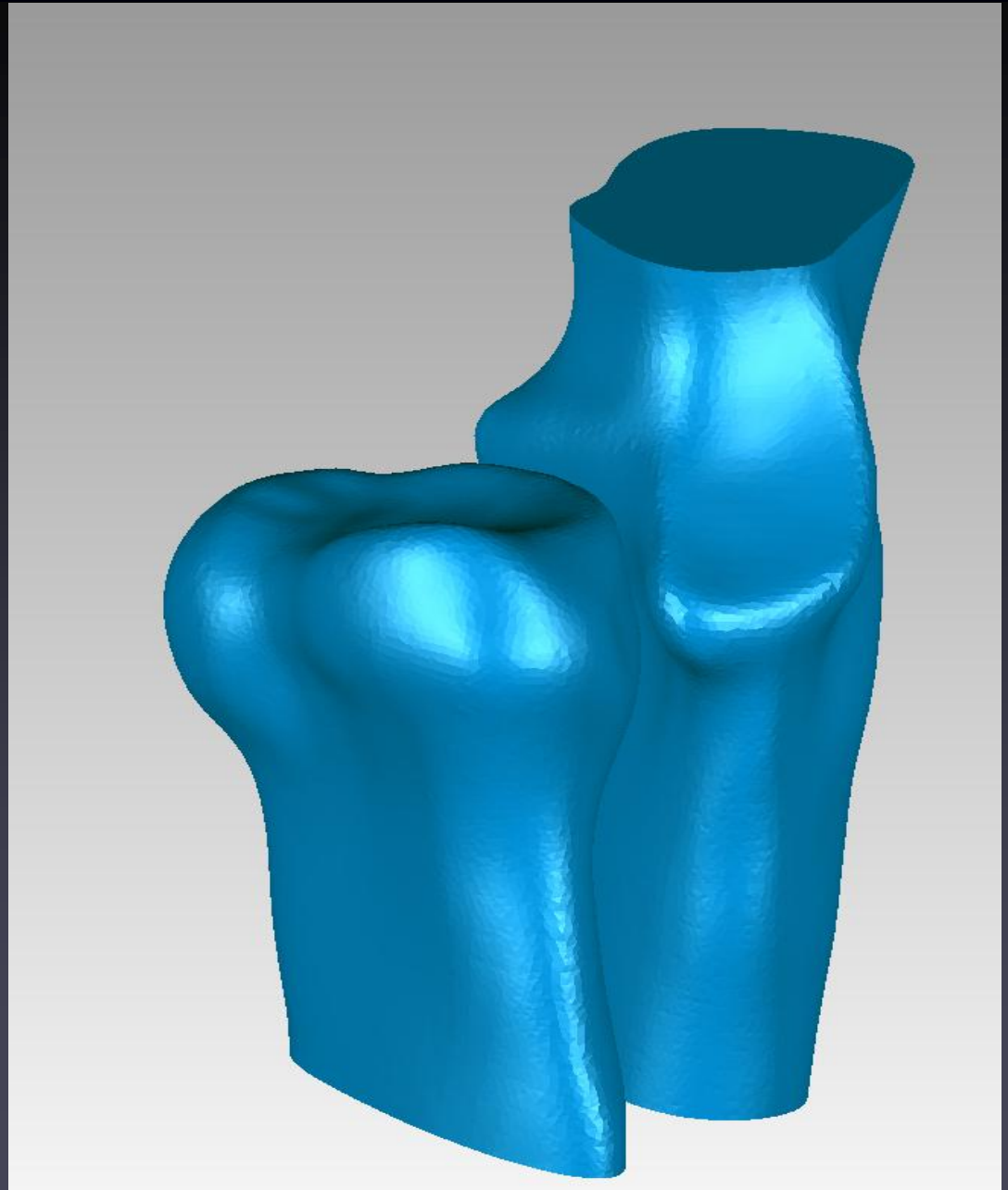


Current Triangles: 399,936  
Selected Triangles: 266

# Methods

## 3. Geomagic

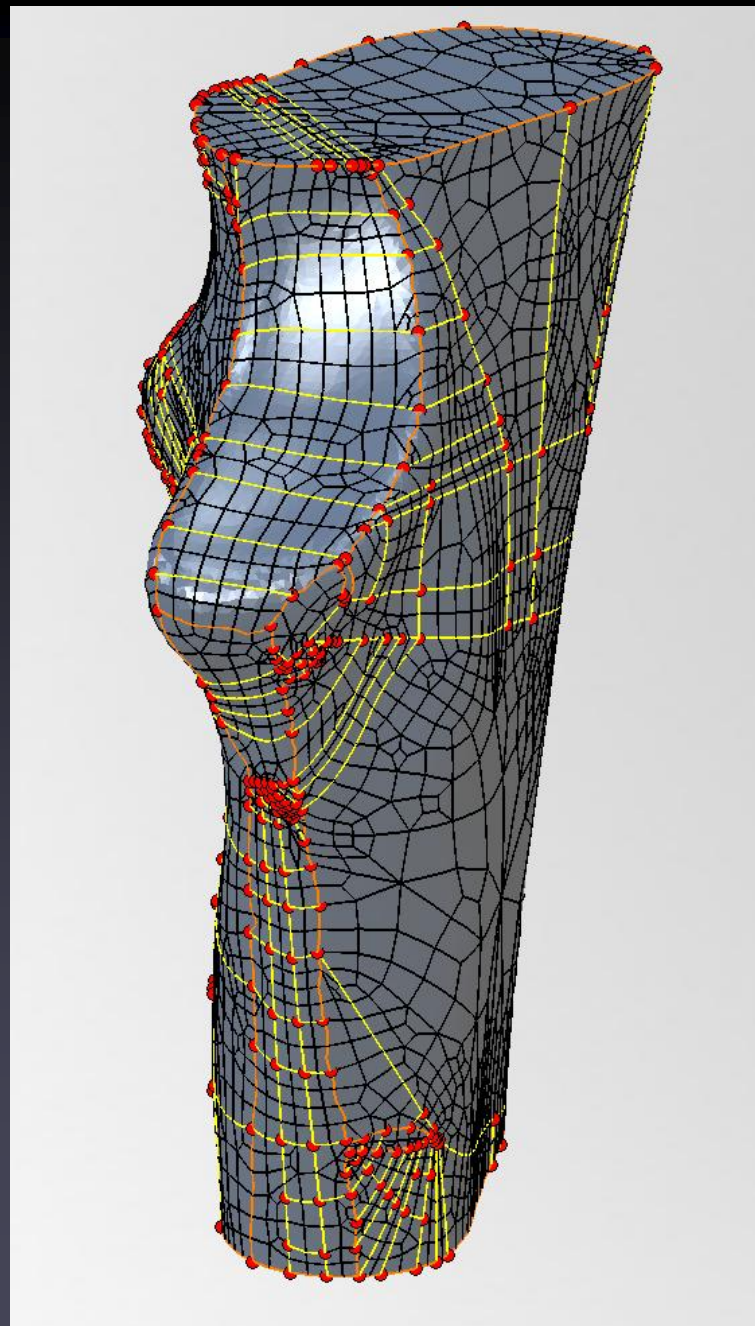
- Simplified geometry
- Decimate 50%
- Export STL



# Methods

## 4. SolidWorks

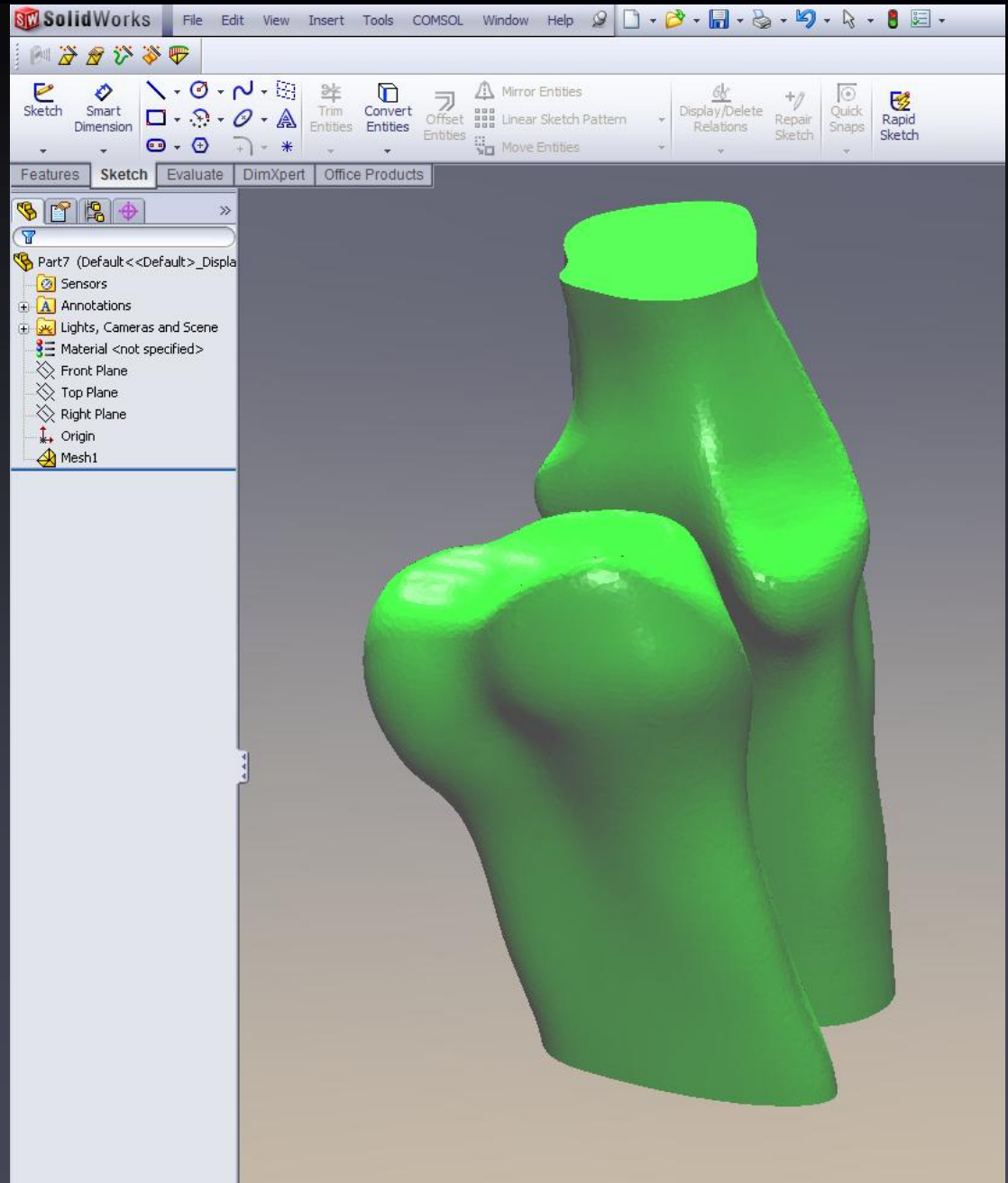
- Create boundaries



# Methods

## 4. SolidWorks

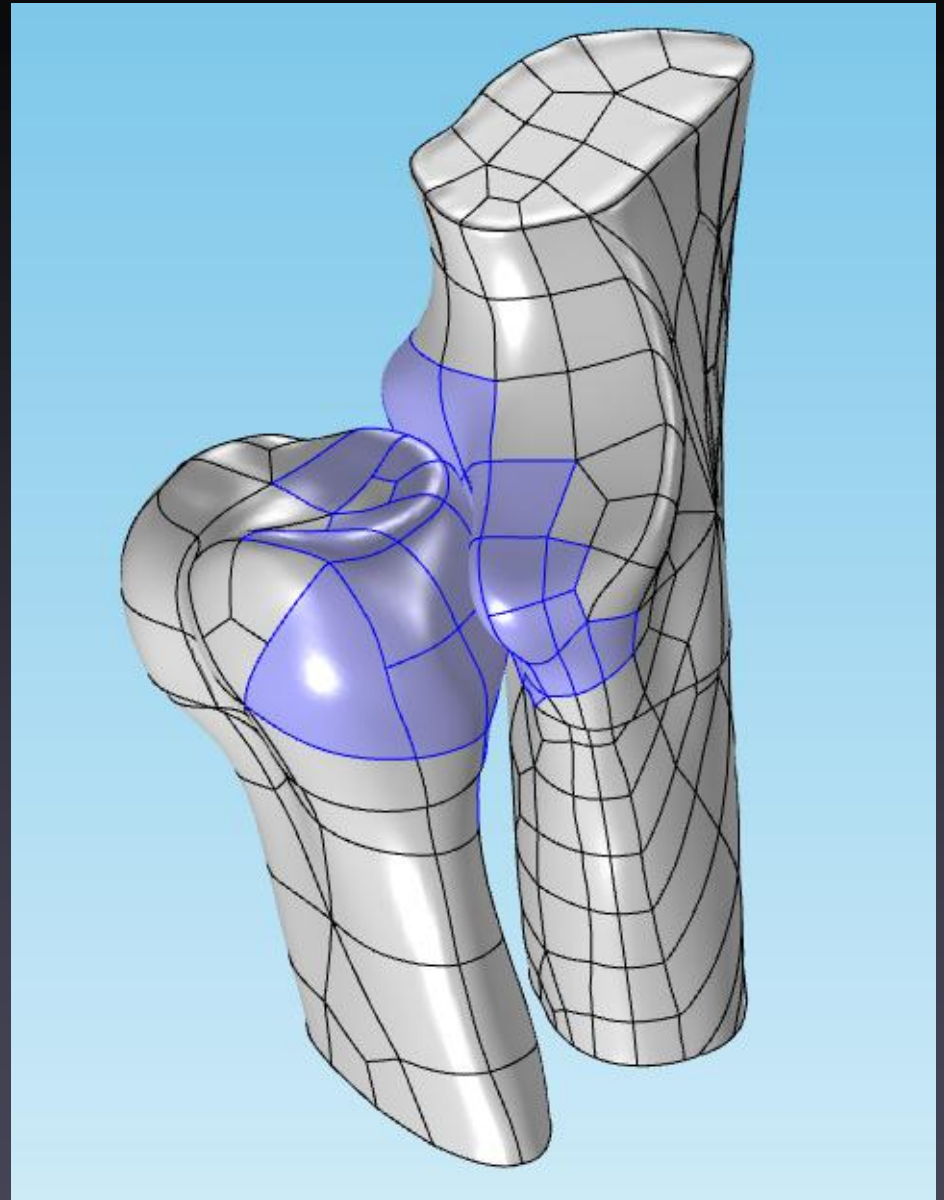
- Auto Repairs



# Methods

## 5. COMSOL

- Stationary solid mechanics physics
- Contact surfaces defined

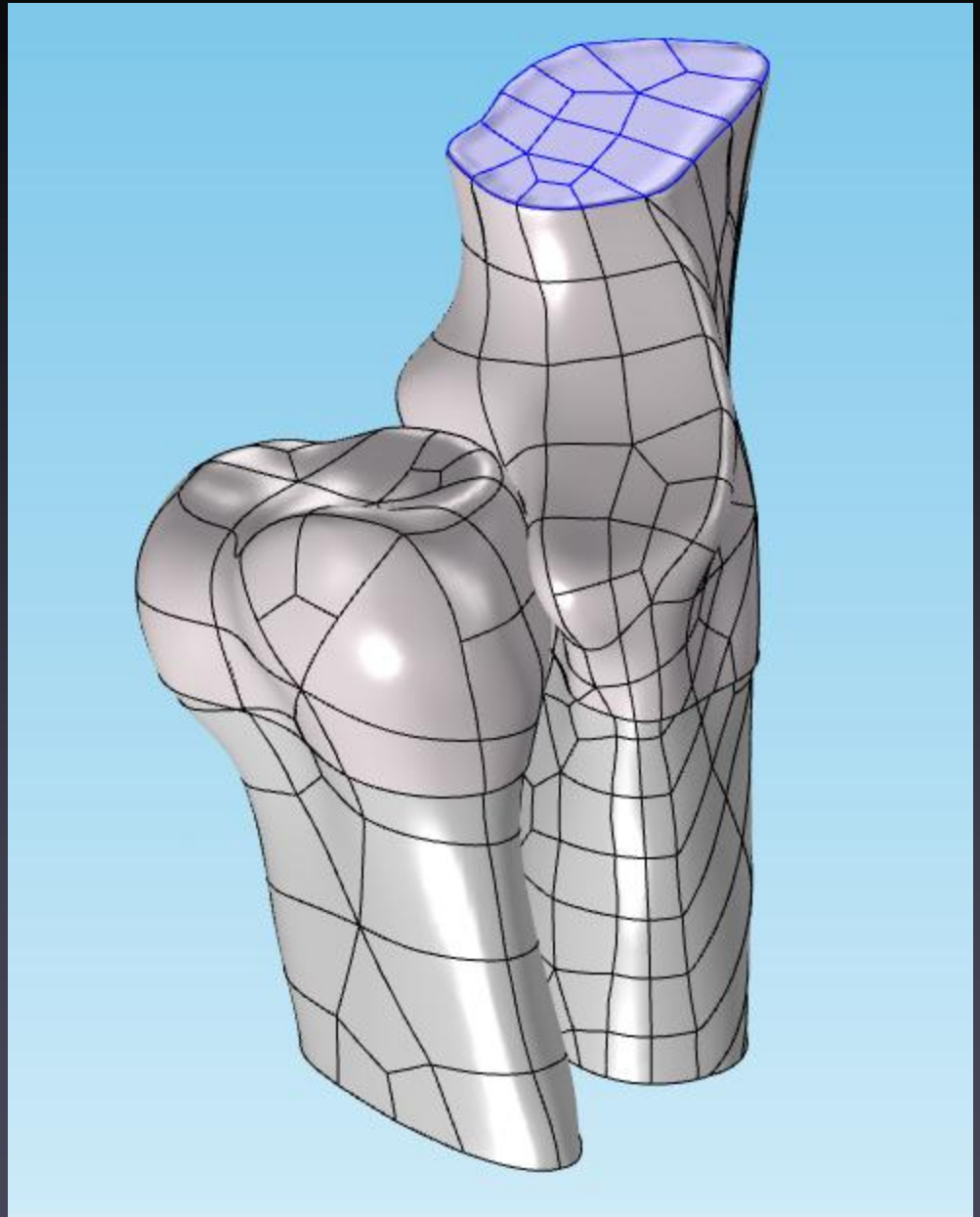




# Methods

## 5. COMSOL

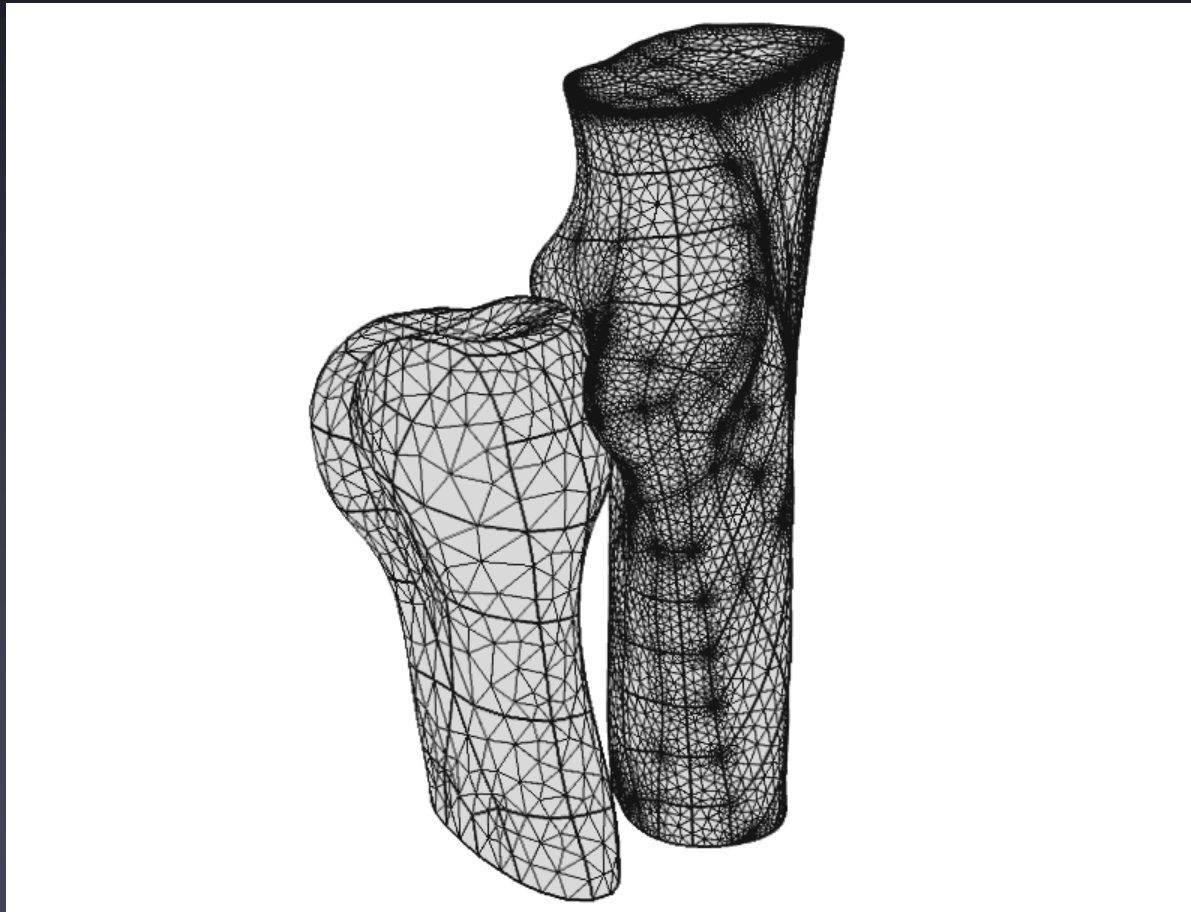
- Rigid connector
- Appropriate boundary conditions



# Methods

## 5. COMSOL

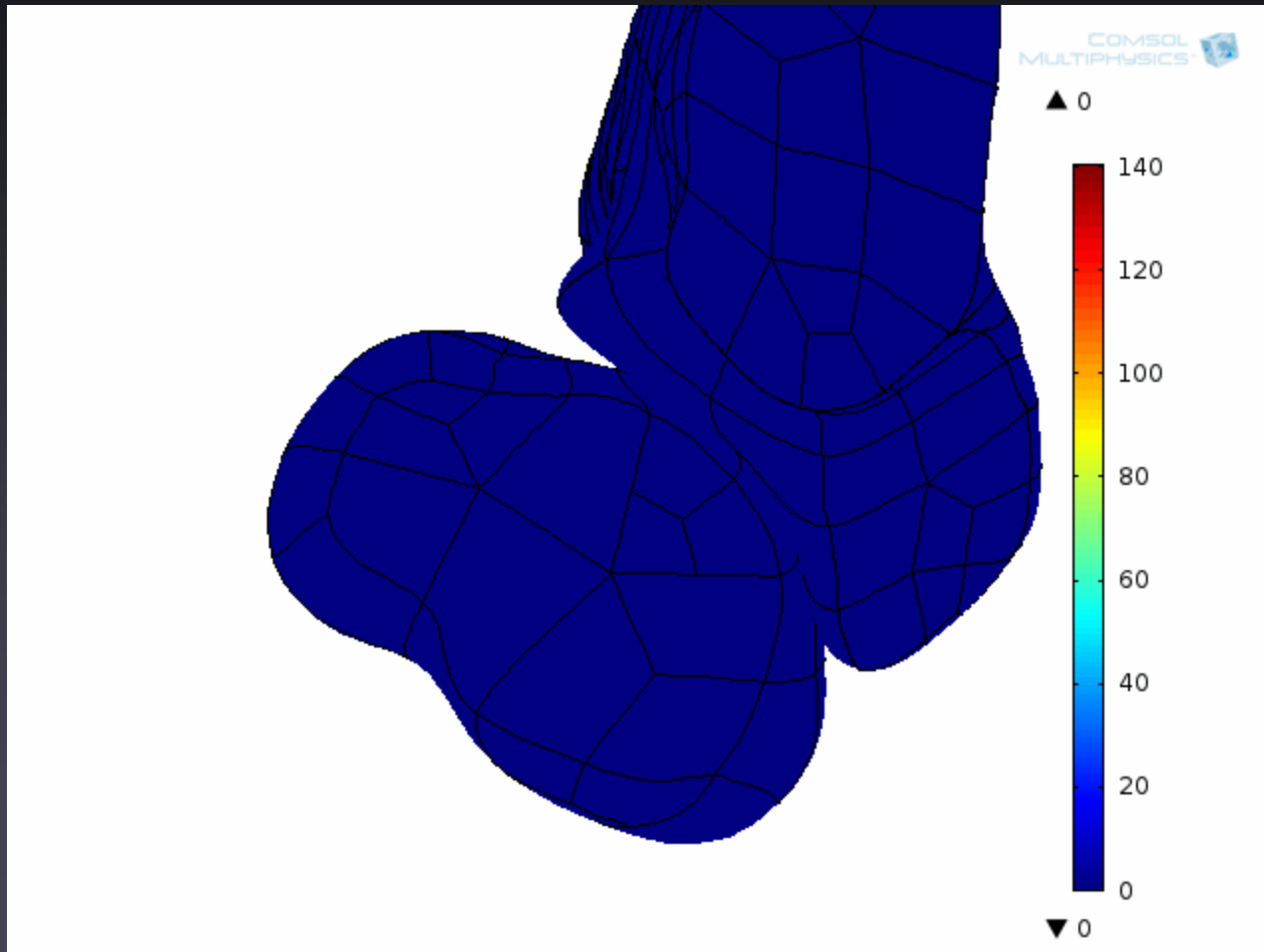
- Isotropic linear elastic material properties
- Meshing 599,835 DOF



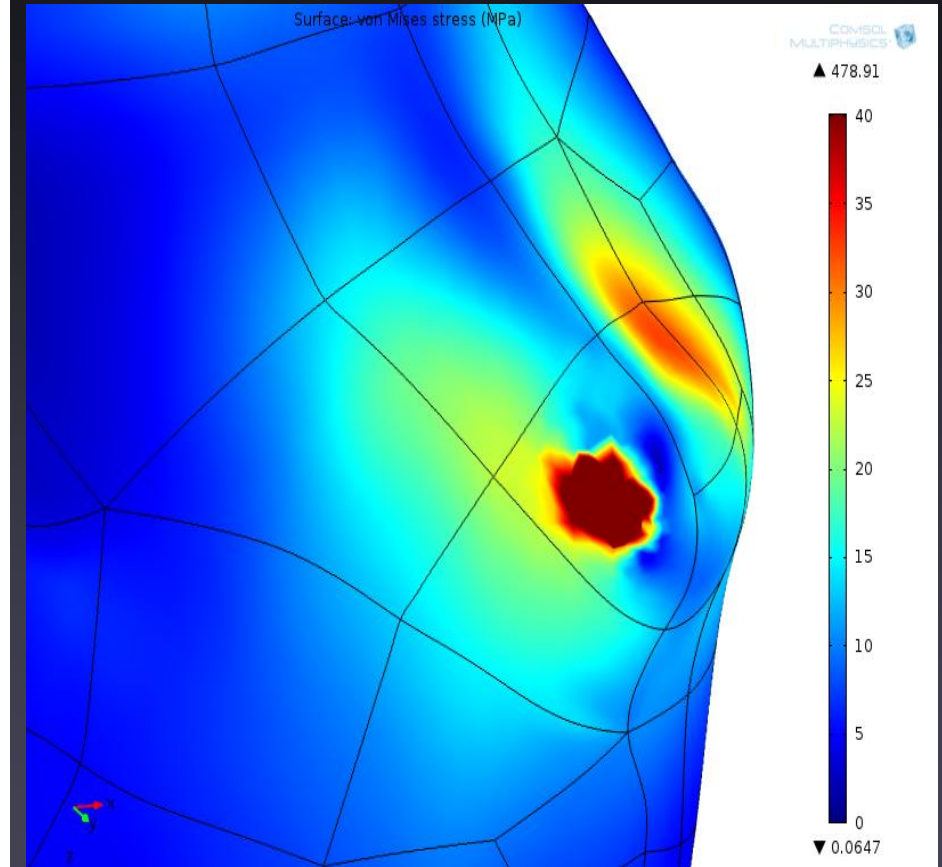
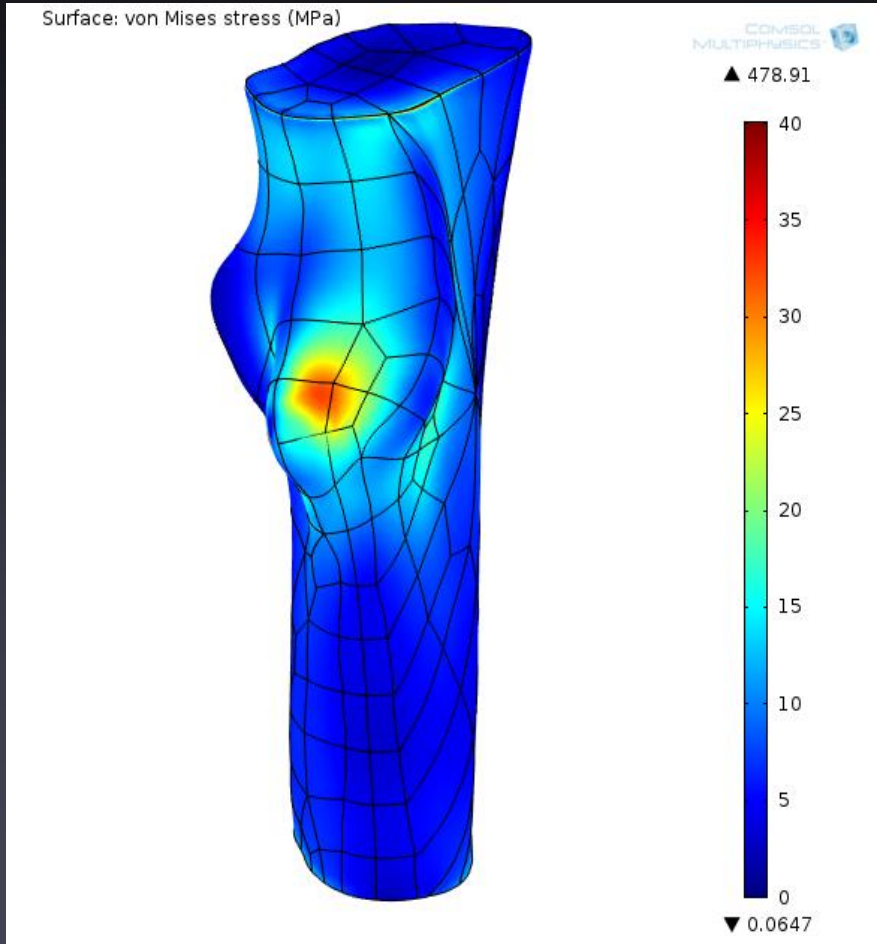
Property	Name	Value	Unit	Proper
✓ Young's modulus	E	12.5[GPa]	Pa	Basic
✓ Poisson's ratio	nu	0.3	1	Basic
✓ Density	rho	1	kg/m <sup>3</sup>	Basic

# Results

- Radius rotated through: 16° Pronation

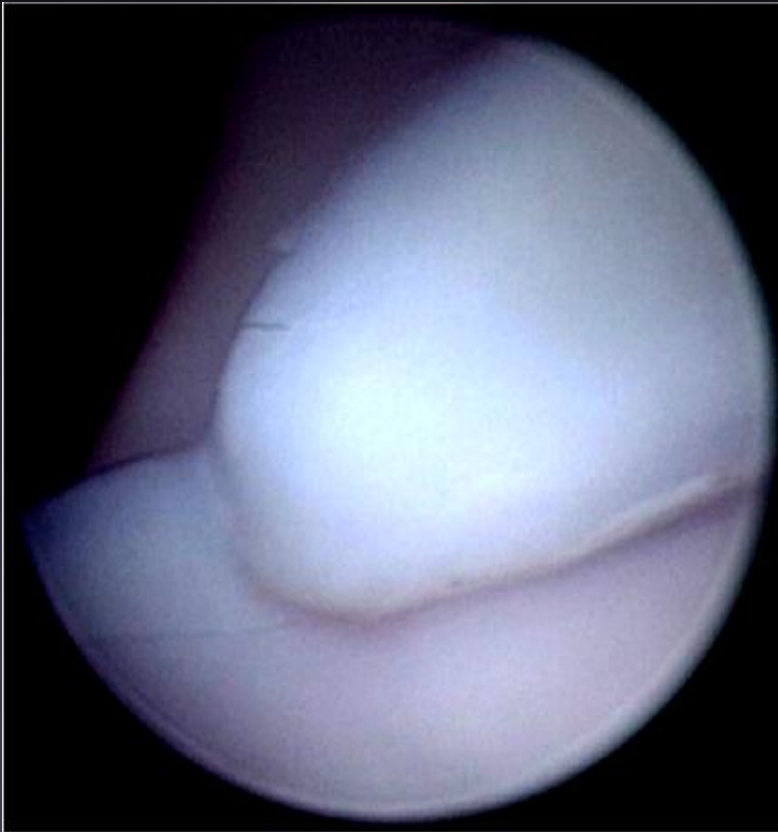


# Results

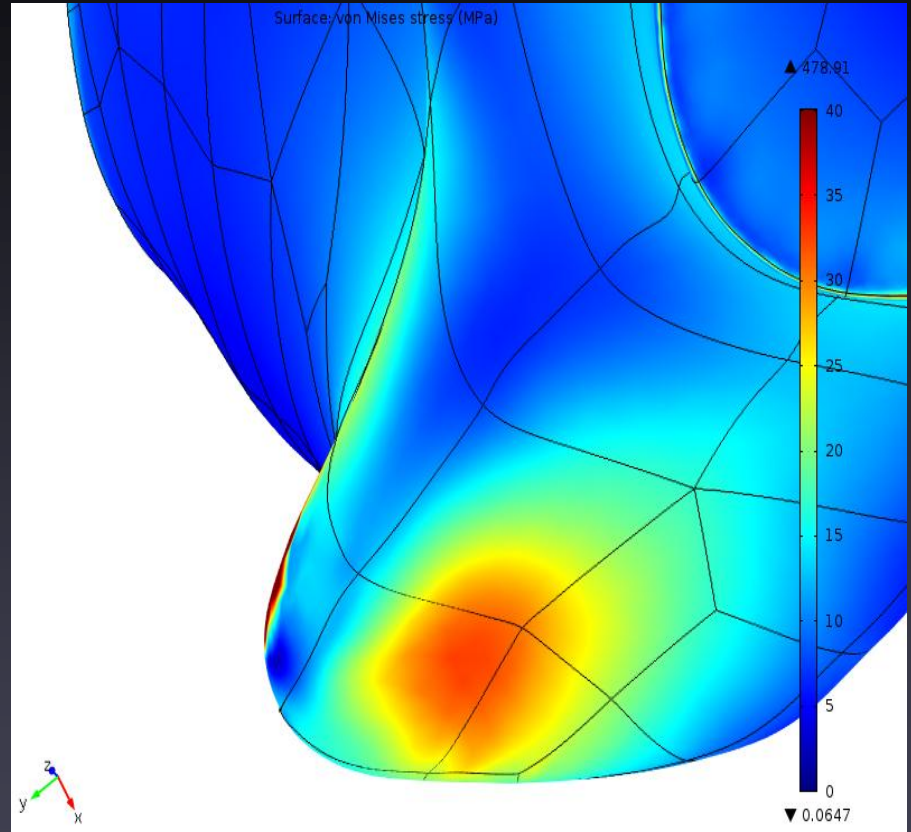


16° pronation

# Results

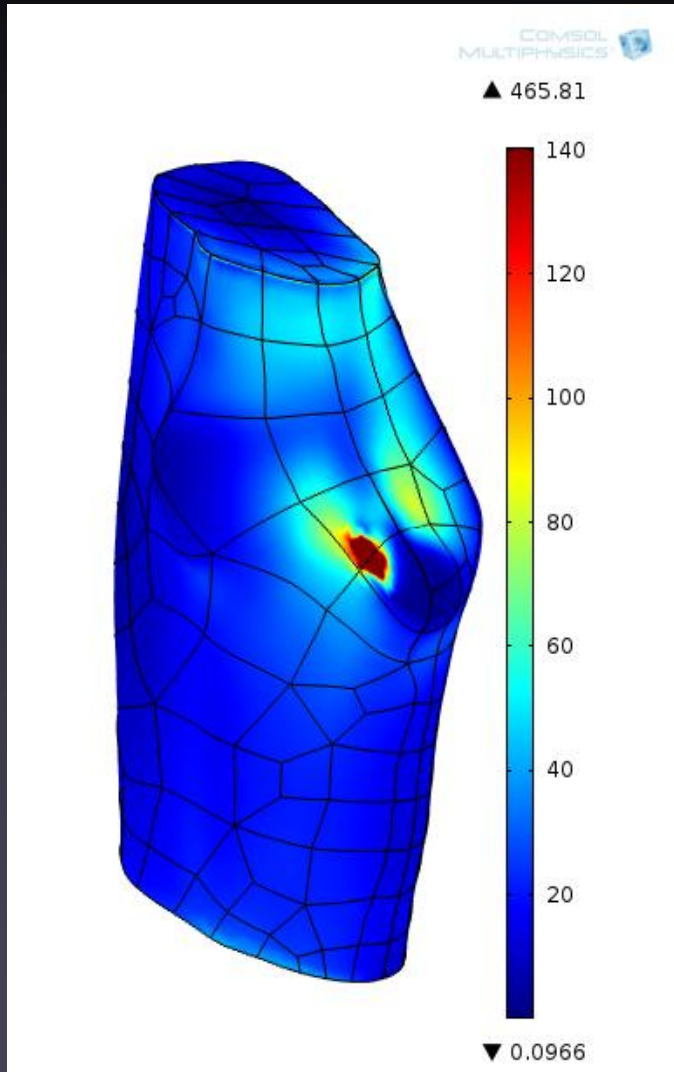


Arthroscopic image of fragment

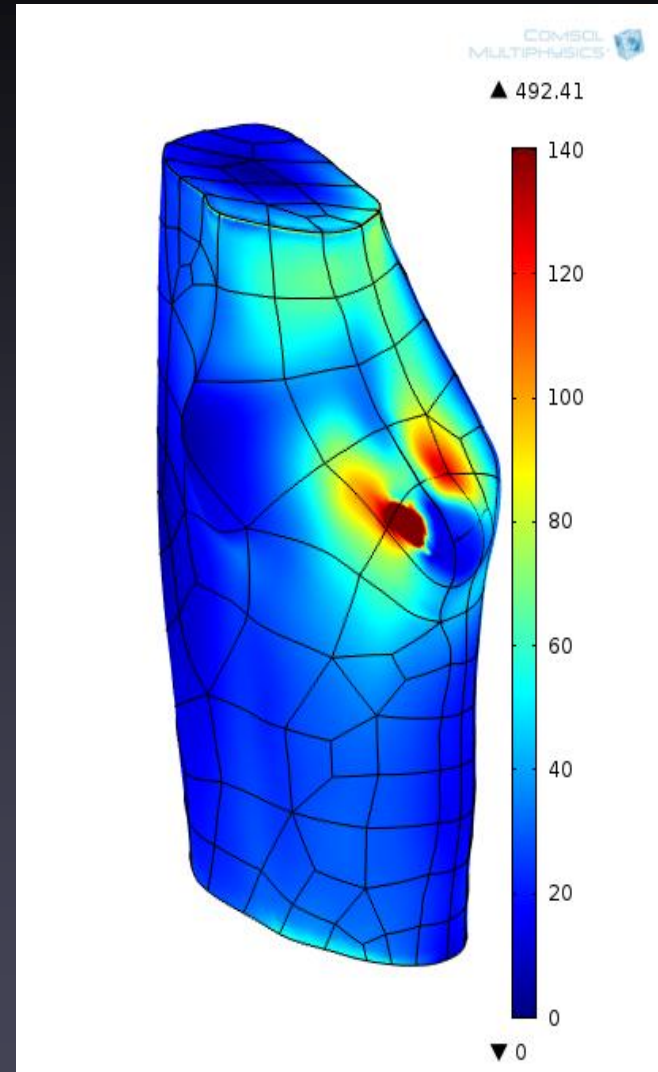


Stress at corresponding site on model

# Results



Lowered radius 'avalanche'



Lowered radius 'avalanche' and 10° rotation

# Results

- High stress concentrations in the area where MCD occurs clinically

# Conclusion

- A robust COMSOL model was created from a CT scan
- Multiple geometric abnormalities were tested to better understand MCD
- Results will be crucial in developing improved techniques to prevent and treat clinically affected patients

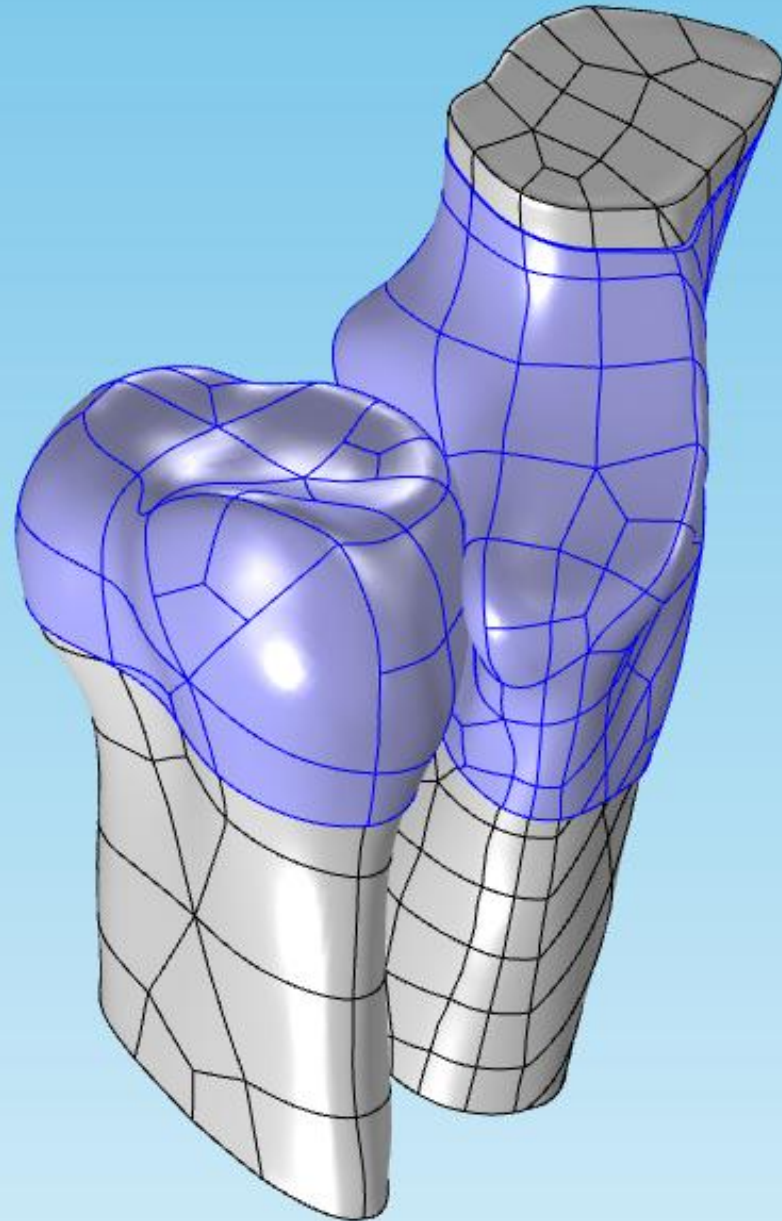


# Future Work

- Ongoing study
- Improve material properties using location specific bone mineral density values from Simpleware
- Add articular cartilage
- Add humerus
- Compare normal geometry to MCD elbow geometry

# Future Work

Articular cartilage  
Model in progress



# Acknowledgements

- The Hendrickson Fund at The Ohio State University
- Fitzpatrick Referrals