



## Distal forearm stability during pro-supination for improved surgical planning

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# Medical Context



Distal forearm instability case: Pre- and Post Operative

# Diagnosis of Instability



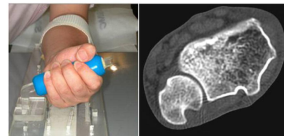
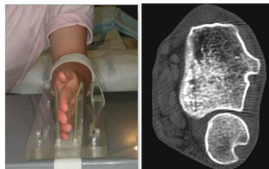
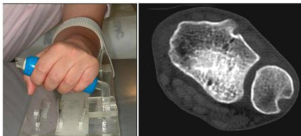
Pronation



Neutral

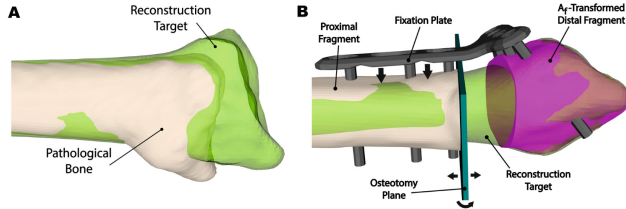


Supination



# Treatment

- Ligaments reconstruction
- Corrective osteotomy (distal radius malunion, ulna shorten)



Radius malunion reconstruction



Intra-Op image



# Application: Computer-assisted PreOp Planning

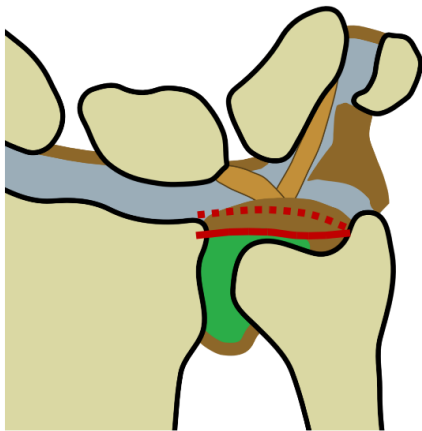
## Limitations:

- Post-operative outcome often unclear
- Soft tissue are not considered
- Absence of motion analysis

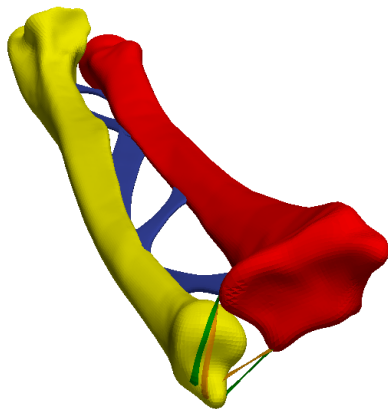
## Objectives:

- Preoperative prediction of the post-operative outcome
- Patient-specific motion simulation
- Simulation of pathological cases
- Identification of the minimal model which is responsible for the stability

# Main Stabilizers of DRUJ

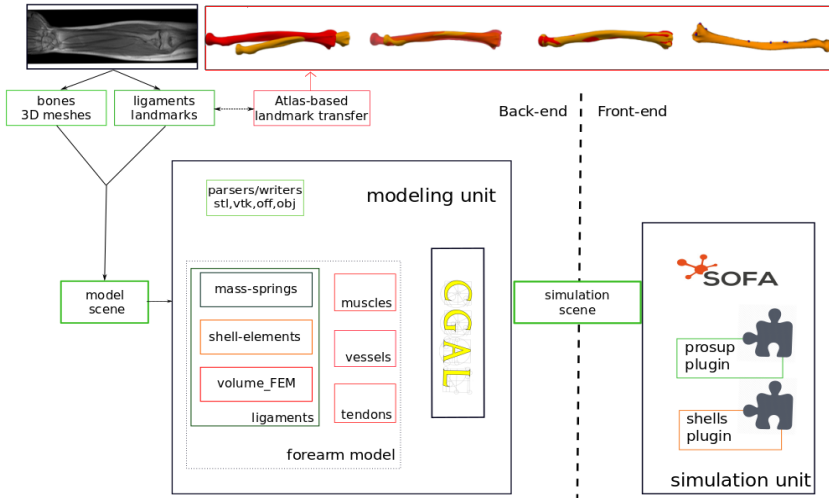


Triangular FibroCartilage Complex (TFCC)

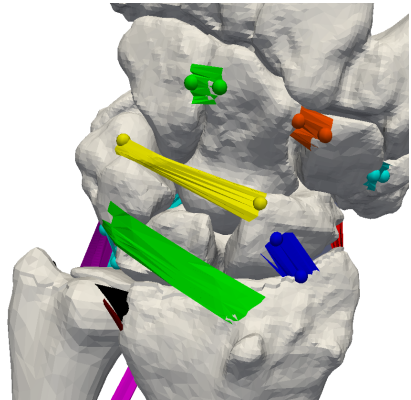
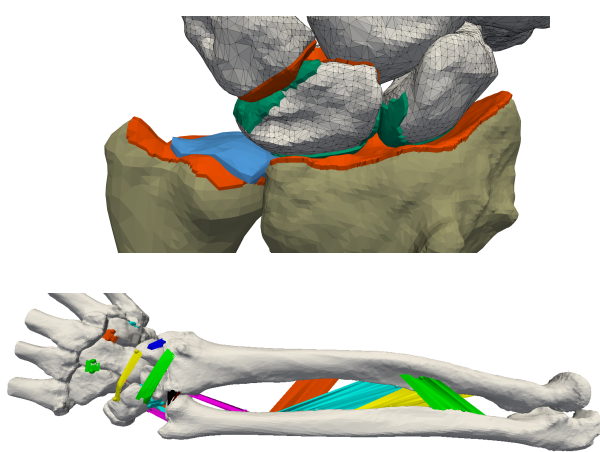


Interosseous Membrane (IOM)

# System Overview



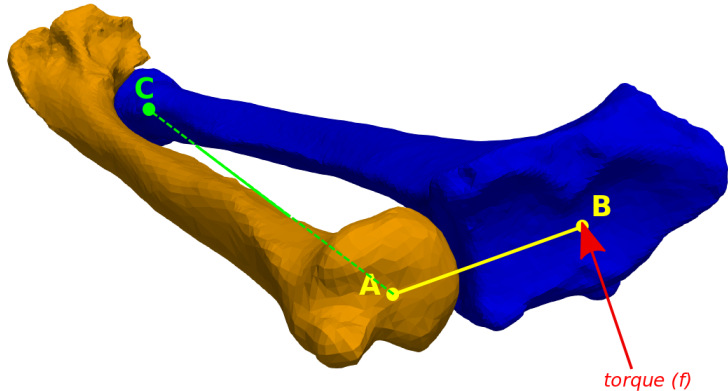
# Geometric Model



Carpal ligaments Dorsal

# Prosup Plugin

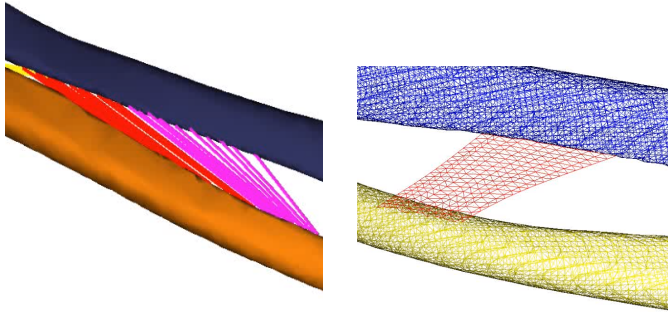
- Torque controller (PID): applied force on the radius (passive motion)
- Boundary conditions: fixed/fixed translation constraints, constant distance.



# video

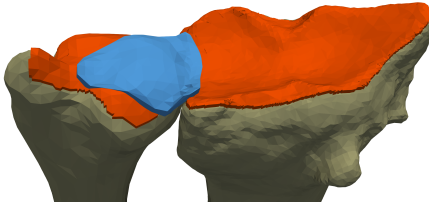
# Behaviour Model: Ligaments

- mass springs (single, band)
- Bilateral Interaction constraints with the bone surface
- Neo-Hookean with Corotational strain
- Shell elements (thickness of 3mm)
- biomechanical parameters from the literature



# Behaviour model: Cartilages

- Volume mesh with barycentric mapping to the bone
- Connection to bones using attach constraints
- Hyperelastic materials (Mooney-Rivlin, others)
- Very small coefficient of friction.



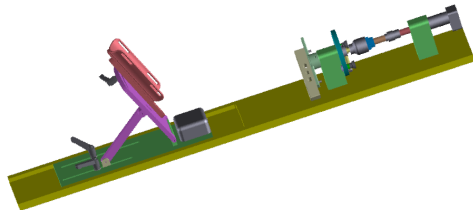
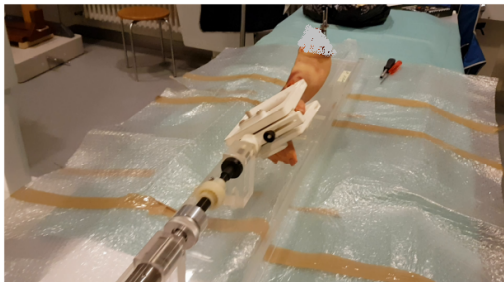


# Collision handling

- Default collision pipeline with brute force detection
- Clustering / collision groups => avoid unnecessary tests
- Downsampled meshes and/or sub meshes
- Response: penalty (more rules could be integrated when necessary)
- Acceleration using an efficient structure "Representative triangle" based on *[Curtis et al.]*

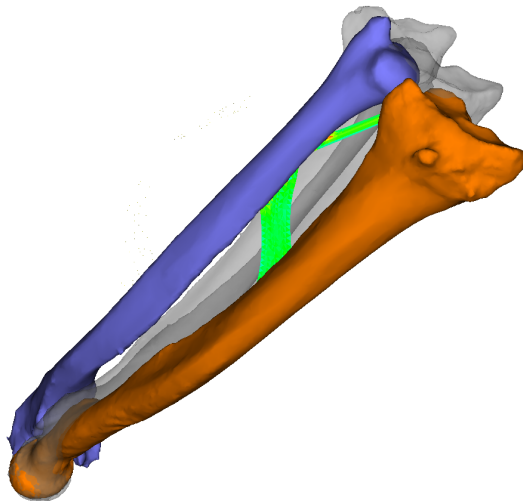
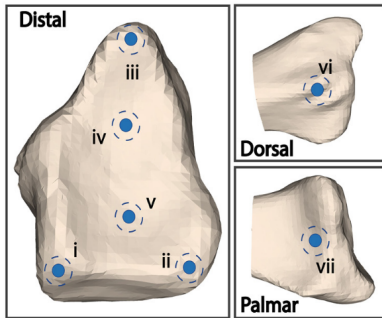
# Validation

- Cadaver studies at CARD research group, Balgrist University Hospital
- Fixation at the elbow
- pro/supination (passive motion)



# Ground Truth

- 2D Dynamic X-ray
- Geometric-based comparison



video

# Work in progress

- Collision handling
- Adjustment of the simulation parameters
- Motion with torque applied on the carpal bones