Team 11: Autonomous Suture Tensioning Management Checkpoint 1

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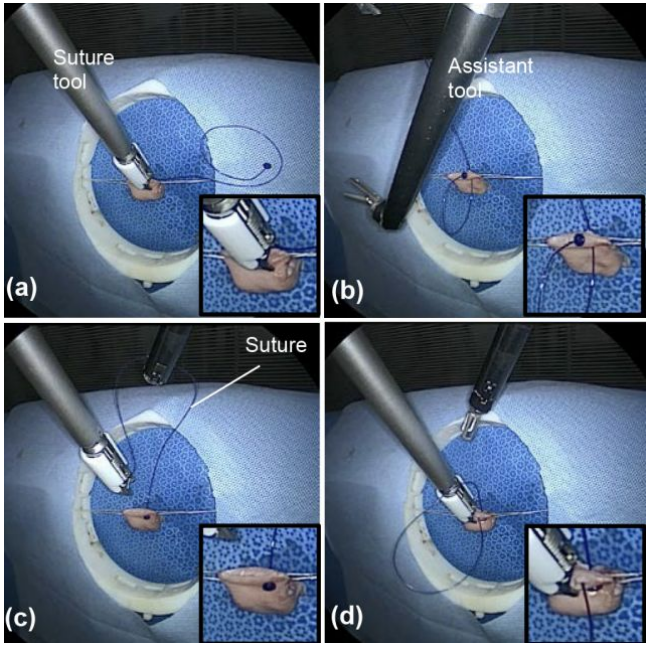
Summary of CIS2 Project



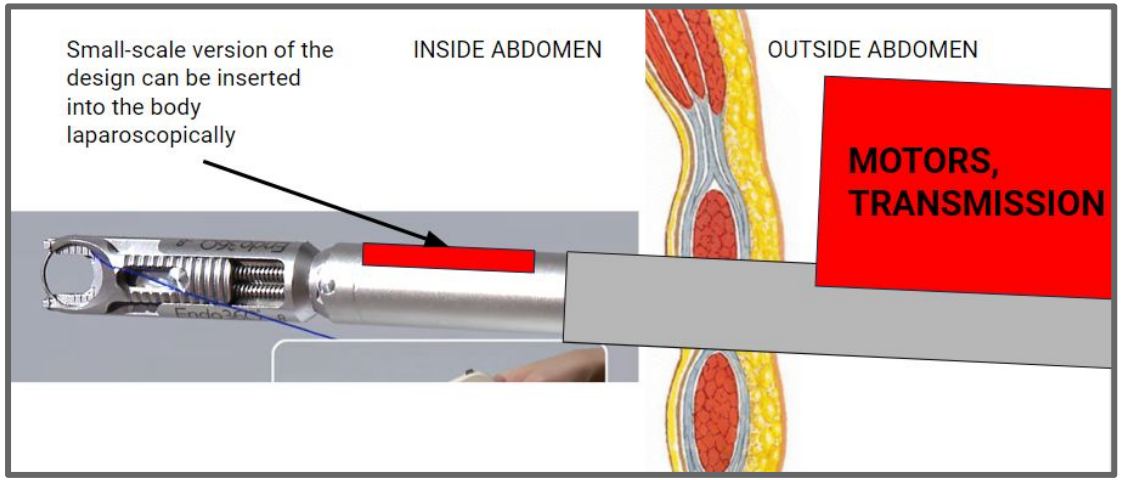


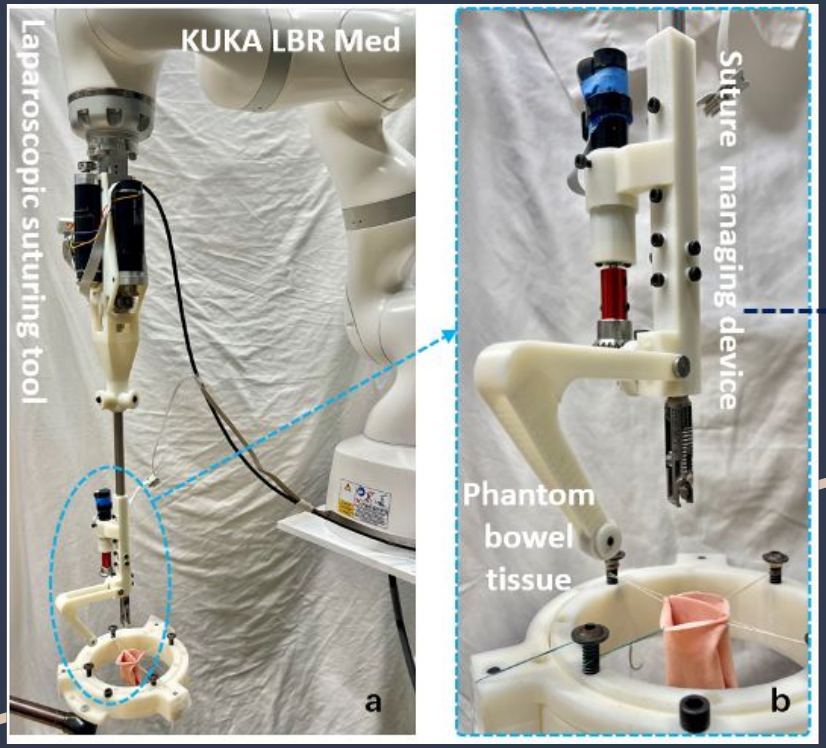
Diagram of our project goal

S. Leonard et al., "Vaginal Cuff Closure With Dual-Arm Robot and Near-Infrared Fluorescent Sutures," in IEEE Transactions on Medical Robotics and Bionics, vol. 3, no. 3, pp. 762-772, Aug. 2021

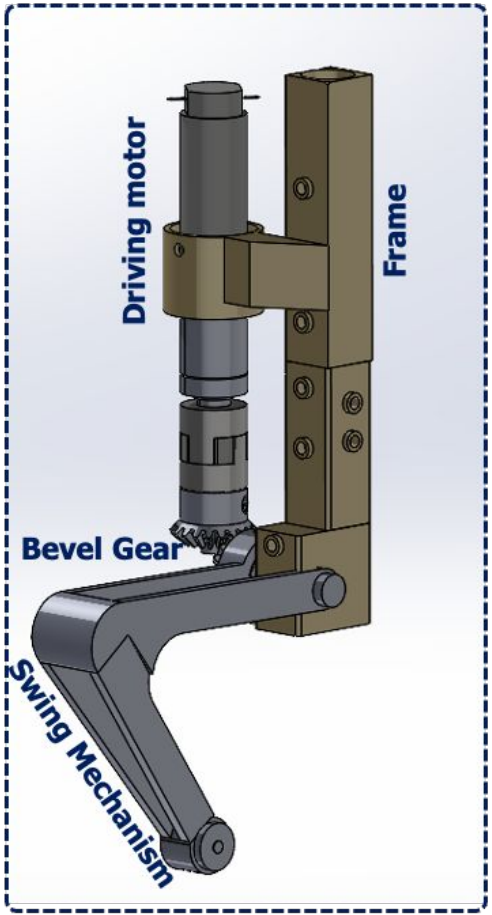
Completed Work - Documentation

- Design specifications document
  - Numbers that our device must be able to satisfy to solve the problem we are trying to solve.
- Design documents for all 3 designs explaining intended function.
- Testing procedure
  - How we are testing these prototypes to verify that they are hitting our design specifications.
- Testing results for large-scale prototype

Large Prototype

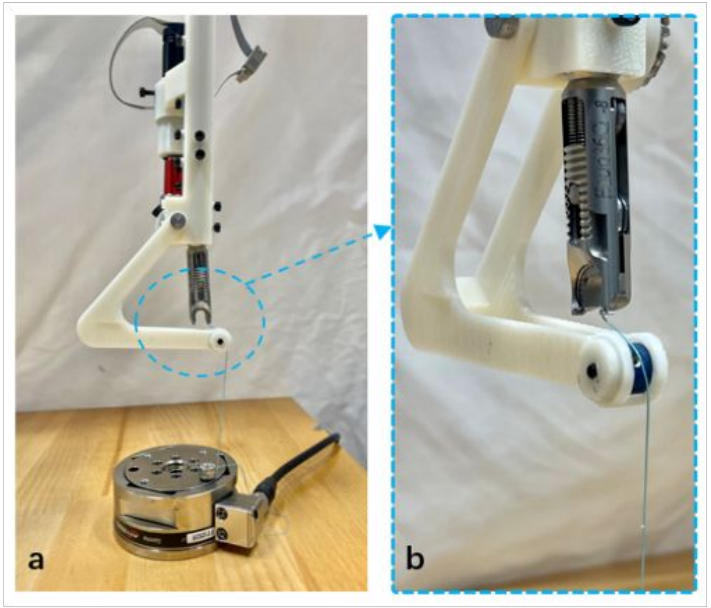


Autonomous suturing structure and working environments

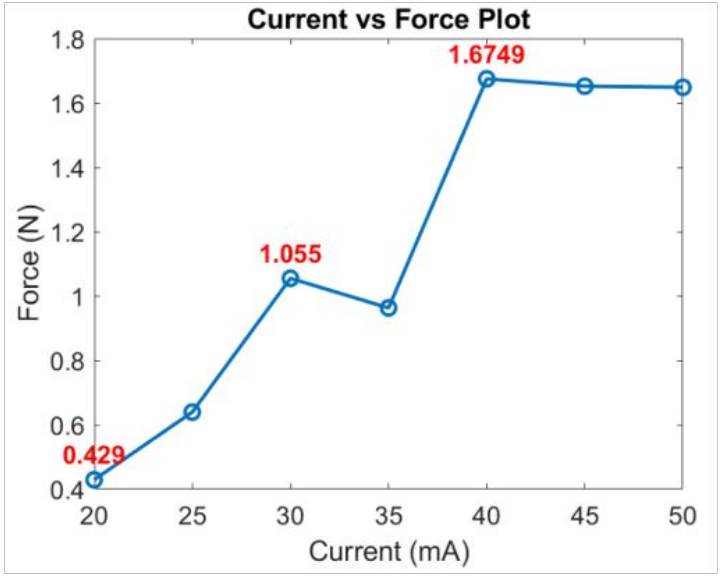


CAD file of SMD

Large Prototype: Tension-force Evaluation

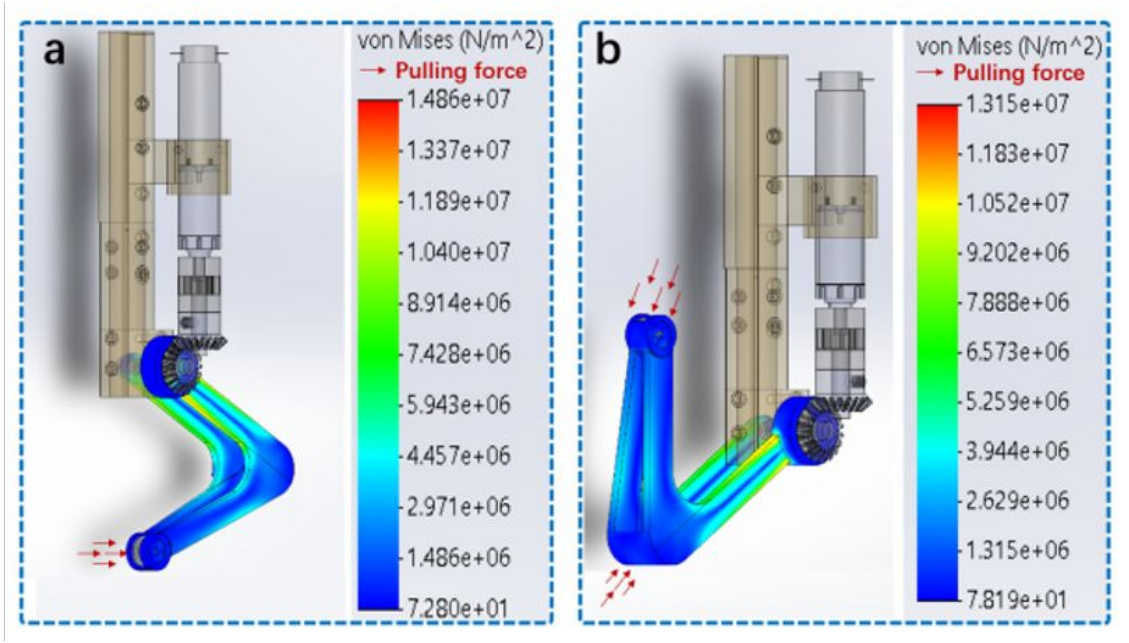


Experiment setup of tension-force evaluation



- Results of tension-force evaluation where maximum tension force was 1.67N with 40mA current input.

FEA of Large Prototype



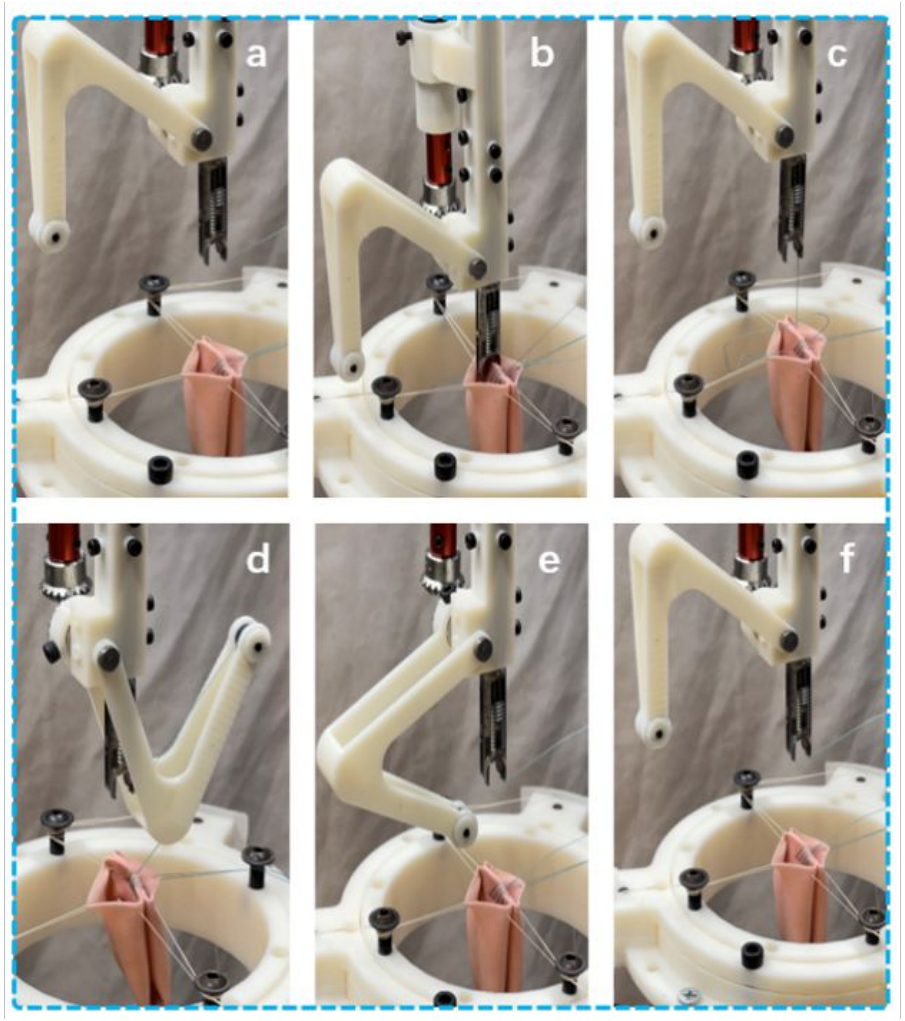
- The configuration that results in the highest stress occurs at the end of the swing mechanism's stroke cycle as shown in Figure b.
- The maximum tolerable stress of the swing arm is approximately 1.315×107 N/m^2 , which implies that the swing mechanism can withstand a maximum force of 13.4 N.

Large Prototype Suturing Evaluation

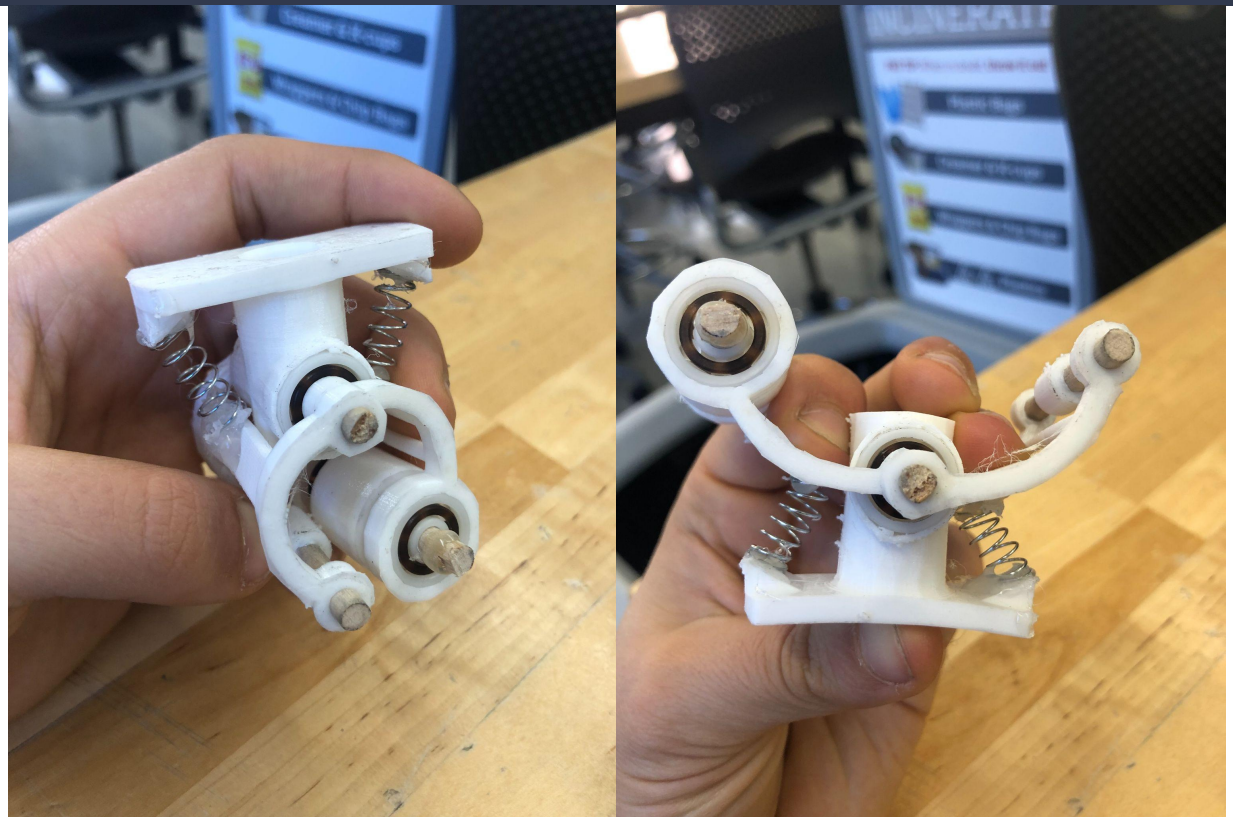
a. Prepare stitch
a. Apply stitch
b. Pull up and prepare tension
c. Tension stitches
d. Release sutures
e. Finish placing a stitch

TABLE II: Comparison Results of Suturing Methods

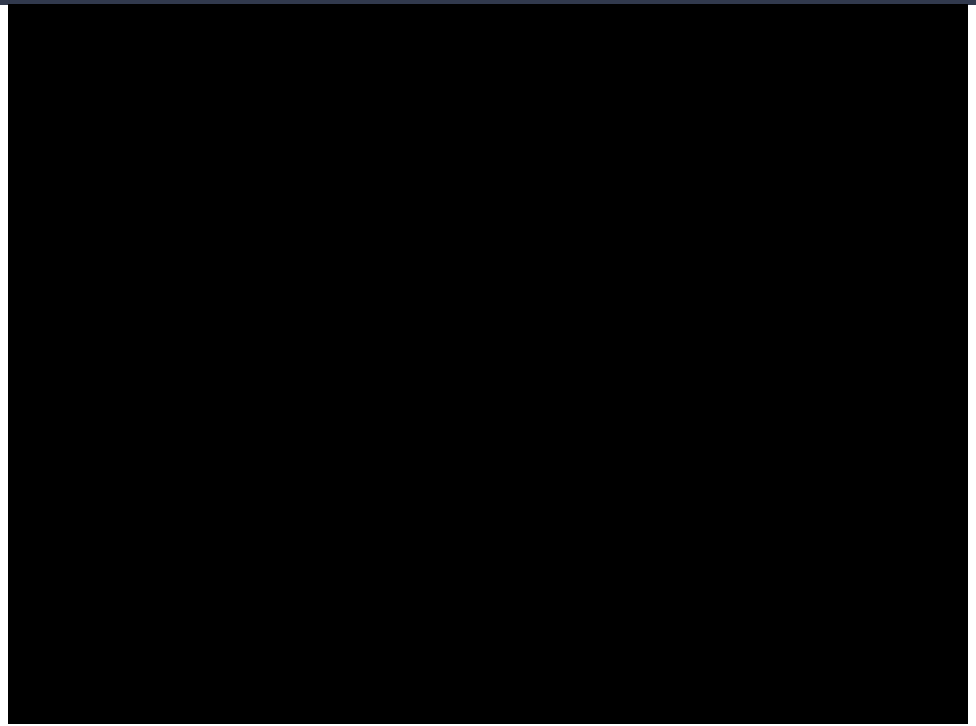
Modality	Time per stitch (second)	Suture spacing (mm)	Bite depth (mm)
STAR (with SMD)	29.10±0.42	3.20±0.17	6.10±0.37
STAR [8] (with robotic assistant)	23.38±2.61	2.63±1.66	3.29±1.32
STAR [8] (with human assistant)	45.63±9.46	2.60±1.04	n/a
LAP [8]	92.15±41.93	4.22±2.64	3.80±1.70
RAS [8]	103.38±44.57	5.05±4.24	2.30±1.49



Completed Work - Small Design #1 Proof of Concept



Completed Work - Small Design #2 Proof of Concept



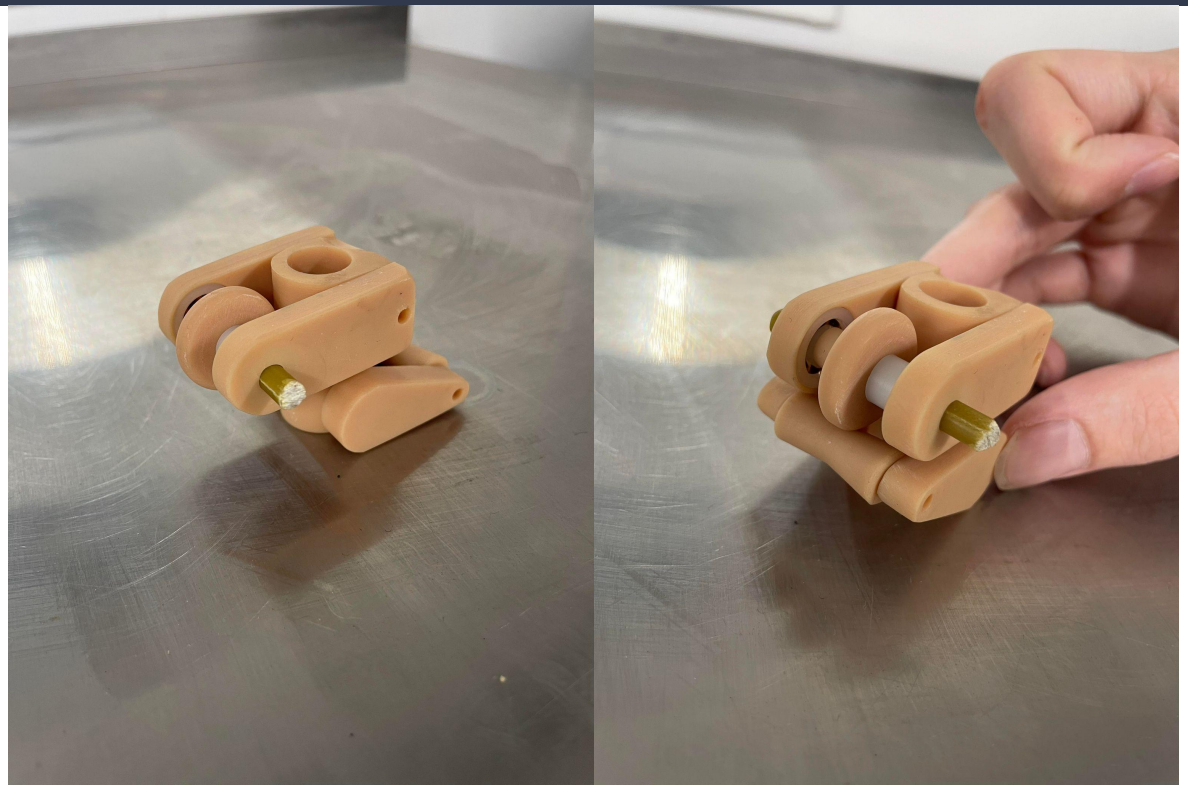
Current version:

- Good fit with ENDO360
- Rigid structure
- Easy manufacturing

Future version:

- Smaller bearings arrived
  - Reduce width to 25mm
- Create simple cable transmission
- Add high-friction rubber to rotors

Completed Work - Small Design #2 Proof of Concept



Timeline

	February				March				April				May			
Preliminary research and brainstorming																
Literature review																
Assess functionality of current design																
Brainstorming																
Choose a design concept to move forward with																
Design				DR1			DR2									
CAD modeling																
Prototyping																
Order parts																
Fully assemble prototype																
Control																
Mount into test setup																
Implement control method																
Test performance of prototype vs. dual-arm approach																
Final Report																

Deliverables

1. Minimum:
    a. Large-scale prototype: completed (done 2/28)
    b. Large-scale prototype design documentation: completed (done 3/15)
2. Expected:
    a. Test results of large-scale prototype: completed (done 3/20)
    b. CAD model of small-scale prototype: in progress (expected 4/3)
    c. Test results of CAD model small-scale prototype: in progress (expected 4/10)
    d. Small-scale prototype design documentation: in progress (expected 4/12)
3. Maximal:
    a. Physical small-scale prototype: not started (expected 5/5)
    b. Test results of physical small-scale prototype: not started (expected 5/7)

Next Steps

1. Final design of small prototype with documentation.
2. Create simple cable transmission
3. Repeat same testing on small prototypes.
4. Documentation of testing with small prototypes.