TRAINING MODEL FOR LEP

Team: Noa Biener, Christian Dittmar Greaves, Michael Lewicki Jr., Cole Miller, Xicheng Yang

Client: Dr. Ali Antar

Advisor: Dr. Yang Lu, PhD

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Problem Statement

- **Benign prostatic hyperplasia (BPH)** is a disorder affecting a **large population** of older men in which **tissue** in the prostate gland **enlarges** abnormally
- Procedure requires **intense preparation** and completion of **multiple cases** by the medical trainee
- Relies heavily on **observation** and **live surgical experience**
- **Limited** opportunity for **safe**, **hands-on practice**
- Model aims to provide **educational platform** for urological residents to **develop** multitude of the **motor skills** required to complete procedure

Background and Impact

Background

- The prostate is a gland located below the bladder and around the urethra, It is divided into zones, including the transition zone, which grows indefinitely
- BPH is a common enlargement that compresses the urethra, causing urinary tract issues[1]
- HoLEP is an effective treatment for BPH but has a steep learning curve, requiring high-fidelity surgical training tools, and navigating a 3D space with a camera[2][3]

Impact

- Provide a more accessible, low-cost training tool for mastering the technically challenging HoLEP procedure.
- Enhances opportunities for performance feedback during training.
- Supports safer, more effective clinical skill acquisition for managing BPH.

Design Specifications

	Silicone Gels	
Criteria (weight)	Score	Weighted Score
Accuracy(30)	5/5	30
Tactile Feedback(25)	4/5	20
Feasibility(15)	3/5	9
Reusability(10)	4/5	8
Ease of Fabrication(10)	2/5	4
Safety(5)	5/5	5
Cost(5)	3/5	3
	Sum	79

Figure 1. Design Matrix

- Model must replicate all relevant anatomical parts to scale
- Model must show clear **color difference** between adenoma and capsule
- Model should simulate traversing a 3D space with a camera
- Model should be **reusable**
- Material should have similar properties to prostate tissue:
  - Young's Modulus of **22.7 KPa**[4]

Final Design

Features

- 3D Scan of **Real 130g** Prostate
- Hole to simulate scope entering urethra
  - Includes **Verumontanum**, an important landmark
- Clear **color distinction** between Adenoma and Capsule
- First cut of surgery pre-made

Materials

- Frame: PLA printed from UW Makerspace
- Negative Space: Smooth-On Dragon Skin™ 30 Silicone Gel
- Prostate Tissue: Smooth-On Ecoflex™ 00-10 Silicone Gel

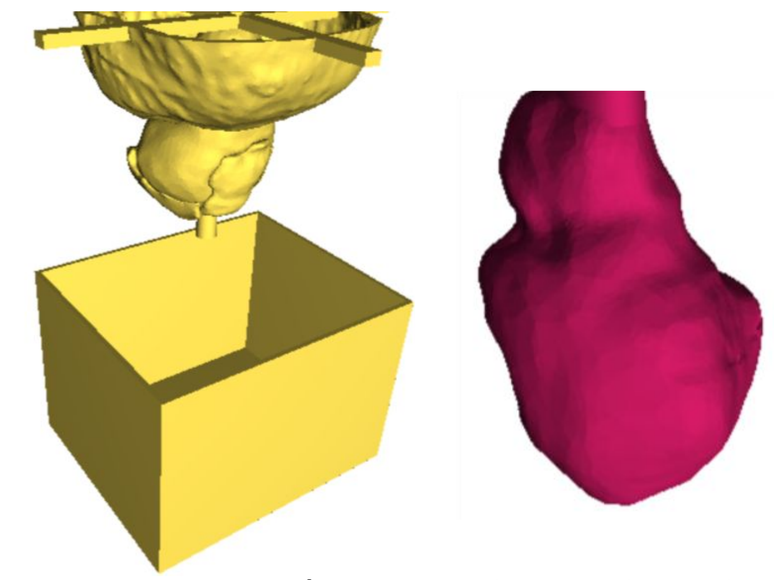

Figure 2a/2b. Model of Capsule(Yellow), Frame, and Transition Zone(Pink-Red)

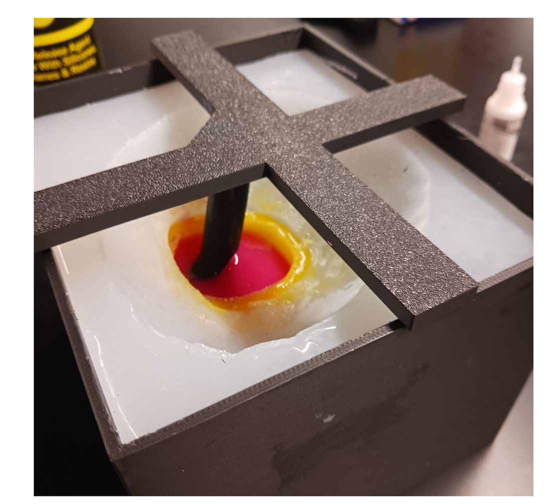

Figure 3. Top view of Final Design during casting

Testing

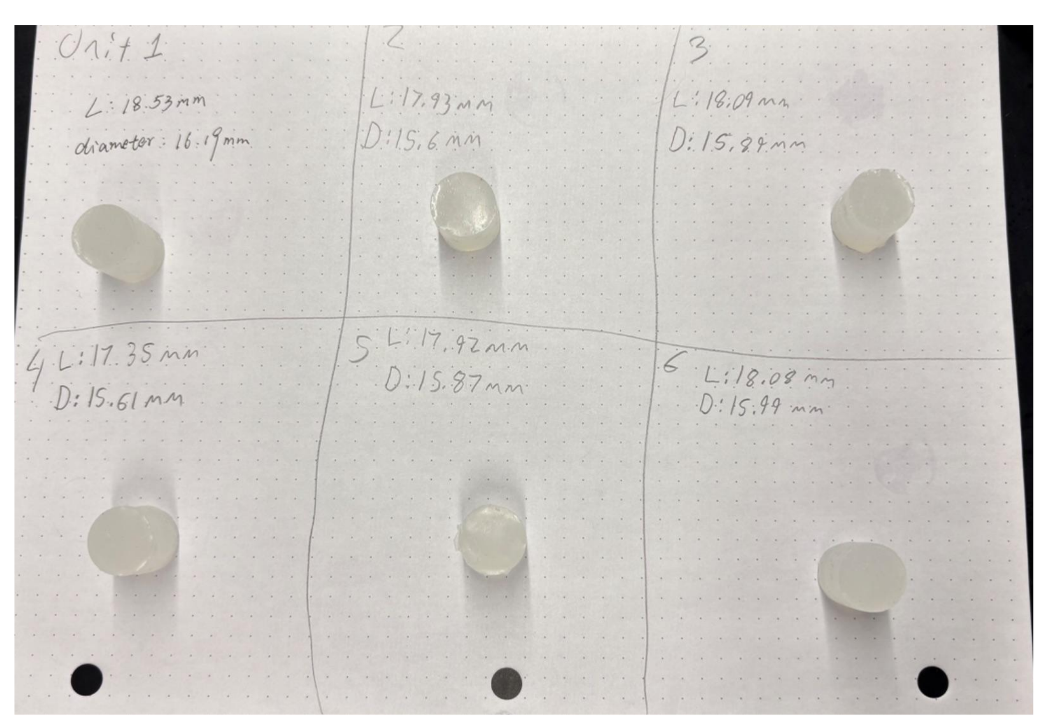

Figure 4. 6 uniform Ecoflex™ 00-10 Silicone Gel testing samples

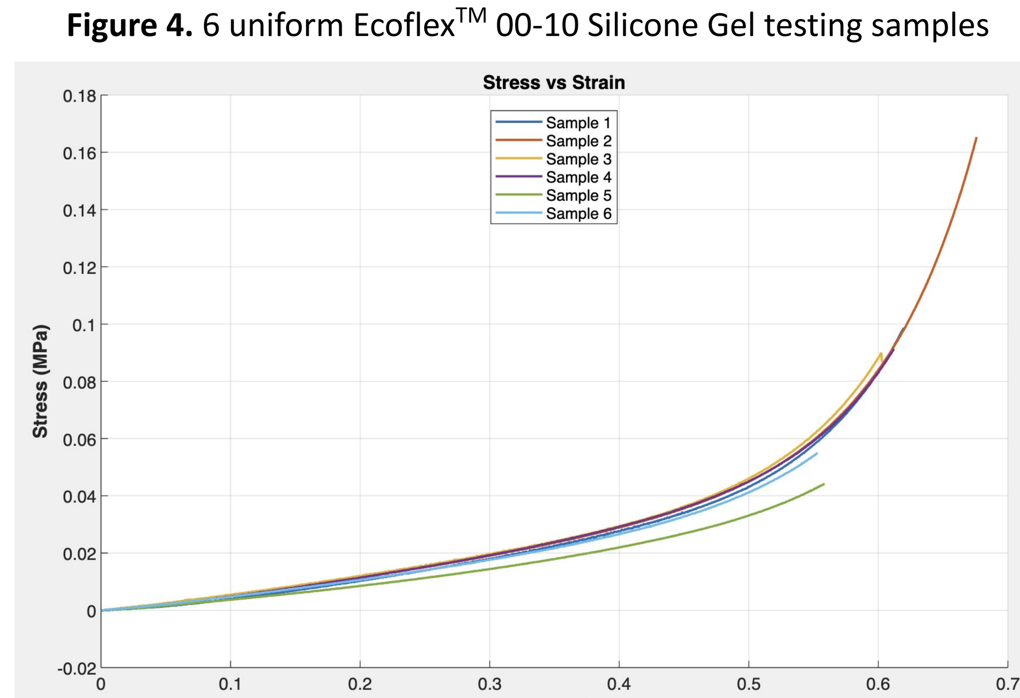

Figure 5. Stress vs. Strain curve of 6 test samples

- Six cylindrical Ecoflex™ 00-10 samples (**Figure 4**)
  - Length: 17.8–18.5 mm
  - Diameter: 15.6–16.9 mm
- Uniaxial compression tests
- Stress–strain curves were generated using MATLAB (**Figure 5**)
- Young's modulus was obtained from the linear region (0–0.4 strain) of each stress–strain curve
  - Average Young's Modulus: **67.73 ± 7.00 kPa**
  - Coefficient of Variation: 10.34%

$$E = \frac{\sigma}{\varepsilon}, where\ \sigma = \frac{F}{A}, \varepsilon = \frac{\Delta L}{L_0}$$

- The measured average Young's modulus is within the same order of magnitude as the target prostate tissue stiffness, indicating a **mechanically relevant approximation** for soft tissue simulation

Future Work

- Fabricate model with hydrogel insert to simulate use of holmium laser
- Developing different sized prostates for the model as it currently only depicts an extremely enlarged 130g prostate.
- Adding veins and arteries to the model to simulate blood containment
- Develop methods of assessing success of simulated surgery

Conclusion

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- Training residents in HoLEP is long and difficult, sometimes offsetting the procedure's benefits.
- A major challenge is learning to cut in 3D space while viewing only a 2D camera.
- Our model provides a **realistic simulation** of the surgical cut, mimicking **tactile feedback**, and including navigation with a camera
- Allows residents to practice safely without the pressure of real surgery.
- This **makes teaching HoLEP easier** and helps its advantages outweigh the steep learning curve.

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References

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