Medical Art Prosthetics: Composite Polymers

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Client: Mr. Gregory Gion

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Overview

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- Design Specifications
- Motivation
- Previous Work Summary
- Improving Tests and Fabrication
- Additional Tests
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- Budget

Problem Statement

- Prostheses achieve adequate levels of realism and comfort, but have significant issues:
  - Expensive fabrication
  - Significant wear and tear
    - Loss of material
    - Discoloration
- **Goal:** Devise a fabrication method using an alternative polymer to change surface properties of the prosthesis while maintaining the desirable properties
  - Increase durability
  - Decrease coefficient of friction
  - Maintain aesthetics

Figure 1: Recreation of a missing finger[1]

1. Gion, G., MMS, & CCA. (n.d.). Home. Retrieved February 10, 2018, from http://www.medicalartprosthetics.com/

Background

- **Client:** Mr. Gregory Gion, BA, BS, MMS
  - Founder of Medical Arts Prosthetics, LLC
  - Maxillofacial prosthetist
  - Specializes in anaplastology and artistic recreation of skin aesthetic on prostheses

Mr. Gregory Gion, BA, BS, MMS[1]

1. Gion, G., MMS, & CCA. (n.d.). Home. Retrieved February 10, 2018, from http://www.medicalartprosthetics.com/

Design Specifications

- **Design Specifications**
  - Budget: $500
  - Must look life-like
  - Lower μ than current silicone models
  - Decrease wear rate
  - Must exhibit UV resistance
  - Must not affect color accuracy or appearance

Figure 2: Recreation of a missing finger[1]

1. Gion, G., MMS, & CCA. (n.d.). Home. Retrieved February 10, 2018, from http://www.medicalartprosthetics.com/

Motivation

- Aid in patient integration into society
- Undergo deformation and discoloration
- High cost → requires longevity of device

Figure 3: Fungal growth on a silicone prosthetic[2]

Figure 4: Recreation of a missing finger[1]

1. Gion, G., MMS, & CCA. (n.d.). Home. Retrieved February 10, 2018, from http://www.medicalartprosthetics.com/
2. A. Udagama, "URETHANE-LINED SILICONE FACIAL PROSTHESES," Journal of Prosthetic Dentistry, vol. 58, no. 3, pp. 351-354, Sep 1987.

Fall 2017 Summary

- **Sample Fabrication**

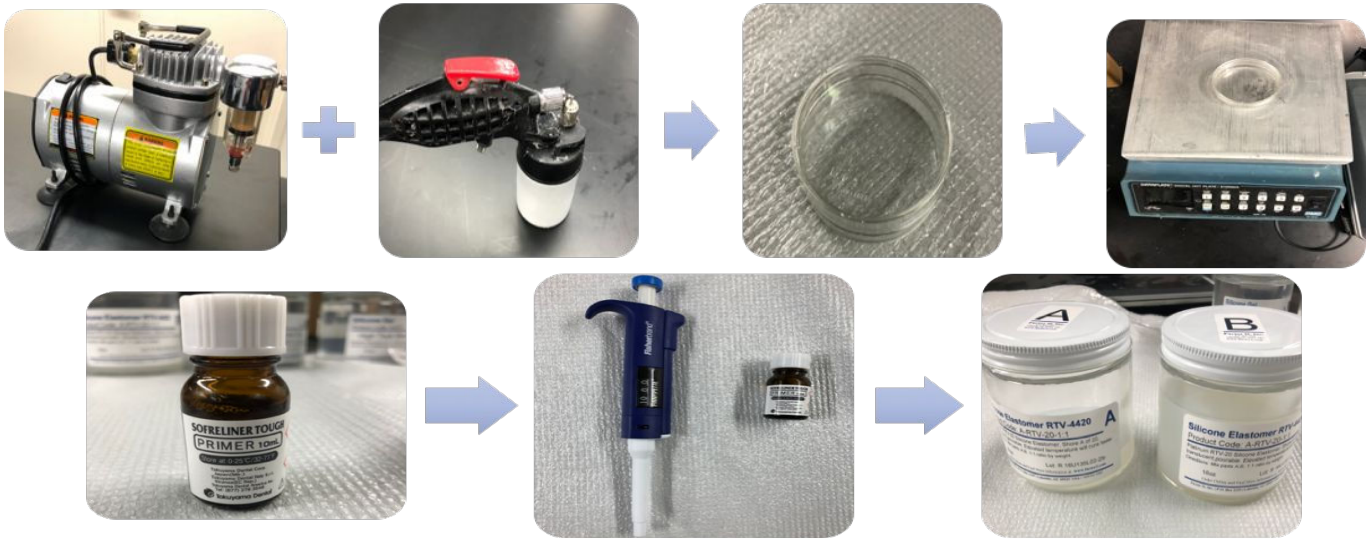
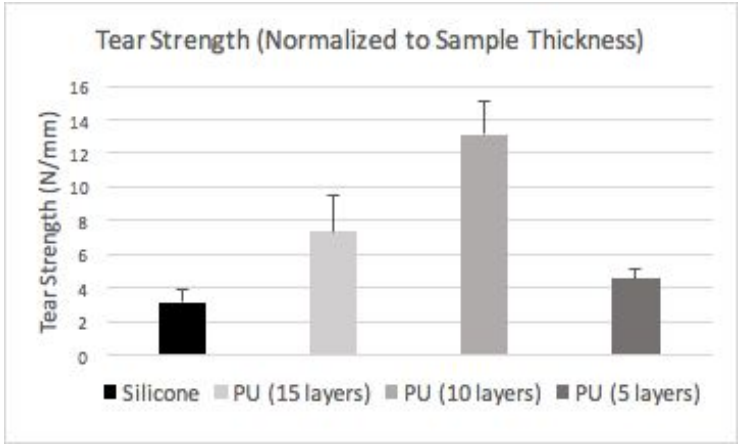
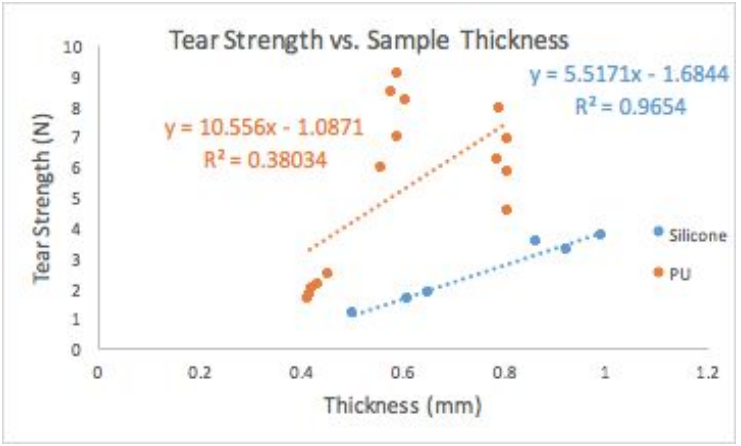


Figure 5: Current sample fabrication schematic

Fall 2017 Summary - Tear Strength





- PU was significantly greater at 10 layers (consecutive coats were applied)
- Limited sample size and a non-linear trend between sample thickness and tear strength for PU

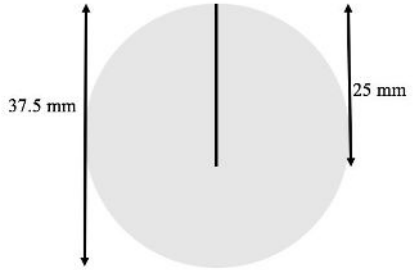


Figure 6: Sample dimensions for tear strength testing

Fall 2017 Summary - Peel Strength

Peak Load	6.648±4.928 N
Peak Peel Strength	0.960±0.709 N/mm
Mean Peel Strength	0.626±0.502 N/mm

- Limited sample size and significant variation in measured strength
- Application method was incompatible with fabrication
  - Ideal method: prime silicone and spray on PU coat with an airbrush

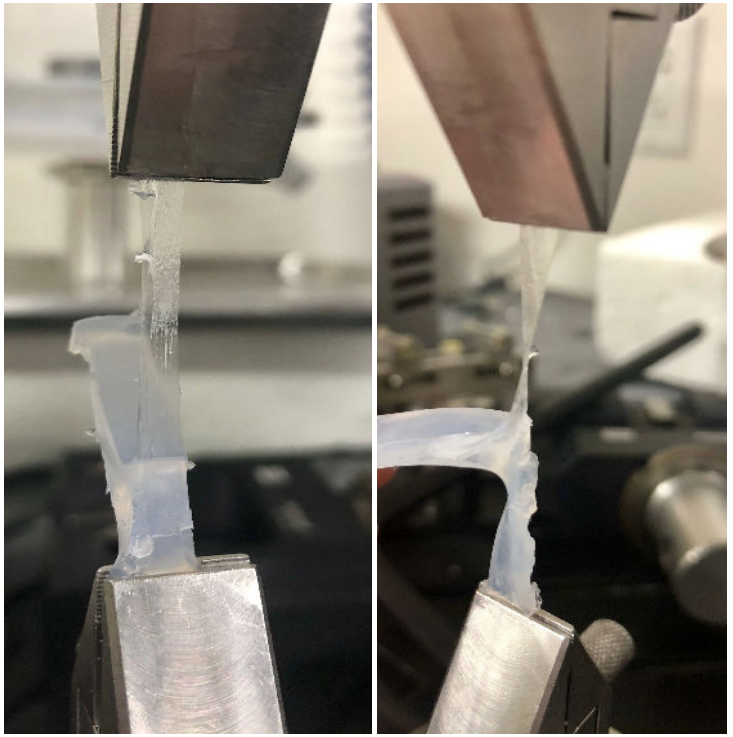


Figure 7: Peeling at the bond interface (left) and peeling into the silicone matrix (right)

Fall 2017 Summary - Coefficient of Friction

Coefficients of Friction of Polyurethane and Silicone				
Material	Average Static Coefficient of Friction		Average Kinetic Coefficient of Friction	
600 grit Sandpaper	PU	0.2474	PU	0.2386
	Silicone	0.2345	Silicone	0.2186
Jean Pocket Fabric – 99% cotton, 1% spandex	PU	0.2397	PU	0.2250
	Silicone	0.2161	Silicone	0.2050

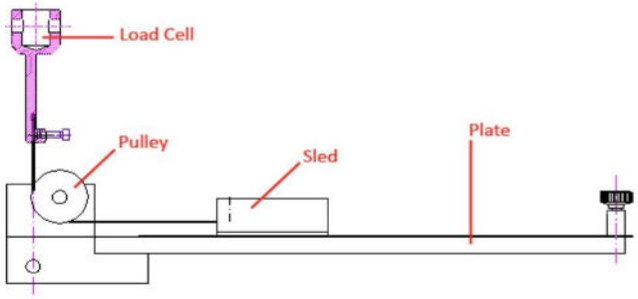


Fig. 8: Setup for testing coefficient of friction[3]

- Counterintuitive results
- Limited sample size
- Equipment resolution was incompatible with sample masses

3. "ASTM D1894 Coefficient of Friction Test on Plastic: How to Guide," ADMET - Materials Testing System Manufacturer, 2017. [Online]

Improving Tests and Fabrication

- **Tests**
  - Tear Test
    - Increase sample size
  - Peel Test
    - Application comparison
  - Coefficient of Friction Test
    - Increase sample mass and amount of samples
- **Fabrication**
  - Ensure consistency in sample fabrication

Figure 9: Process of recreation of a missing finger[1]

1. Gion, G., MMS, & CCA. (n.d.). Home. Retrieved February 10, 2018, from http://www.medicalartprosthetics.com/

Spring 2018 - Additional Tests and Evaluation

- Taber Abrasion Test
  - ANSI/ISEA 105 → ASTM D3884 & ASTM D3389
    - PU lined silicone on Rotary Platform Abrader
    - 500g load for testing for 500 revolutions
- UV Exposure Test
  - ASTM D 1148-95
    - PU lined silicone UV light
    - 6, 24, 48, 100, 500, 1000, 1500 hours
    - qualitative Δ in color
- Water Absorption Test
  - ASTM D 471-06
    - PU, silicone, PU lined silicone in DW
    - Δ in mass every 2 weeks

Figure 10: Rotary Platform Double Head Abrader for ASTM D3884

$$\%Absorption = 100\% * \frac{W_i - W_f}{W_i}$$

Final Design and Prototype

- Prosthetic silicone finger with PU coating
  - Silicone in mold primed first, then PU is applied
- Maintenance and Long-Term Use
  - design allows for routine cleaning and washing

Figure 11: Mold used for prosthetic fingers

Management Plan

- **Spring 2018**
  - Fabrication research
  - Design Development
  - **Mechanical testing**
  - **Fabrication**
  - **Characterization and statistical analysis**
  - **Working prototype**
- **Testing Plan**
  - UV {Feb 12 - May 1}
  - Tear Strength {Feb 19 -23}
  - Peel Strength {Feb 19 - 23}
  - Water Absorption {Feb 20 - May 1}
  - Coefficient of Friction {Feb 26 - Mar 2}
  - Wear Resistance {Mar 5-9}

Budget

Material	Product Number	Cost
Silicone Elastomer	A-RTV-20	$41.95
Silicone Elastomer	A-2186-F	$139.95
Sofreliner Tough Primer 10ML	76750186	$46.00
Single Component Aliphatic Water-Based Coating (Polyurethane)	SC-92	$54.00

Miscellaneous	Cost
Shipping and Handling and Tax	~ $10.00
Final Poster	~ $30.00

- Total Spent: ~ $321.90
- Budget Remaining: ~ $178.10

References

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Thank you!

Questions?