Universal Surgical Abscess Drain

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Outline

- Project Overview
- Last Semester
- Final Design
- Prototype Fabrication
- PDS Requirements
  - Insertion/removal force
  - Flexural testing
  - Protein adsorption
  - Drain placement and stability
- Future Work

Project Overview

- Abscesses are localized infections under the skin which result in the accumulation of pus, local tissue ischemia and potential systemic infection

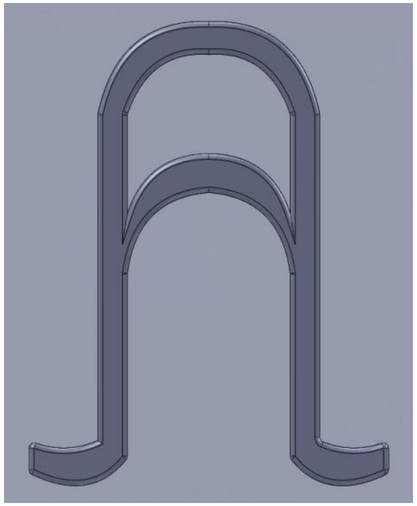
- Goal: Develop an abscess drain which eliminates the need for suturing and primary nursing care for drain replacement and cleaning

Figure 1

Figure 2

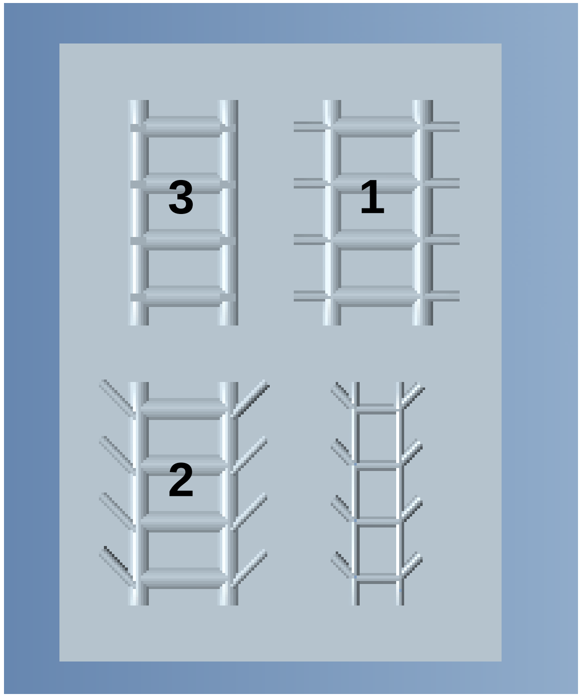
Last Semester

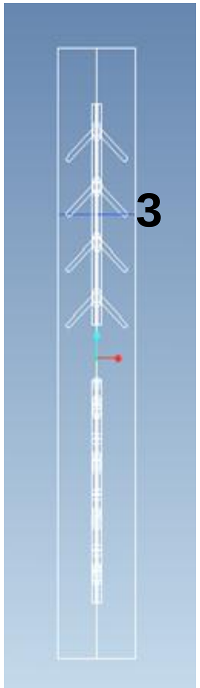
- Developed mold of ‘A’ drain model and fabricated silicone prototypes
- Identified several design flaws
  - Universality: abscess depth and width varies
  - Stability within abscess cavity
  - High above-skin profile



Final Design

- After internal discussion and collaboration with client, decided upon 'Ladder' drain model to address potential design flaws of 'A' drain
- Developed three design variants with different abscess-anchoring mechanisms
    1. 90° In-plane bars
    2. 45° In-plane bars
    3. 45° Out-of-plane bars





Prototype Fabrication

- Designed CAD molds for each ladder variant, printed on WID/MIR 3D printer
  - Accurate dimensions for smooth, precise prototypes
  - ABS is strong, can withstand temp needed to cure silicone (MP = 221 °F)
- Drain will be made from non-toxic, medical grade silicone (PDMS)
  - 30A and 10A durometer two-part silicone
  - Vacuum degassed, packed into mold and fired at 180 °F for 90 min

Figure 3

PDS Requirements

- Optimize insertion and removal force to ensure stability and patient comfort
- Minimize above-skin profile to prevent accidental snagging
- Prevent heightened inflammatory response and device biofouling during extended use
- Confirm drain maintains position in wound during patient motion

PDS Requirements

- Optimize insertion and removal force to ensure stability and patient comfort
  - **Insertion/removal force calculations and testing**
- Minimize above-skin profile to prevent accidental snagging
  - **Flexural testing**
- Prevent heightened inflammatory response and device biofouling during extended use
  - **Protein adsorption testing**
- Confirm drain maintains position in wound during patient motion
  - **Simulated patient activity with cadaver torso and limb**

Insertion and Removal Force

- Calculations based on model with simplified geometry (legs 3/8" x 3/16", posts 3/16" diam.) and 30A PDMS
  - Buckling equation: $F = \frac{\pi^2 EI}{(KL)^2}$
    - Calculated force to buckle 'Ladder' leg to be 2.8 lb
  - Beam deflection: $\delta = \frac{PL^3}{3EI}$
    - Used to calculate max post width based on 2.8 lb load
    - Max post width = 0.681"; used 0.1875"

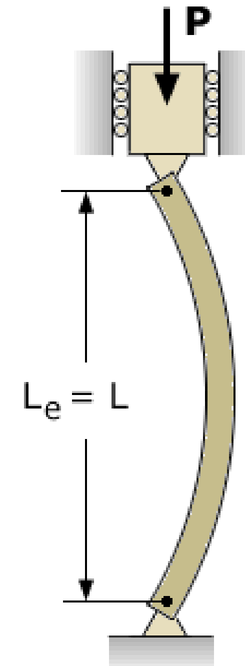


Figure 5

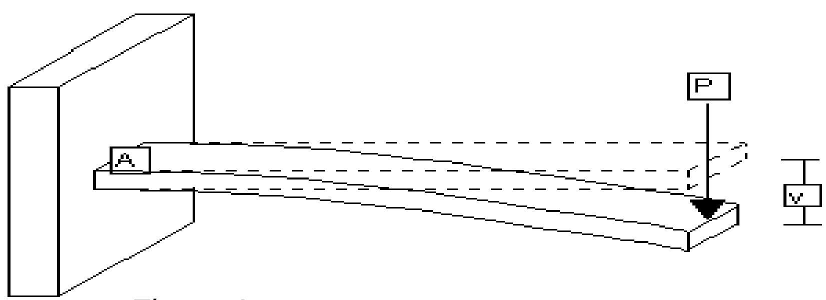
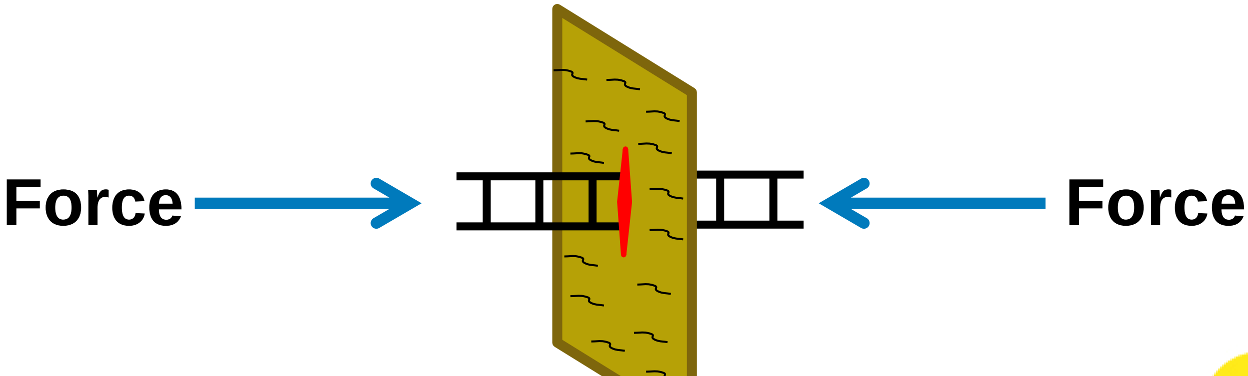


Figure 4

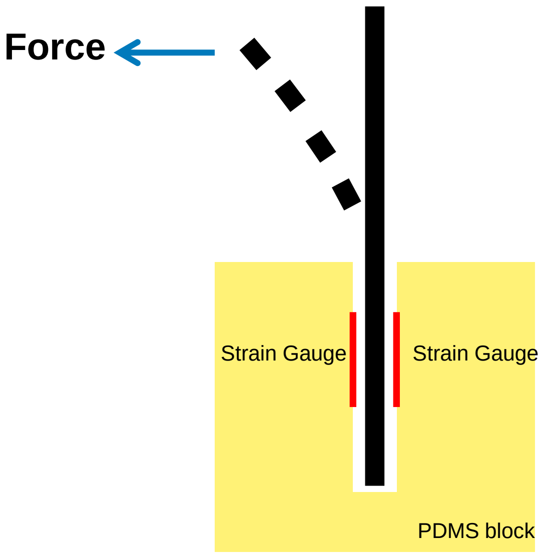
Insertion and Removal Force

- Goal: determine insertion and removal force using porcine skin model
  - Freshly incised porcine skin with 1-2” subcutaneous fat
  - Use force dynamometer to quantify force needed to insert and remove three ‘Ladder’ variants
- Anticipated results:
  - Force needed to insert and remove through skin < 5 lb
  - 45° In-plane/out-of-plane bar variants will be easier to insert, but more difficult to remove



Flexural Testing

- Goal: determine force applied on inside of abscess cavity when drain is bent
  - Drain will be folded over, increasing localized pressure in abscess cavity
  - Strain gauge used to measure deformation, determine pressure
- Anticipated results:
  - Pressure spots will be greatest in cavity at skin level; pressure will increase with drain height
  - Above-skin profile will be optimized



Protein Adsorption

- Goal: compare the level of protein adsorption between the ‘Ladder’ and Penrose drains *in vitro*
  - High level of protein adsorption indicative of biofouling; abscess drain may remain in place for up to 30 days *in vivo*
  - ‘Ladder’ and Penrose drains placed in 7.5% BSA in DPBS for 96 hours
  - Quantify protein adsorption after detergent protein desorption with Bradford assay
- Anticipated results:
  - Lower level of protein adsorption on ‘Ladder’ drain compared to Penrose drain
    - Shape and surface area: tubular vs. rods
    - Material: latex vs. PDMS

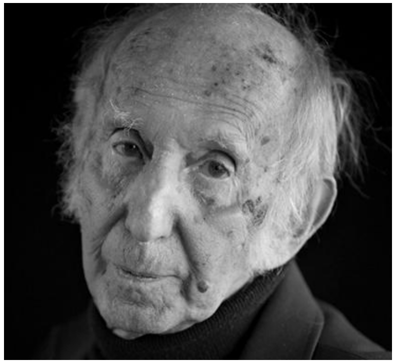


Figure 6

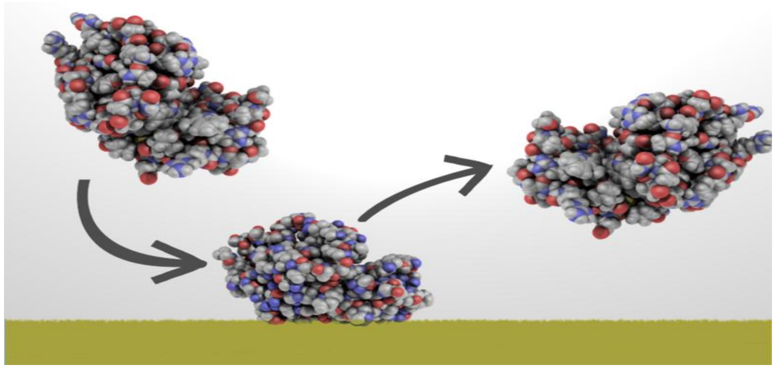


Figure 7

Drain Placement and Stability

- Goal: evaluate stability of drain using cadaver to simulate typical patient movement
  - Drain inserted in different “abscess” locations near joint
  - Quantify drain dynamics during joint circumduction, abduction, adduction, flexion and extension
  - Compare all three ‘Ladder’ drain variants and sutured Penrose drain
- Anticipate results:
  - Further validation of drain insertion and removal
  - ‘Ladder’ drain will be as effective as Penrose drain in maintaining position within “abscess” cavity

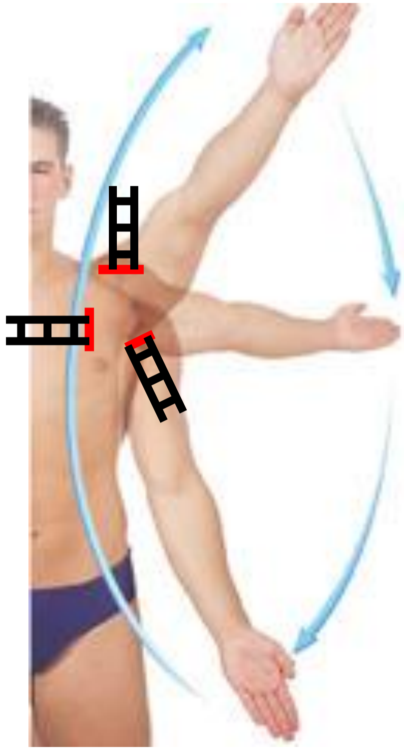


Figure 8

Future Work

- Fabricate prototypes using 3D printer molds
- Perform testing described herein
- Contact Dr. Bersu, Director of Body Donor Program, about cadaver body
- Fill out WARF IDR per request of client

Acknowledgments

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