

Improved Method of Securing Surgical Drains Team: Dana Stumpfoll, Lauren Heller, Rebekah Makonnen, Oscar Zarneke, Abdoulahi Bah **Client: Dr. Katie Kalscheur Advisor: Dr. Tracy Puccinelli**

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Background

Motivation:

- Surgical drain usage is increasing with a rise of prevalent chronic diseases [1]
- Market projection increase from 75.5 million units to 95.5 million units in 2030 [1]
- Current methods to secure surgical drains involve a single suture that aims to prevent dislodgement of the drain from a body [2]
- Tugging or brushing over the suture site creates significant discomfort to patients, and can potentially result in disruption of the drainage process [3]

Clinical Significance:

- Surgical drains are used to prevent accumulation of blood, pus, and other fluids following a surgical procedure [2]
- Drainage bulbs must be emptied and fluid measurements are taken to determine proper removal time [4]
- Drain site must be kept clean, and drain tubing must stripped twice daily to prevent clotting in the tube [5]

Jackson-Pratt Drain

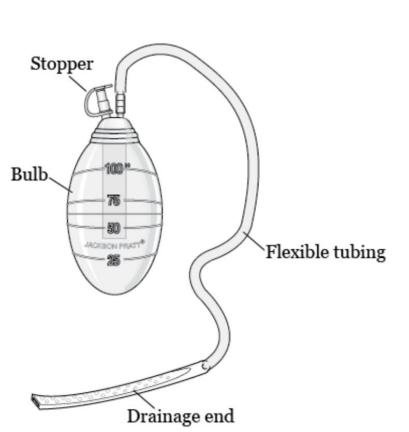
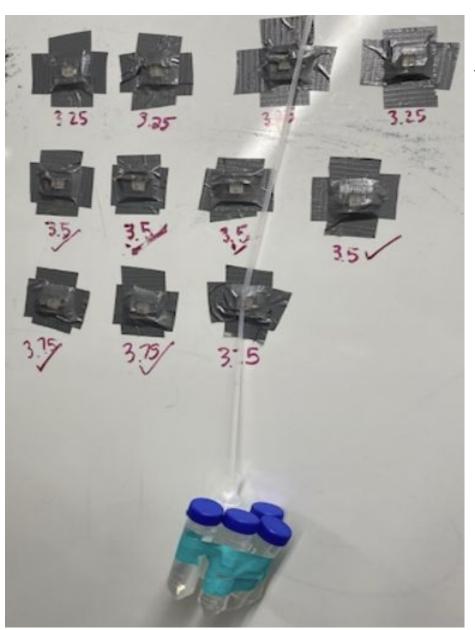
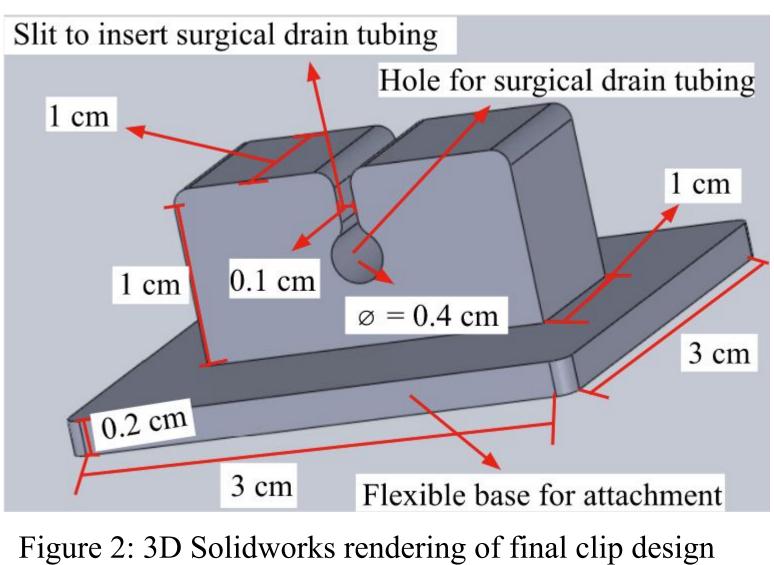


Figure 1: Jackson-Pratt Surgical Drain [6].





Previous Work



used

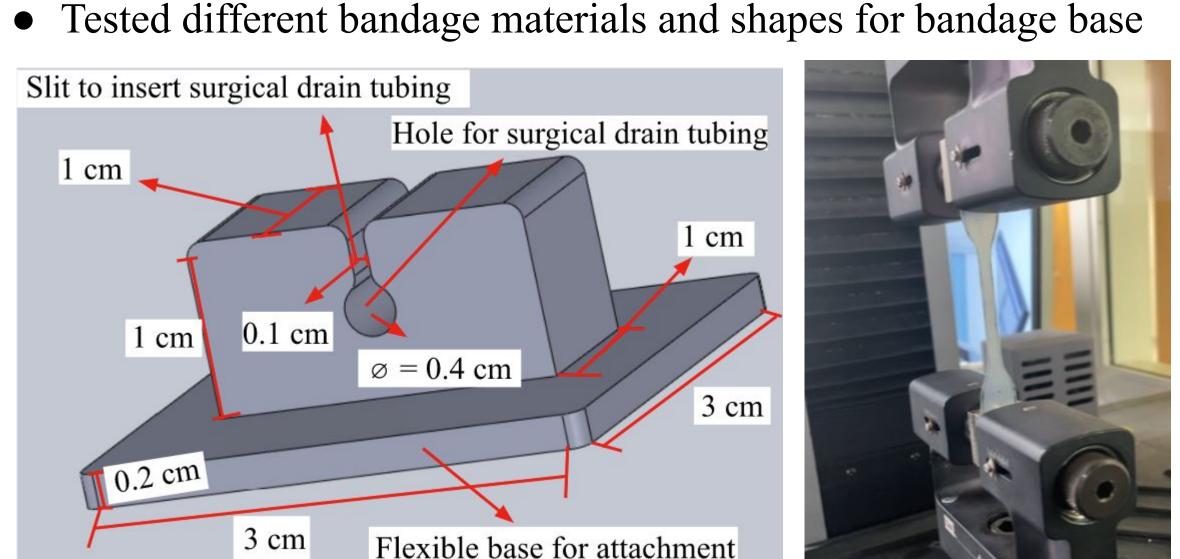


Figure 3: Bandage material sample in MTS machine.

Design Criteria

• Compatible with surgical drain tube diameter 0.400 cm [7]

• Created and tested clip design to hold surgical drain tubing

- Allow for continuous use for up to 1 week
- Prevent tube displacement greater than 3.6 ± 1 cm [8]
- Water resistant design
- Allow for access to entire length of external drain tube
- Allow for the patient to do daily activities
- Prevent tugging of the sutures

Fabrication

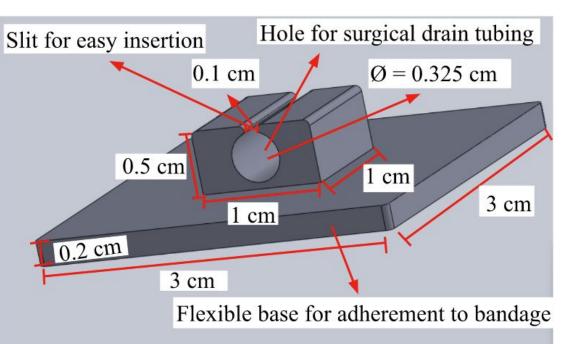


Figure 4: 3D print clip using Formlabs Elastic Resin.

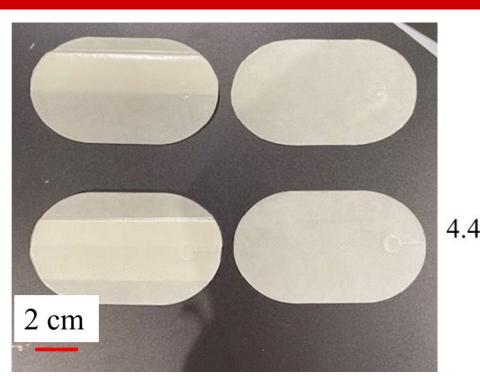
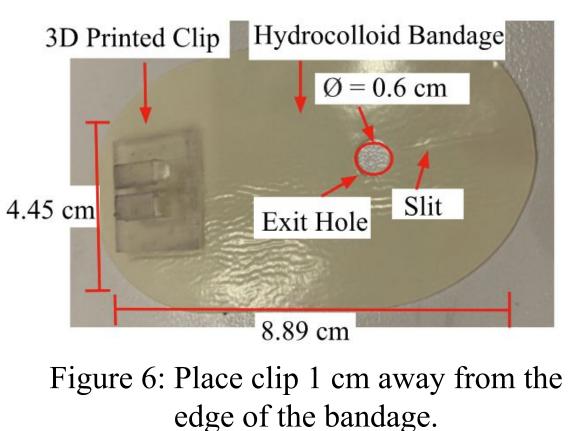


Figure 5: Cut out hydrocolloids using CriCut Machine.



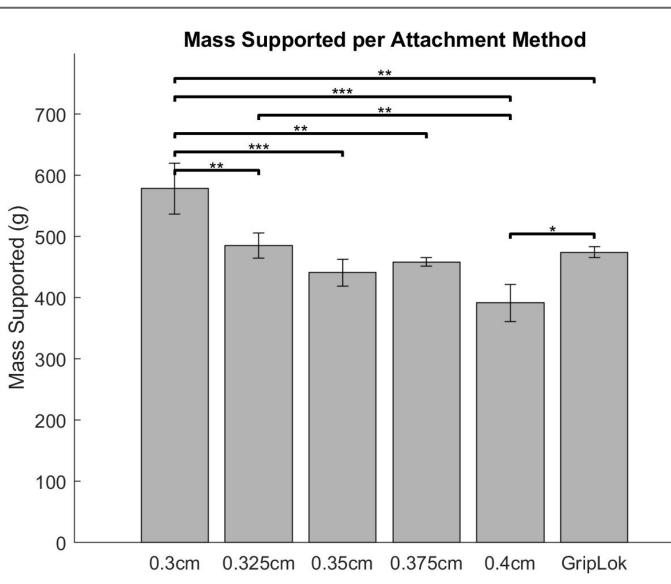
Testing

Figure 9 (left): Force testing was conducted on different diameter clips to determine which clip size would hold the most weight. Clip diameters ranged from 0.300 cm to 0.400 cm with 0.250 cm increments. Weight was added by filling the surgical drain bulb with water and then using centrifuge tubes with water added in 10 mL increments.



Figure 10: Flow testing was conducted on each clip iteration to determine if the clips impinged on the surgical drain, obstructing flow. A fluid with a viscosity similar to blood were conducted on each sample and was used to mimic the standard exudate of the rated based on how well the bandage drain. The vacuum in the biosafety cabinet appeared to be adhered. The rating scale was used to create a consistent flow.

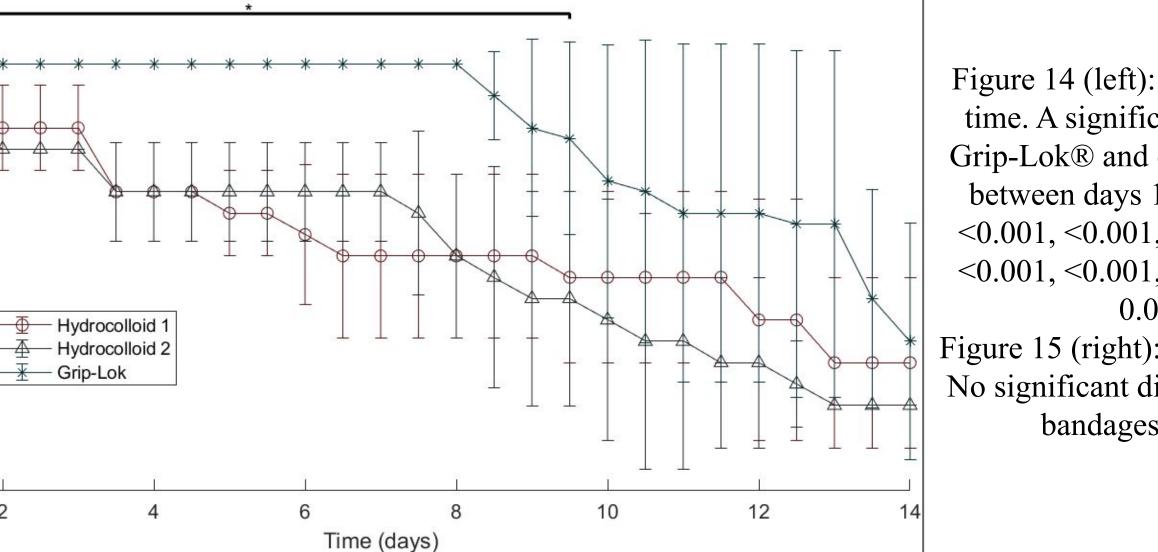
Results



Wear Rating of Bandages over Time

Figure 12 (left): The average mass supported per attachment method. A significant difference exists between the 0.300 cm clip and the 0.325 cm clip (p=0.0095), the 0.350 cm clip (p<0.001), the 0.375 cm clip (p=0.0019), the 0.400 cm clip (p<0.001), and Grip-Lok® (p=0.0065). The 0.400 cm clip was also significantly different from the 0.325 cm clip (p=0.0043) and Grip-Lok® (p=0.0212).

Figure 13 (right): The average flow velocity of water and the corn syrup-water mixture through clips with varying interior diameters. No significant difference existed when water flowed through the drain (p=0.9502, F=0.18, df=4), but a significant difference existed between at least two of the clips when the corn syrup-water mixture flowed through the drain (p<0.001, F=28.25, df=4). Multiple comparisons of means revealed the 0.300 cm clip had a significantly different flow velocity than the 0.325 cm clip (p<0.001), the 0.350 cm clip (p<0.001), the 0.375 cm clip (p<0.001), and the control (no clip) (p<0.001).



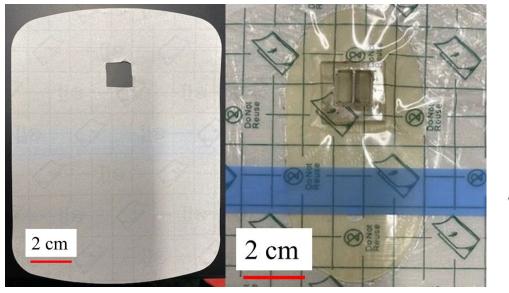


Figure 7: Cut hole in adhesive for clip. Starting in the center of the bandage below the clip, adhere the waterproof adhesive over the clip and hydrocolloid.

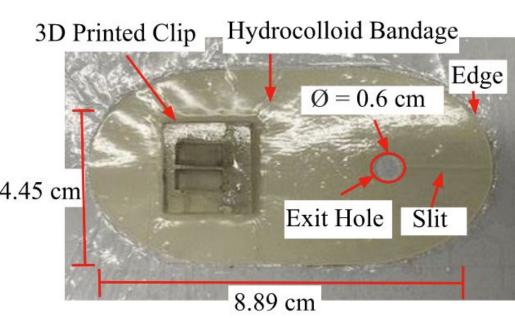


Figure 8: Trace the edges of the hydrocolloid using a razor blade to remove excess adhesive.

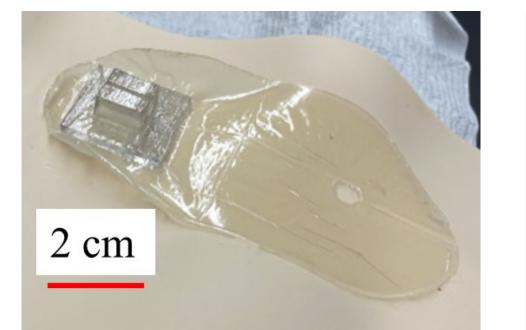
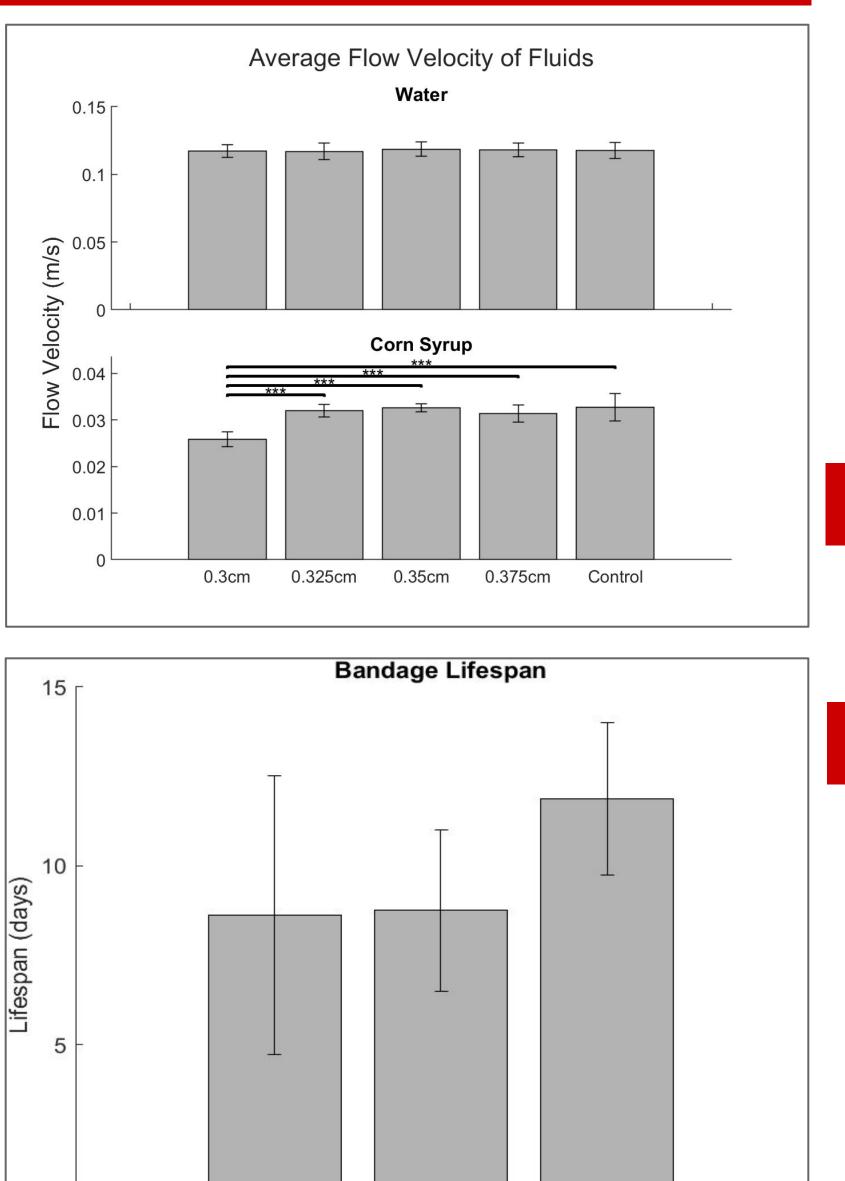


Figure 11: Wear testing was conducted for two weeks using the prototype and Grip-Lok® on a skin mimic (tattoo skin). A sweat and a water simulation can be seen in the table to the right.



Figure 14 (left): The wear rating of bandages over time. A significant difference exists between the Grip-Lok[®] and either or both of the hydrocolloids between days 1-9.5 (p=0.0124, 0.0026, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, <0.001, 0.0017, 0.0183, 0.0269)

Figure 15 (right): The average lifespan of bandages. No significant difference exists between any of the bandages (p=0.0942, F=2.85, df=2).



Hydrocolloid 1 Hydrocolloid 2 Grip-Lok

Final Prototype

Features:

- Hydrocolloid bandage base
- Waterproof Adhesive Layer
- 3D printed clip to secure drain tube
- Exit hole for drain tube
- Slit to easily place bandage

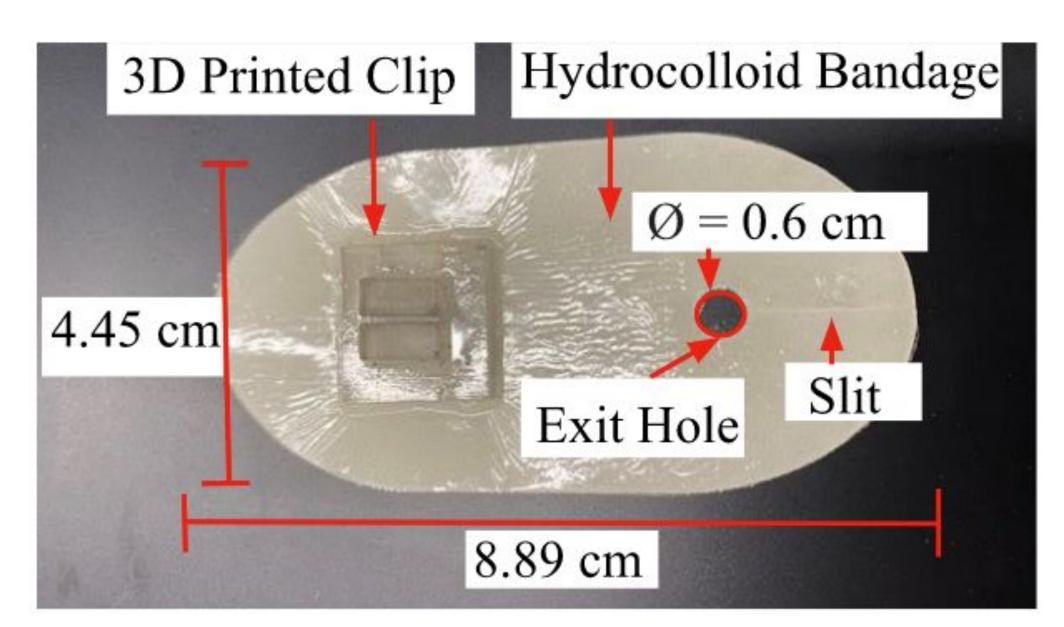


Figure 16: Completed hydrocolloid bandage clip design.

Future Work

- Conduct additional testing of fully assembled prototype • Human testing, heat testing, sterilization testing
- Streamline fabrication of the prototype
- Determine Packaging
- Cost
- Quantity
- Customization
- Determine sterilization technique
- Autoclaving, ethylene oxide, radiation

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- Dr. Tracy Puccinelli
- Dr. Katie Kalscheur
- BME Department
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