Improved Method of Securing Surgical Drains

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UW BME Design

Abstract

Developing a new and improved method for securing surgical drains can improve the lives of patients who need them after surgery to prevent accumulation of bodily fluids. The current method of securing surgical drains is to attach them to the body using a single suture. This method can be very uncomfortable for patients as the drain tends to get tugged on and pulls on the single suture site. Additionally, the tugging can lead to drain displacement, slowing down the overall healing process. After extensive research on current methods, two designs have been created that aim to distribute the pressure at the suture site and secure the surgical drain in place. The proposed final design must be comfortable for the patient and also effective at decreasing tension at the suture site for the duration that the drains need to be used. After evaluating the designs and deciding on moving forward with the adhesive bandage with clip design, plans for fabrication and testing were created to evaluate the design's effectiveness. These plans include obtaining all materials and alternatives and creating a surgical drain site model. Following testing, the team decided to move forward with the hydrocolloid clip design. This design is the most reliable for holding the drain in place and the most reliable adhesive material.

Background

Motivation:

- Current methods to secure surgical drains involve a single suture that aims to prevent dislodgement of the drain from a body
- Tugging or brushing over the suture site creates significant discomfort to patients, and can potentially result in disruption of the drainage process

Clinical Significance:

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

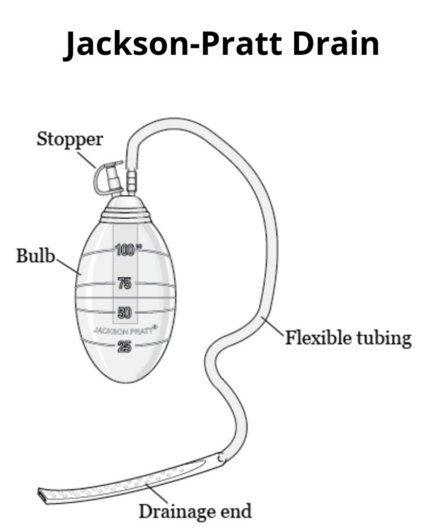


Figure 1: Jackson-Pratt Surgical Drain [1]

Client:

- Dr. Katie Kalscheur is a professor within the UW-Madison college of Engineering and was familiar with the BME Design process. Her idea was brought to the team with the aim to turn it into a product that could aid in patient comfort.

Design Criteria

- Compatible with surgical drain tube diameters 6.35-25.4 mm [2]
- Allow for continuous use for up to 1 week
- Prevent tube displacement greater than 3.6 ± 1 mm [3]
- Waterproof 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 and Testing

Fabrication:

Clip Fabrication

- The proposed clip design was rendered in Solidworks, then 3D printed in the Makerspace with the Formlabs Form 2 SLA printer using Formlabs Elastic Resin material

Hydrocolloid Bandage

- Using the Cricut Maker 3, the hydrocolloid bandages were cut into uniform oval shapes that allow for an attachment site for the drain tube away from the suture site

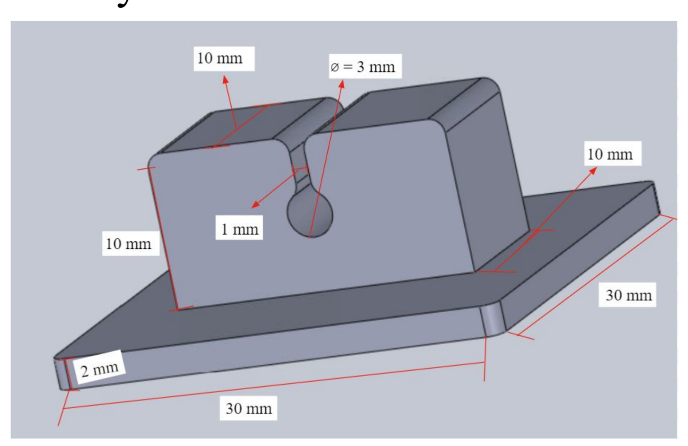


Figure 2: Clip design with dimensions.

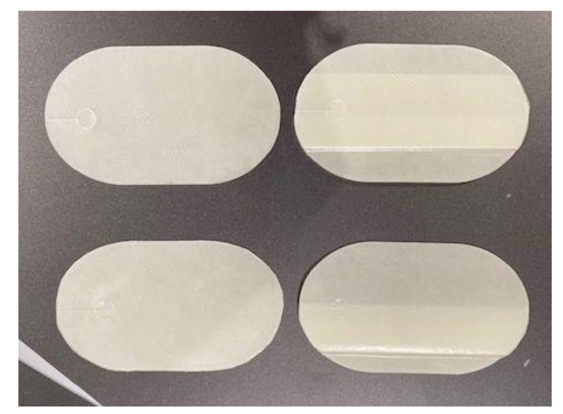


Figure 3: Hydrocolloid cutouts from using the Cricut machine.

Complete Bandage Assembly

- The complete bandage design is composed of an oval hydrocolloid bandage, and consists of a Grip-Lok® or 3D printed clip to hold the surgical drain in place
  - To assemble the bandage, take a single oval hydrocolloid bandage and place it on a flat surface
  - Use super glue to attach the 3D printed clip or Grip-Lok® on top of the hydrocolloid bandage on the opposite side of the bandage, away from the opening for the drain.

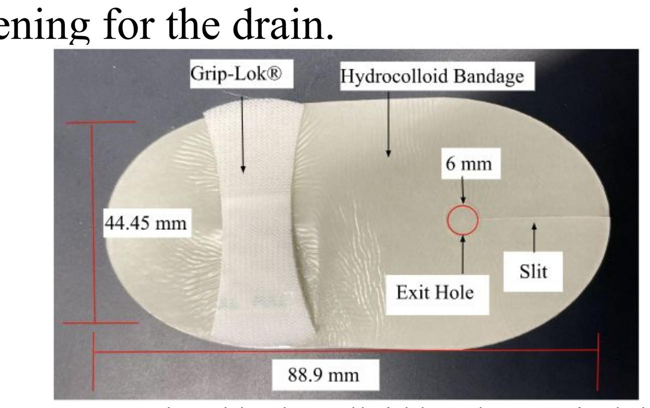


Figure 4: Completed hydrocolloid bandage Grip-lok® design.

Testing:

- MTS to obtain mechanical properties of each material for testing in FEBio
- FEBio was used to test different geometries of the bandage design to determine if the shape of the bandage would affect the stress distribution
- Force testing was conducted to determine whether the Grip-Lok® design or the clip design would hold the drain in place better when varying weights were applied

Figure 5: MTS testing setup for hydrocolloid bandage.

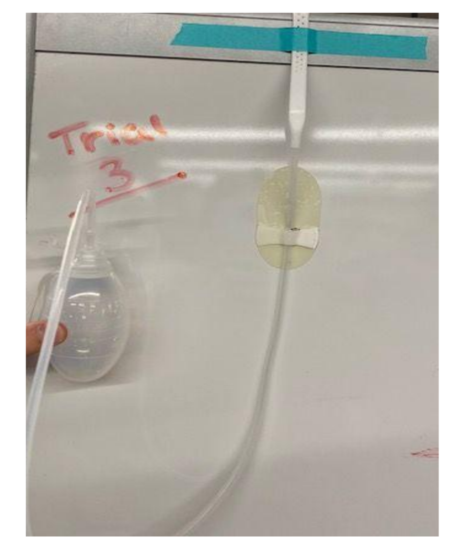


Figure 6: Force testing setup for Grip-Lok® design.

Figure 7: Force testing setup for clip design.

Results

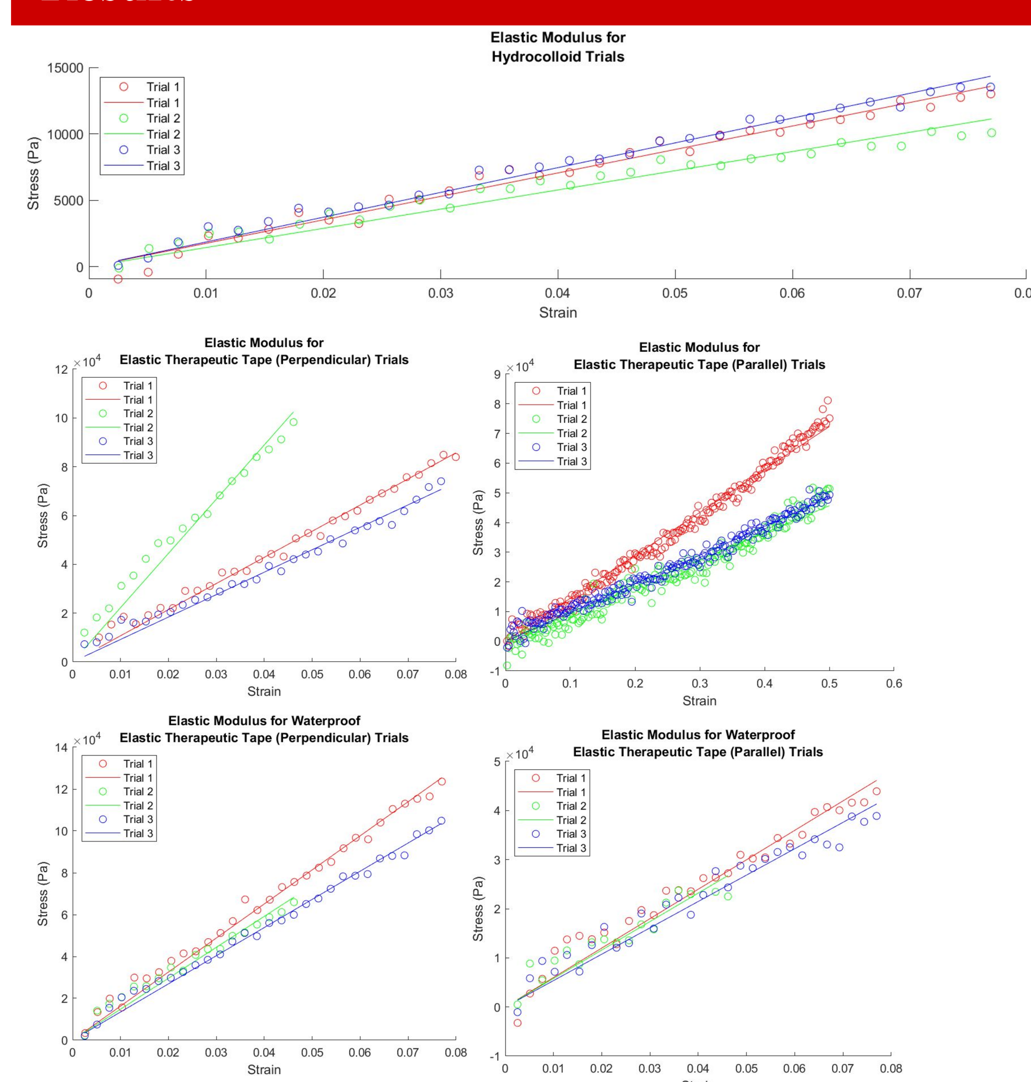
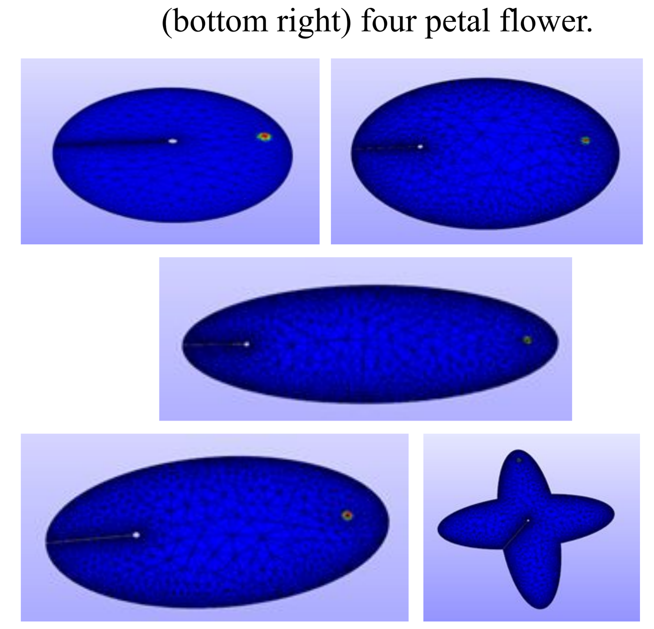


Figure 8 (left): MTS data used for elastic modulus calculations for (top) hydrocolloid, (middle) elastic therapeutic tape, and waterproof elastic therapeutic tape (left) parallel to and (right) perpendicular to the fibers.

Figure 9 (below): Sample FEBio stress analyses for (top left) circle, (top right) 1:0.75 oval, (middle) 3:1 oval, (bottom left) 2:1 oval, and (bottom right) four petal flower.



- T-test between parallel and perpendicular directions of elastic therapeutic tape
  - Elastic therapeutic tape (tstat=-3.141, df=4, p=0.0348)
  - Waterproof elastic therapeutic tape (tstat=-10.933, df=4, p=0.000398)
  - Model as orthotropic material
- ANOVA between bandage geometries and materials
  - Geometries (F=0.754, df=4, p=0.583)
  - Materials (F=6.098, df=2, p=0.0246)
  - Geometries do not impact stress distributions
  - Material does impact stress distribution
- T-test between clip and Grip-lok® maximum supported weight
  - Clip supports more weight (tstat=3.450, df=4, p=0.0261)

Final Design

Features:

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

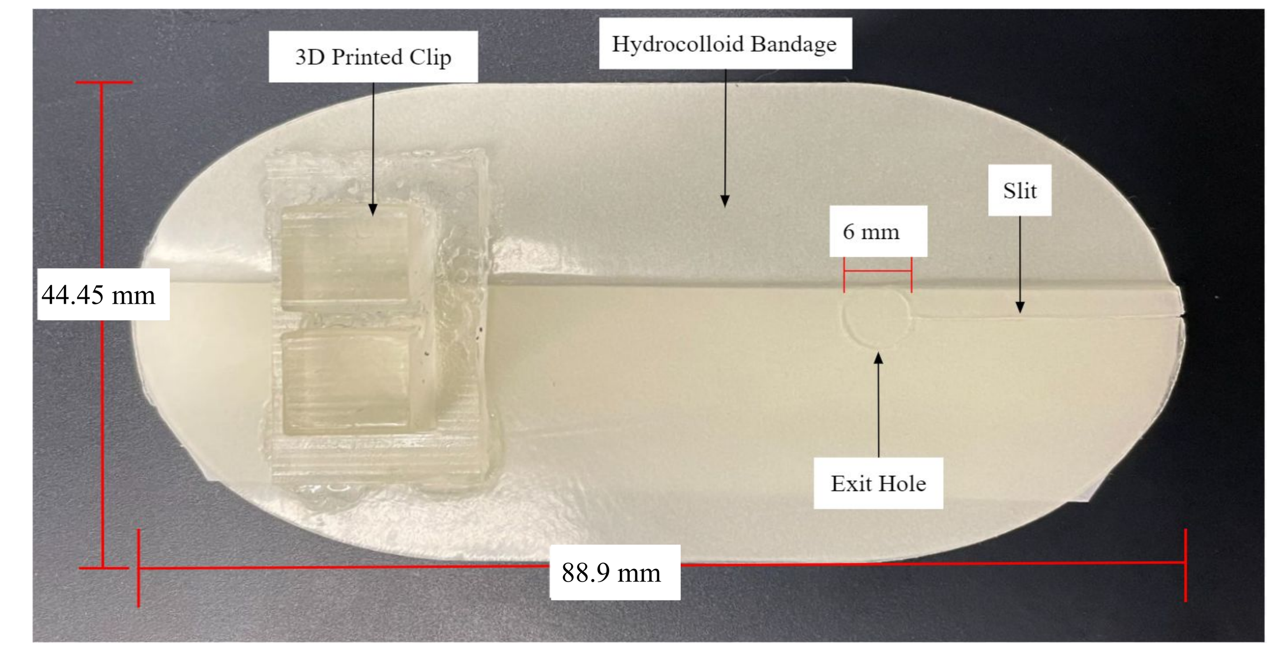


Figure 10: Completed hydrocolloid bandage clip design.

Future Work

- Conduct more testing on final design
  - Adhesive test, Longevity test (on pig skin or chicken skin), Waterproof test, Sweat test, Fluid flow test through tubing
- Further explore fabrication of the double adhesive layer
- Redesign the proposed clip to better secure the drain tube
  - Explore different ways to make the drain clip less bulky for comfortability
  - Add an adhesive similar to the Grip-Lok® design where the tubing touches the clip

Acknowledgements

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- Dr. Russ Johnson
- BME Department
- Dr. Lee Wilke
- Makerspace Staff

References

[1] "Jackson Pratt (JP) Drain - Saint John's Cancer Institute," Melanoma, 30-Jul-2019. https://www.saintjohnscancer.org/melanoma/patient-resources/jackson-pratt-jp-drain/.

[2] "Vertical Tube Attachment Device (VTAD) | Critical Care Products | Hollister US," Hollister. https://www.hollister.com/en/products/critical-care-products/tube-securement/tube-attachment-devices/vertical-tube-attachment-device-_vtad_# (accessed Oct. 10, 2022).

[3] L. Heskin, V. Cahill, G. Filobbos, P. Regan, S. O'Sullivan, and K. Bryan, "A new adaptation for a secure surgical drain placement and a comparison with four common drain fixation methods," The Annals of The Royal College of Surgeons of England, vol. 101, no. 1, pp. 60–68, Jan. 2019, doi: 10.1308/rcsann.2018.0177.