BME Design-Fall 2022 - Dana Stumpfoll
Complete Notebook

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Dana Stumpfoll

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Oscar Zarneke - Sep 13, 2022, 12:00 PM CDT

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Project description

Dana Stumpfoll - Oct 11, 2022, 11:26 PM CDT

Course Number: BME 400 Design

Project Name: Improved Method of Securing Surgical Drains

Short Name: Drain Pain

Project description/problem statement:

The current method of securing surgical drains can be painful for patients and require a lot of post-operative care to keep the drain functional. Sutures are commonly used and get tugged on when following post-operative care of "stripping" the drain tubing, OT treatment plans, daily activities, and exercise. Drains are in place for patients for a month or more until drainage gets to a consistently low volume. Clots may develop and may not be able to pass through drains because sutures can constrict the tubing. Since drain sites are open wounds, infection risk should also be considered for an improved method of securing surgical drains.

About the client:

Dr. Katie Kalscheur is a professor at UW Madison in the engineering department. She has her PhD in Civil and Environmental Engineering and mainly teaches the interdisiplinary freshman design course. She has tasked us with developing a new and more comfortable method for securing surgical drains.

2022/09/16 - First Client Meeting

Dana Stumpfoll - Sep 16, 2022, 1:10 PM CDT

Title: First Client Meeting

Date: 09/16/2022

Content by: Everyone

Present: Dana, Beki, Lauren, Oscar, Abdoulahi

Goals:

Content:

- Were there any problems you faced with securement of surgical drains when cleaning or emptying drains? And was there a specific kind of soap or antiseptic you were required to use when cleaning the area?
    - Stripping requires holding the tubing and pulling on the tube, your hands have to be a little wet. Pulls on the single suture and the ones wrapped around the tubing constricted the tubing and would cause clots in the tubing.
    - Alcohol wipes were used to clean the site. Suggested by the doctor to use an antibacterial product to prevent infection.
    - Might be some fluid that leaks around the site, she was given pads with a slit in it to absorb any excess fluid that would leak.

- Did your surgical drains ever displace due to it getting caught in clothes/cleaning? Was the displacement of the drains the cause of pain?
    - Drains had a bulb on the end to collect the fluid. The tubing was outside of her body for about a foot and a half. Post - mastectomy shirts you can use. Easily bumped on things, and even pinned up they would go below her waistline. Easy to bump into.
    - When it came to sleeping she had one on each side so she could only sleep on her back. Sleeping on her side became a problem too because one that is still attached would still pull on her.
    - Had drains for about a month.

- Do you want this new method to not require sutures to secure the surgical drains on to the patient?
    - Aim to take the weight all off of one site. Using sutures alongside something else would be helpful.

- How many sutures were used to secure your drains in place? Did you feel that they were tightly secured or that they would fall out?
    - One suture, all tugging at one site, less than an inch area.

- It was mentioned that clothing would tug and create discomfort. Were there any other notable activities or movements that would cause you added discomfort?
    - Showers were difficult. She was given a lanyard to attach the drains to when she showered. Standard lanyard with a clip on it on the end.

- Were there activities that were recommended for you to perform?
    - Stretching, reaching up and down, arm ROM, moving lymph fluid throughout body. 2 weeks post surgery - any activities (biking, yoga). Recommended to be active.

- Was the drain removed before the sutures? How much longer if so?
    - Suture and drain all removed at once, placed bandage over it and let it heal naturally after removal.

- There are many types of drains with different techniques to secure them; is there a type that we should focus on? Or should the design work for all the drains?
    - Up to us to determine what type of drain we would like to focus on or if we want to develop a universal device.

References: NONE

Conclusions: Katie was very helpful in answering our questions and is open to meeting with us on an as needed basis. She will be contacting her surgeon to get in touch with us.

Action items: Follow up with Katie’s surgeon to possibly obtain some surgical drain tubing and work on the PDS.

2022/09/16 - Advisor Meeting 1

Dana Stumpfoll - Sep 16, 2022, 12:41 PM CDT

Title: Advisor Meeting

Date: 09/16/2022

Content by: Everyone

Present: Dana, Beki, Lauren, Oscar, Abdoulahi

Goals:

Content:

- Each team member went through what they researched and talked about their biggest take away from the week.
- Discuss questions based on the PDS with client.
- Try to determine if we can find a surgeon who places these and get their opinion.
- Get a practice suturing kit by filling out a request for funding form.

References: NONE

Conclusions: Continue to do research and work on the PDS after talking with Katie. Brainstorm on your own before meeting with the team to brainstorm ideas.

Action items: Fill out a request for funding form and turn it into Tracy so we can start ordering materials like practice suturing kit and surgical tube. Next week we will stay in the tong lecture hall to meet with Dr. Puccinelli for our weekly meeting.

2022/09/23 - Advisor Meeting 2

Dana Stumpfoll - Oct 09, 2022, 1:02 PM CDT

Title: Advisor Meeting

Date: 09/23/2022

Content by: Everyone

Present: Dana, Beki, Lauren, Oscar, Abdoulahi

Goals: Discuss PDS

Content:

- Each team member went through what they researched and talked about their research for the PDS.
- Everyone conducted research on the existing devices on the market and patents that exist.
- Dr. Puccinelli got us in contact with Russ Johnson who has ideas for our project and is able to provide us with a surgical tube from Cardinal Health.
- The meeting was pretty short following the outreach seminar.

References: NONE

Conclusions: There is a lot of devices already on the market. We plan to keep brainstorming and will decide on designs next week.

Action items: Contact Russ to obtain surgical drain and set up a meeting to discuss his ideas for the project. Email Dr. Puccinelli if she does not forward us the email by 4 pm today.

2022/09/30 - Advisor Meeting 3

Dana Stumpfoll - Oct 17, 2022, 11:55 AM CDT

Title: Advisor Meeting

Date: 09/30/2022

Content by: Everyone

Present: Dana, Beki, Lauren, Oscar, Abdoulahi

Goals: Discuss Design Matrix

Content:

- We went through each design with Dr. Puccinelli and described why we picked the categories we did for each section.
- Dr. Puccinelli asked that we change the safety category to be something more descriptive that each design would score differently in.
  - We felt this category was not useful for evalutating our designs so we decided to remove it from our matrix.
- Dr. Puccinelli also asked that we change our versatility category to be something more understandable.
  - We renamed this category to be called adaptability since we wanted our design to be adaptable to different size drains.

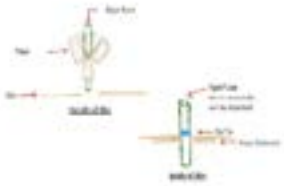
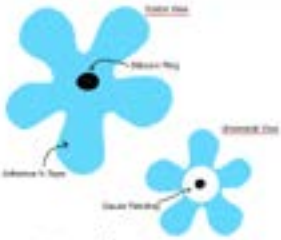
		 Adhesive Bandage with Clip		 Interior Pressure Distributing Flap		 Exterior Pressure Distributing Flap	
Criteria	**Weight**	**Score (10 max)**	**Weighted Score**	**Score (10 max)**	**Weighted Score**	**Score (10 max)**	**Weighted Score**
Effectiveness	30	8	24	6	18	8	24
Patient Comfort	25	8	20	3	8	9	23
Ease of Use	20	7	14	9	18	6	12
Cost	15	8	12	9	14	6	9
Adaptability	10	10	10	7	7	8	8
Sum	100	**Sum**	80	**Sum**	66	**Sum**	76

Table 1: This is our final design matrix after completing the edits Dr. Puccinelli suggested.

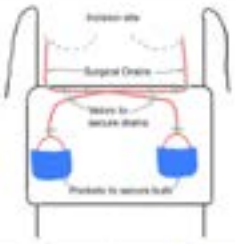
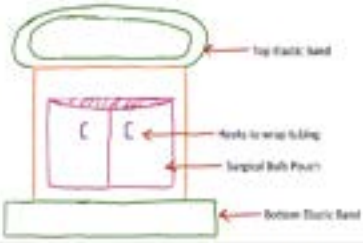
			Belt with Velcro		Kangaroo Pouch	
	Pouch Holder					
Rank	Criteria	Weight	Score (10 max)	Weighted Score	Score (10 max)	Weighted Score
1	Patient Comfort	25	8	20	5	13
2	Compactibility	25	6	15	8	20
3	Ease of Use	20	8	16	10	20
4	Compatibility	15	8	12	8	12
5	Safety	10	10	10	7	7
6	Cost	5	7	4	8	4
	Sum	**100**	**Sum**	**77**	**Sum**	**76**

Table 2: This is the design matrix for the pouch holder designs.

- We also came up with some designs for the surgical drain holder since our client said it was difficult to hide her drain tubing and bulbs.
- Dr. Puccinelli told us to focus solely on our attachement device design for the presentation and that we could worry about this aspect later.
    - Both designs were very similar and we would plan to combine aspects from each for the final design if we move forward with creating a pouch design.
- We also told Dr. Puccinelli about the meetings we set up with Russ Johnson and Dr. Wilke and our plan for fabrication and testing.

References: NONE

Conclusions: Dr. Puccinelli made great suggestions for our design matrix and told us to focus on researching materials for our preliminary presentation.

Action items: Everyone will focus on preparing for the preliminary presentation and do materials research.

2022/10/14 - Advisor Meeting 4

Dana Stumpfoll - Oct 17, 2022, 12:24 PM CDT

Title: Advisor Meeting

Date: 10/14/2022

Content by: Everyone

Present: Dana, Beki, Lauren, Oscar, Abdoulahi

Goals: Discuss research from the past 2 weeks and preliminary presentations

Content:

- Dr. Puccinelli went over our presentation grading with us.
    - Told us to have CAD drawings for the final presentation, was not required for preliminary presentations.
- Each team member went through their notebook and talked about the materials research we did.
- The top three materials we found were hydrocolloid bandages, silicone adhesives, and KT-tape.
- We will focus on ordering these materials and have them ready for our next advisor meeting.
- We will also focus on creating our first prototype.

References: NONE

Conclusions: Everyone conducted materials research and we have a solid foundation for ordering materials to start prototyping.

Action items: Beki will put together another ordering proposal form and get it to Dr. Puccinelli by Monday night. Dana will work on creating the clip design in SolidWorks and begin printing that at the Makerspace for our initial prototype.

2022/10/28 - Advisor Meeting 5

ABDOULAHI BAH (anbah@wisc.edu) - Oct 28, 2022, 6:49 PM CDT

Title: Advisor Meeting Notes

Date: 10/28/2022

Content by: Everyone

Present: Dana, Beki, Lauren, Oscar, Abdoulahi

Goals: Discuss our progress on the project in the past two weeks

Content:

- summarized what was discussed with Dr. Russ Johnson and how we applied that to our design
- summarized the meeting with Dr. Wilke and showed the sutures she installed in the fake skin to Dr. Puccinelli
    - highlighted that both meetings had different ideas
- Asked Dr. Puccinelli how BME 402 is: Usually don't start over on a new idea BME 402 - it is mostly looking at outsourcing, intellectual property, journaling work, looking at the market, and thorough testing
    - basically not really changing much
- Dr. Puccinelli - thinks the design is very simple and we could look into other potential designs before next semester
- Discussed our outreach project idea - using a robotic hand
    - Dr. Puccinelli - thinks that it is a good project, but requires a lot of prep - so like cutting straws, cardboard
    - Could incorporate the use of candy to pick up with the hand
    - has connections to East Highschool and other middle schools in the Madison area - Ms. Chin
    - kids our tracked nowadays starting in 6th grade - so want to motivate them to do STEM
    - Dr. Puccinelli can also fund the project
- test the different ways to secure the drain using - Velcro, clips, etc.
- Dr. Puccinelli is looking for more detailed 3D printers on campus - could reach out to her if she finds some when printing components of the design
- Dr. Puccinelli - thinking the clips should be less stiff, especially on the base
- Dr. Puccinelli - is there a way to simulate the design in SolidWorks? - kind of confused about why using tensile testing would help
    - look at tensile testing in two directions of a material

Conclusions/action items: The team will be meeting on Monday night to start prototyping the design and practice our elevator pitch.

2022/11/11 Advisor Meeting 6

LAUREN HELLER - Nov 11, 2022, 2:04 PM CST

Title: Advisor Meeting 6

Date: 11/11/2022

Content by: Lauren Heller

Present: All team members present.

Goals: Discuss show and tell results and discuss concerns for testing and fabrication of soft materials.

Content:

- We shared the feedback we received in show and tell, as well as what information we used to help us create our initial testing protocols. We also shared some feedback we got regarding design concerns, and shared how we had already accounted for these factors (adhesive reapplication, adhesive use irritation, showering, infection, etc.).

- We raised concerns surrounding the fabrication of soft materials. We want to be able to fabricate a specialized bandage, however most resources on campus (such as the makerspace and teamlab) are more geared towards fabrication of hard materials. She will be thinking of possible ways we could do this. For now we will continue with testing, and we will continue searching for ways to specify the material once it has been tested.

- The team did share our plans to use FEBio simulation to avoid the need to test all geometries manually. This would reduce the amount of time we would need to reserve for testing, as well as the amount of materials we would need to order.

Conclusions/action items:

Today, the team will submit the request to use the MTS machine to Dr. Puccinelli. From there, we will prepare all necessary samples to test, and will bring them to the teaching lab to test on the scheduled date. The calculated and determined properties will be entered into FEBio to allow for us to decide on the proper geometry of bandaid to use based on simulation results.

2022/11/18 - Advisor Meeting 7

ABDOULAHI BAH (anbah@wisc.edu) - Nov 18, 2022, 12:39 PM CST

Title: Advisor Meeting 7

Date: 11/18/2022

Content by: Abdoulahi Bah

Present: All team members present.

Goals: Discuss what the team has accomplished in preparation for testing

Content:

- Team discussed making the test samples (different fiber direction, and the different materials we were testing)
- Lauren and Dana briefly went over their meeting with Dr. John Puccinelli on how to use the MTS machine
    - We should record videos of the MTS testing
- Ways to fabricate soft materials:
    - Dr. Tracey Puccinelli recommended we use a stiffer silicone
    - Do a google search and find faculty on campus that does research with adhesive or specifically about silicone
    - Could also look into Sector 67 - https://www.sector67.org/blog/ - they could provide us resources in creating a bandage kind of material
    - have a foam cutter which uses heat and wire - @ the makerspace - makerspace can cut fabric - https://making.engr.wisc.edu/textiles/
    - depending on the testing results it would determine weather we should use the bandage material or make our own
        - would need to do extra research to look at materials to make our own band aid if testing does not go so well
        - if we do use the band aid materials that we bought - Dr. Puccinelli does not think that is really engineering and we would have to be a little more creative

Conclusions/action items: The team will conduct preliminary testing the different bandage samples to find their properties and determine which bandage material is the best for our design.

2022/12/02 - Advisor Meeting 8

Dana Stumpfoll - Dec 02, 2022, 1:46 PM CST

Title: Advisor Meeting 8

Date: 12/2/2022

Content by: Dana Stumpfoll

Present: Dana, Beki, Abdoulahi, Oscar

Goals: Discuss what the team has accomplished in the past two weeks with testing and prototyping.

Content:

- The team discussed the progress we made with the MTS testing as we had to redo it since the data did not export correctly the first time.
- We then explained that we 3D printed our clip designs and it turned out too small the first time.
    - We then showed Dr. Puccinelli the new clip design that was being printed and how the elastic material would be better for the new thickness of the clip.
- We then explained how we were going to attach a griplok to the cutout hydrocolloids and the clips.
    - She suggested we try a double adhesive for the clip attachment design, but we were unsure if this would hold it enough.
    - We may stick with gluing the designs to the bandages.
- We then described our force testing that we will conduct to see whether the griplok design or the clip design will hold the tubing in place better.
    - This will be done using a water bottle attached to the tubing and measuring the displacement of the tubing through each design to determine how well it holds the tubing in place.
- We also discussed our outreach with Dr. Puccinelli and we are going to email our contact to let them know we will be doing outreach next semester.
    - We will send Dr. Puccinelli our activity guide so she can review it before we send it to our contact.

Conclusions/action items: The team will finish testing and prototyping and contact Dr. Puccinelli if we have any questions about our poster or prototyping for next week.

2022/09/09 - First meeting

Dana Stumpfoll - Sep 26, 2022, 7:20 PM CDT

Title: First meeting/making questions for the client

Date: 09/09/2022

Content by: Dana

Present: Dana, Beki, Lauren, Oscar, Abdoulahi

Goals: Discuss questions for the client and research

Content:

- During this meeting we introduced ourselves and came up with a plan for next week.
- Everyone was told to do their own research and develop questions for the client meeting.

References: NONE

Conclusions: Everyone met on zoom to introduce themselves and we began our inital research/planning for the semester.

Action items: Everyone will conduct individual research to understand the problem and come up with questions to ask our client for the first meeting. Oscar will email our client, Katie Kalscheur, to set up our first meeting with her by next Friday (09/16).

2022/09/22 - PDS/Brainstorming Meeting

Dana Stumpfoll - Sep 26, 2022, 7:21 PM CDT

Title: Finalize PDS/ Initial Brainstorming

Date: 09/22/2022

Content by: Dana

Present: Dana, Beki, Lauren, Oscar, Abdoulahi

Goals: Discuss PDS and initial brainstorming

Content:

- Each team member completed their part of the PDS and we met to go over it and edit it.
- We discussed possible routes we could take with each persons designs.
- Each team member brought their own design ideas and shared them with the team.

References: NONE

Conclusions: Everyone came up with good ideas for our first brainstorming session. We decied we will do an attachment device as well as a housing design to hold the extra tubing and surgical bulbs. The PDS will be completed and turned in on 09/23.

Action items: Everyone will continue to brainstorm ideas and we will meet next week to evaluate them and create a design matrix. Everyone will also think of criteria to evaluate our designs.

2022/09/26 - Design Matrix Meeting 1

Title: Design Matrix Meeting

Date: 09/26/2022

Content by: Dana

Present: Dana, Beki, Lauren, Oscar, Abdoulahi

Goals: Discuss criteria for design matrices/ plan for the week

Content:

- We met to dicuss the design matrix criteria.
- We made two design matrices one for the attachment device and one for a containment device for the surgical drain tubing and bulbs.
- The criteria we chose for the attachment device is effectiveness, patient comfort, ease of use, cost, versatility, and safety.
    - We ranked effectiveness the highest because the most important aspect of our device is that it works to hold the drain in place.
    - Next we had pateint comfort because our client came to us with the problem noting that the worst thing about her drains was that they were uncomfortable. We hop
    - Ease of use was the next category because the patient will need to be able to easily remove and replace the attachment design.
    - Cost was rated lower in the matrix because our device should not be super costly compared to the current method which uses a single suture.
    - Versatility was used as a category because we hope to eventually make our design universal for all drain types and sizes.
    - The last category was safety because our design should not cause any safety issues with the surgical drains and should not block the patients access to their drain
- The criteria we chose for the containment device for the surgical drain tubing and bulbs was patient comfort, compactibility, ease of use, compatibility, safety and cost.
    - We put patient comfort and compactibility as the highest because our client noted that she wished she could hide her drains better and in a comfier way.
    - Next we had ease of use and compatibility since we want our design to be easy to use for multiple different surgeries/ drain types.
    - Lastly we had safety and cost since our device will not interfere with the function of the drain and should be taking weight off of the wound site. It will not be costly e
- We decided to not rate any of our designs yet and continue to brainstorm since we all only have 1 idea so far.
- We discussed meeting with Russ to obtain a surgical drain and purchasing a suture practice kit from amazon.
- We discussed meeting with Dr. Wilke by emailing her assistant to set up a meeting once we have obtained a suture practice kit and a surgical drain from Russ.
    - When we meet with Dr. Wilke we intend to ask her to set up the surgical drain system on our practice suture kit.
- We also discussed our notebook grades and how we can improve our entries.
- We also discussed our outreach project and decided we would all like to do it together.

References: NONE

Conclusions: We have decided to move forward with developing an attachment device design as well as a containment device for the surgical drain tubing and bulbs.

Action items: Everyone will bring more of their brainstormed ideas to our meeting on Thursday (9/29). Oscar will email Russ and Dr. Wilke's assistant to set up meetings with th

2022/09/29- Design Matrix Meeting 2

Dana Stumpfoll - Oct 09, 2022, 1:03 PM CDT

Title: Ranking Designs in Design Matrix

Date: 9/29/2022

Content by: Rebekah

Present: Rebekah, Lauren, Oscar, Abdoulahi, Dana

Goals: To fill out our design matrix and begin working on the preliminary presentation

Content:

The team decided to grade three different designs for an alternative method for securing a surgical drain at the attachment site and two different designs for a housing system for the drain tubes and bulb. The designs for the attachment site matrix are:

- Adhesive Bandage with Clip
    - This design uses an adhesive bandage to cover the wound while also using a clip to secure the surgical drain in place
- Pressure Distributing Flap Inside
    - This design uses rigid flaps that will be installed under the skin to secure the drain in place, the reason for these flaps are to more evenly distribute the stress at the attachment site
- Pressure Distributing Flap Outside
    - This design is similar to the previous one in that they both use some type of flap to more evenly disperse the stresses that the skin is under, the main difference is that the flaps will made out of an adhesive similar to KT tape and will be placed on the surface of the skin instead of underneath it

While the designs for the housing system are:

- Belt with Velcro
    - This design consists of a belt that is secured around a patient's midsection that has two pockets to hold the drainage bulbs and velcro along the belt to secure the tubing in place to prevent it from getting caught on anything
- Kangaroo Pouch
    - This design is similar to a sleeve that is tight around the midsection of the patient and it has a pouch that secure the drains and bulbs, it is a more discreet option than the belt with velcro.

The winning design for the attachment site is the adhesive bandage with a clip, while the belt with velcro design won the pouch holder matrix. After some discussion, the team decided to initially focus on the attachment site design and in the future the team plans to come back and work on the housing system designs. Once the design matrices were completed the team decided to begin working on the preliminary presentations by assigning sections to everyone on the team. The next team meeting will be on Monday 10/3 where we plan to finish the preliminary presentation, begin working on preliminary deliverables, and practice for preliminary presentation. The practice suture kit was also ordered for amazon and should arrive by Saturday 10/1. After reaching out to Russ, he mentioned that he had surgical drains that we would be able to use so he is sending them to Oscar, the team also discussed meeting with him the week of 10/3. Once we receive all of the materials we plan to meet with Dr. Wilke to ask her to set up the surgical drain system using sutures.

Conclusions/action items:

We were able to use our design matrix to determine which design the team will focus on developing for the attachment site and housing system. The team also determined that it would be best to focus on the attachment site design and once the team is happy with that design we plan to move on to working on developing the housing system. The team also plans to work on preliminary presentations.

2022/09/16 - PDS

Dana Stumpfoll - Sep 26, 2022, 7:14 PM CDT

Title: PDS

Date: 09/16/2022

Content by: Dana

Present: Dana, Beki, Lauren, Oscar, Abdoulahi

Goals: Discuss PDS

Content:

- During this meeting we discussed who would be doing what part for the PDS.
- Everyone was fine with the section they were assigned.
- We also had just met with Katie so we made sure to include her concerns and answers in the PDS.

References: NONE

Conclusions: Everyone has a section of the PDS to complete. Our meeting with Katie went well and she answered all of our questions that we asked regarding sections of the PDS.

Action items: Everyone will complete their section of the PDS by 9/23 and will begin individual brainstorming.

2022/10/03- Preliminary Deliverables Meeting

Dana Stumpfoll - Oct 09, 2022, 1:11 PM CDT

Title: Preliminary Deliverables

Date: 10/03/2022

Content by: Dana

Present: Rebekah, Lauren, Oscar, Abdoulahi, Dana

Goals: To work on the preliminary presentation

Content:

- We met to discuss the preliminary presentation.
- Everyone was given their parts for the presentation and we also split up the sections for the report.
- Everyone discussed what they were going to talk about and asked any clarifying questions for the presentation.
- We also discussed the materials research we found.
    - We found that the rigid clip component of the first design and the insert under the skin design would be best if they were made from high density polyethylene.
    - We found that the best bandage material for the first clip design would be a hydrocolloid bandage since this is what waterproof bandaids are made from.
    - We also found that the cotton-woven based material of KT-tape is what makes it desirable for long term wear.
- Once we finished discussing materials we decided we were going to continue to do research.
- Oscar also got in touch with Russ Johnson and we set up a meeting on10/10 to discuss our designs with him and get his professional opinion.

Conclusions/action items:

We were able to discuss our questions for the presentation. We plan to meet with Russ to discuss our designs once preliminary presentations are complete. Everyone will continnue to do materials research for the fabrication plans so we can get started on fabrication within the next few weeks.

2022/10/06- Practice for Preliminary Presentation

Dana Stumpfoll - Oct 09, 2022, 1:15 PM CDT

Title: Preliminary Deliverables

Date: 10/03/2022

Content by: Dana

Present: Rebekah, Lauren, Oscar, Abdoulahi, Dana

Goals: To practice our preliminary presentation

Content:

- We met to do a run through of our presentation and discuss any materials we found this week.
- We added our materials research to the presentation and clarified that our clip design and our pressure distribution flaps on the skin designs would be used with sutures.
- The pressure distributing flaps underneath the skin would be used in place of the sutures.
- Our dry run went well and we were under 10 minutes when we practiced.
- Oscar said the drains are scheduled to be delivered on 10/07 and that if they arrive before the presentation he will bring them.

Conclusions/action items:

We completed a good run through of our presentation and will all practice before the actual presentation tomorrow.

2022/10/10- Preliminary Report

Dana Stumpfoll - Oct 11, 2022, 11:17 PM CDT

Title: Preliminary Report

Date: 10/10/2022

Content by: Dana

Present: Rebekah, Lauren, Oscar, Abdoulahi, Dana

Goals: Work on editing the preliminary report for submission

Content:

- We met to work on editing the preliminary report for submission.
- Oscar and Lauren worked on arranging all of the citations using Zotero.
- We made sure to check over each others work and made sure all figures had captions and were labeled the correct number.
- We also went through and fixed the PDS based on the edits Dr. Puccinelli suggested we make.

Conclusions/action items:

We completed editing the report. Once everyone has completed their citation we will turn it in.

2022/10/21- Meeting to Work on Solidworks Drawings

Rebekah Makonnen - Oct 21, 2022, 2:03 PM CDT

Title: Meeting to Decide on Final Clip Design and Complete Solidworks

Date: 10/21/2022

Content by: Rebekah

Present: Team

Goals: To finalize the clip type the team will use and complete the solidworks drawing

Content:

Dana initially began working on a solidworks model of the plastic clip that was mentioned in preliminary deliverables and it was decided that the a torsion spring would be the best type of spring to be used in the clip. After the team's meeting with Dr. Russ we discussed other methods of securing the drain, such as griplok which is a catheter securement device, as an alternative to using a clip. The team discusses that some possible drawbacks of this securement method are the same as the drawbacks of the clip design, such as that the tube would become kinked from the sharp angle that it will be at in order for the tube to become secured and these kinks could cause the drain to become blocked. We also talked about possibly needing to use a stronger adhesive, as it would wear down over time and as it is reused.

The team then discussed alternative methods to using an adhesive on the griplok device to get around the issue of the adhesive being worn out. The team decided to test three methods of securing the device including the griplok device, velcro tape, and a cable clip to determine which device is the most secure and the most comfortable on the patient. Possible testing methods were also discusses, including using a universal mechanical testing machine so we are able to determine the forces that would cause the device to fail. It was also mentioned that a wear test could be completed to test the adhesive and that either chicken or pig skin could be used as they are the most similar to human skin (get pig skin from a butcher). The test would be done on the skin in 3 states dry, soaked in water, and soaked in an artificial sweat solution.

Dana completed the solidworks drawings for the three designs that the team plans on testing, the griplok method, the velcro method, and the cable clip method, and uploaded the files into the project files folder.

Conclusions/action items:

Meet with Dr. Wilke on Monday to ask her questions and have her attach the surgical drain to the suture kit. Order the velcro tape and griplok in order to begin testing. Contact the butcher to see if pig skin is available for us to use.

2022/10/24 - Meeting with Dr. Wilke

Dana Stumpfoll - Oct 24, 2022, 5:11 PM CDT

Title: Meeting with Dr. Wilke

Date: 10/24/2022

Content by: Lauren, Dana, Rebekah

Present: Lauren, Dana, Rebekah

Goals: Have Dr. Wilke attach surgical drain to suture kit for our testing model

Content:

- Dr. Wilke told us she commonly uses a Blake drain for mastectomy surgeries.
- She was able to suture the surgical drain into the suturing pad by creating a hole in one of the slits for the drain to go through.
- She suggested we research:
    - Wound Vac
    - G-tube - specifically pediatric tubes
    - A balloon deployment mechanism
    - Antibiotic fenestrated discs
- We then showed her our preliminary designs.
    - She liked the flaps under the skin design the most and told us to look more into that and a way to deploy and flatten the flaps for it to be removed easily.
        - This contradicted with opinions of other advisors like Dr. Russ Johnson who said we should avoid being directly at the wound site.
    - The ideas she brought up will help us with initial prototyping.
- Design ideas did shift away from the aim of our design project, as she brought up that improving the securement method is only the beginning of making the process less outdated and painful
    - Drains need to be redesigned to better aid in drainage, the basic bulb design consistently needs to be stripped- this is not ideal
    - Continuous accelerated suction to pull the wound closed for no build-up of fluid

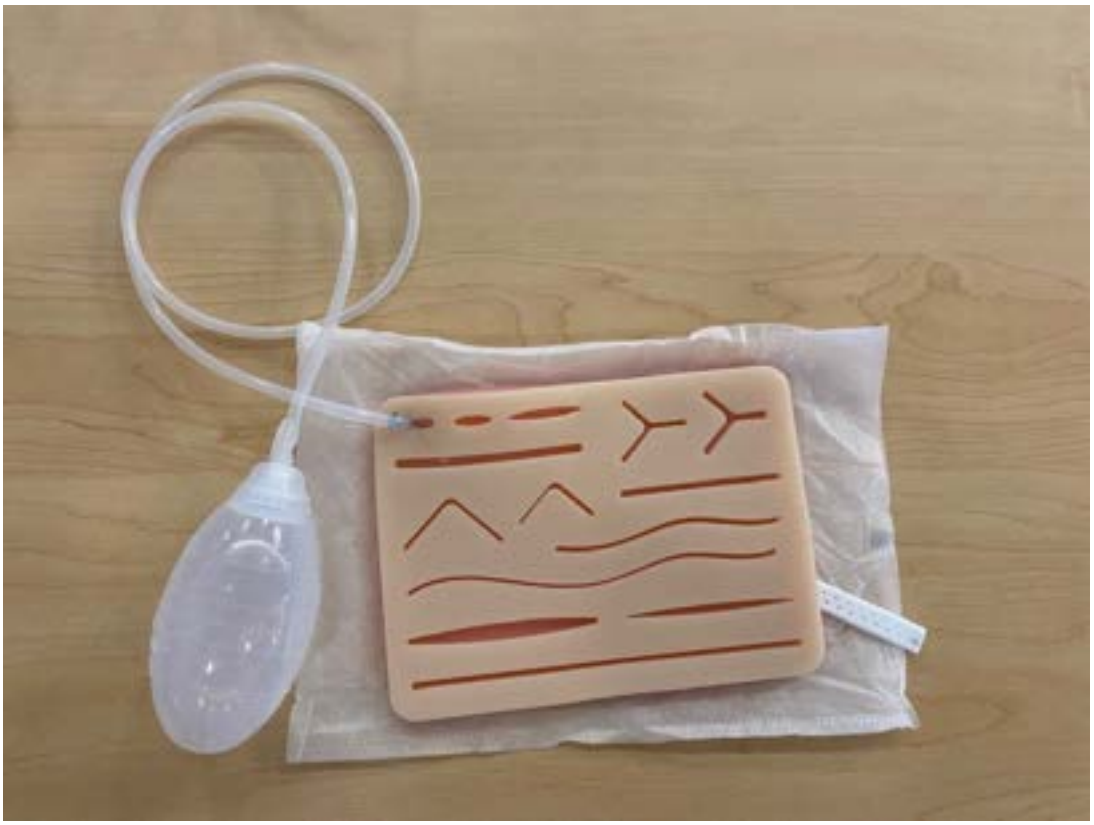


Figure 1: The surgical drain inserted into the suturing pad.

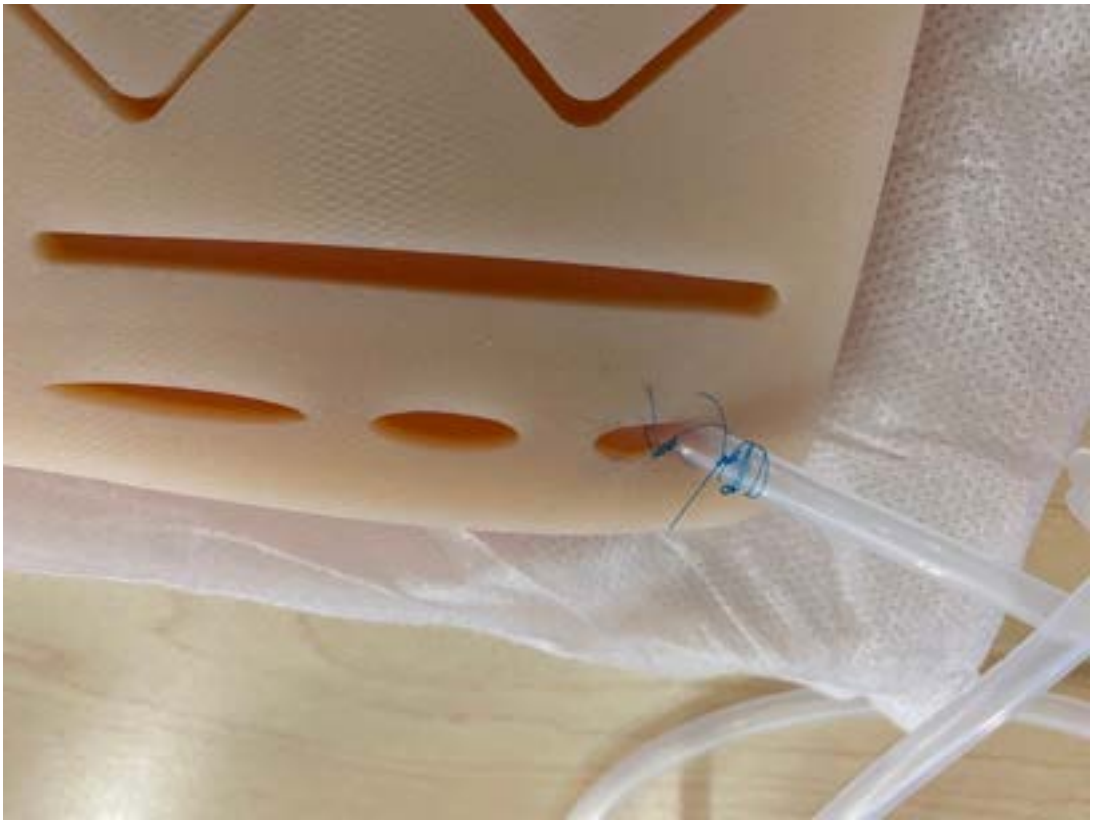


Figure 2: A close up of the suture used to secure the surgical drain.

Conclusions/action items:

We will look more into the research topics she suggested and begin prototyping. For now, we will continue with our initial plans for fabrication and testing, but will reference some of her suggestions to help troubleshoot issues we run into. Additionally, we may want to consider the process of applying to visit the OR to watch placement of the surgical drain if deemed necessary. We should contact Dr. Wilke's scheduler if this is something we want to pursue.

2022/10/27 - Meeting to Plan for Show-and-Tell/Brainstorm BME Outreach

LAUREN HELLER - Oct 27, 2022, 6:00 PM CDT

Title: Meeting to Plan for Show-and-Tell/Brainstorm BME Outreach Project

Date: 10/27/2022

Content by: Lauren Heller

Present: All team members were present.

Goals: Outline the elevator pitch, create the display slide, and decide on a project for the BME Outreach event.

Content:

- Lauren, Dana, and Beki shared the topics discussed in the meeting with Dr. Wilke to the other members of the team to make sure that everyone was on the same page.

- From this, we moved towards the topic of the show and tell, discussing what aspects of our project we wanted to reach out for help about.

- We want to ask for ideas regarding quantifiable testing methods, as we have thought of some but want to see if others can come up with additional ideas. We also want to see if any of our peers have any ideas for how to improve the device so it doesn't need to be replaced as often. We want it to be able to last the entirety of the drain placement duration, ideally up to five weeks.

- The presentation of our work so far may allow for our peers to come up with potential design issues, and will allow us to see if we have already accounted for these issues or if it is something we should consider as we continue.

- We also talked about the BME outreach project. Ideally, our team would like to work with elementary school kids, as we feel they will be the most engaged in our potential project, and will be the most receptive to our presentation. We also hope to expose them to what biomedical engineering is early on, as they likely are not familiar with what BME entails.

- As of now, the team is interested in a 'robotic hand' craft, in which students can make their own robotic hand out of craft supplies. The goal is to give them a fun way to learn about how much one relies on motor skills. It can also expose them to the role biomedical engineers play in the development of more advanced prosthetics.

The link to the project is attached below this entry.

Conclusions/action items:

The team will meet with Dr. Puccinelli tomorrow morning to go over the events and progress over the last two weeks. We will also ideally consult with her about our idea for the outreach project. If our materials have arrived, we will create low-fidelity prototypes to bring to our show and tell event next week.

LAUREN HELLER - Oct 27, 2022, 6:01 PM CDT

Link: https://kansasdiscovery.org/robotic-hand-discovery-at-home/

IEEE Citation:

“Robotic hand: Discovery at home,” *Kansas Children's Discovery Center*, 25-Apr-2022. [Online]. Available: https://kansasdiscovery.org/robotic-hand-discovery-at-home/. [Accessed: 27-Oct-2022].

2022/10/17 - Meeting with Dr. Russ Johnson

Dana Stumpfoll - Oct 17, 2022, 11:54 AM CDT

Title: Meeting with Dr. Russ Johnson

Date: 10/17/2022

Content by: Dana

Present: Rebekah, Lauren, Oscar, Abdoulahi, Dana

Goals: Consult Dr. Johnson about our designs

Content:

- Worked at cardinal health for 10 years.
    - Cardinal Health is the market leader for jackson pratt drains.
- Had a wound drain before that was more superficial.
- There is controversy between preventing and creating infection with the use of wound drains.
- He showed us the Grip Lok securement devices for catheter placements by TiDi products.
    - They are medical adhesives that have another adhesive that the tube goes through.
- He suggested that we get away from sutures for the final design.
- Look at other ways they are adhered to the skin.
    - At the wound site versus away from the wound site.
- If we choose to go right on wound he suggest we use hydrocolloid bandage since it can absorb exudate.
- If we choose to do an attachment away from the wound site he suggests we try to stay away from hydrocolloid unless we are using it for long term use.
- Ideally we shouldnt use the device directly at the wound site because this would allow for a longer term use.
- M1050 in ECB - where his office is if we need to find him or email him if we need more help.

Conclusions/action items:

After discussing our options with Dr. Johnson we are considering our material options and determining if it would be best to completely get rid of the use of sutures with our design. We will consult Dr. Wilke and her opionion of using sutures or not and what would be better.

2022/10/31 - Prototyping

Dana Stumpfoll - Oct 31, 2022, 7:01 PM CDT

Title: Initial prototyping of material

Date: 10/31/2022

Content by: Dana Stumpfoll

Present: Oscar, Lauren, Abdoulahi, Dana

Goals: Begin initial prototyping

Content:

- With the materials we received on 10/28 we began initial prototyping.

- To start Lauren placed one of the waterproof adhesive tape bandages on her arm and found that when pulled against the direction of hair it was very uncomfortable to remove.

- When she removed it with the way her hair on her arm was growing it was very easily removable.

- We then began with a piece of KT-Tape and cut a small hole in the center of it by cutting a slit from the edge to the middle and makin g a circle.

- The KT- Tape was stretchable in only 1 direction.

- The clip wrapped tightly around the surgical drain but did not compress it enough to close the tube off.

- Lauren came up with the idea to test the clip design to ensure it does not close of the draining of the tube by filling a bag with water or another viscous fluid to make sure the negative pressure in the bulb can still pull the fluid through the drain.

- We started by super gluing (Gorilla super glue gel) a clip to the KT-Tape.

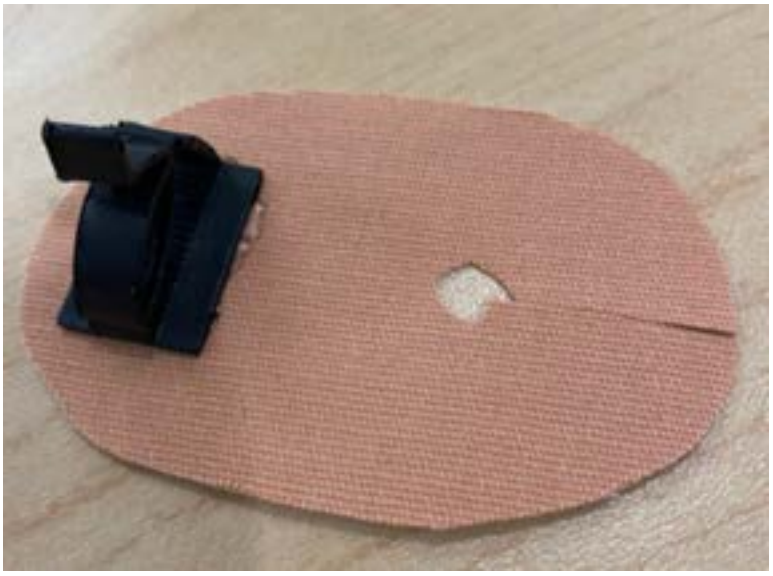


Figure 1: Clip glued onto the KT-Tape.

- We also super glued a clip to the silicone bandage.

Figure 2: Pin glued to silicone bandage adhesive.

- Once these two designs were creared we contemplated the different testing methods we could conduct.

- We then created a water proof KT-Tape by layering the waterproof adhesive on top of the KT-Tape.

Figure 3: KT-Tape with waterproof adhesive layer on top.

- We then worked on solidifying our elevator pitch for the show and tell.

Conclusions/action items:

We will continue to prototype once the rest of our materials arrive such as the hydrocolloid bandage and the velcro design. We will continue to think of testing protocols to determine which adhesive will be the most comfortable and stay adhered for the longest amount of time.

2022/11/03 - Prototyping Day 2

ABDOULAHI BAH (anbah@wisc.edu) - Nov 14, 2022, 8:09 PM CST

Title: Prototyping Day 2

Date: 11/3/2022

Content by: Abdoulahi Bah

Present: Rebekah, Lauren, Oscar, Abdoulahi, Dana

Goals: Continue initial prototyping

Content:

- made another prototype that utilizes Velcro to secure the surgical tube
    - Lauren cut another hole through the KT Tape
    - Oscar super glued the Velcro loop side to the KT Tape

Figure 3: Grip Lock attached to the KT Tape

Figure 4: Grip Lock attached to the KT Tape and how it is supposed to attach to the skin

Conclusions/action items: During this meeting, the team was able to do some initial prototyping. The team will have a show and tell tomorrow and hopefully receive some more insight about different ways we can test the device and things we can change.

2022/11/04 - Show and Tell Event

LAUREN HELLER - Nov 04, 2022, 1:41 PM CDT

Title: Show and Tell Event with Other Teams

Date: 11/04/2022

Content by: Lauren Heller

Present: All team members present.

Goals: Present an elevator pitch to other groups and seek advice on various aspects of the project. Specifically, we would like feedbacks on concerns with our low-fidelity prototypes and ideas for testing protocols that we may not have considered.

Content:

Points of our elevator pitch:

- Showed them the current method of securing the surgical drain, as well as what proper care of the drain is needed, so that the design cannot inhibit it.

- We showed our different design variations, as well as our current plans for testing ideas.

- We asked for ideas for testing procedures that could be quantified for stretch, pull, and wear tests

- We asked for any feedback on our current design shapes, as well as the securement methods for holding the drain tube.

- Our team would ideally like to find the best distance to secure the tubing from the drain without creating any downwards pulling on the drain site.

Feedback from other teams:

- Using MTS machine clamped down on the material when attached to mimicked skin

- Look for weak point in each test with the MTS machine, if the failure is consistently at the same place, there is a weak spot versus failures at lots of different points may be representative of a more consistent pressure distribution

- FSRs to measure negative force on each FSR to compare the force registered at each point along the adhesive

- Test to quantify how the device is working using a numerical scale for relative characteristics, that turns qualitative data into quantitative data, scale needs to be very descriptive.

- One of our peers had back surgery, and stated that they had significant irritation and an infection from constant bandage removal and reapplication. They thought that our idea for a longevity test in different conditions was a good idea, and agreed that it was a very important property to test.

- Looking at shear test, as the person may be bending and moving, should be able to stay adhered in flexible twisting motions of the torso.

- Some teams suggested a daily use adhesive, but we did explain the irritation that would be caused with frequent removal and reapplication. This would be counterintuitive to the design's purpose.

- Butterfly shape/dog-bone shape design for the adhesive might be a good shape to consider to distribute pressure.

- Could look into a suture glue or dissolvable adhesive that would come off over time, a new one could then be applied, and it would ideally lead to less skin irritation

- For ergonomics, measuring ease of use for application, removal, potentially do a blind study, and could get some testing of how likely a person is to use that design.

- Christmas light clips rather than a cable clip -> push the tubing down into the clip rather than having a piece going over the team

- Using videos and analysis software to measure deformation at various points, could mark points or draw a square to measure in the X and Y directions

- Testing of tube compression? Making sure that any of the securement methods do not interfere with drainage by clamping on the tube

- Hydrocolloid was a favorite for one peer who had shoulder surgery, said the bandage stayed on for a whole month with no issues.

Conclusions/action items:

Overall, the show and tell event provided a lot of useful feedback that we will refer back to as we continue prototyping and begin testing. We will share these comments with our advisor, Dr. Puccinelli, in our next advisor meeting. Some of the comments received were things that we had thought of, which was a good sign that others had similar methods of thinking. Others were things we had not thought of, and some may be incorporated.

2022/11/07 - Prototyping/Testing Planning/Outreach

LAUREN HELLER - Nov 07, 2022, 8:32 PM CST

Title: Team Prototyping, Test Planning, and Outreach Planning

Date: 11/07/2022

Content by: Lauren Heller

Present: All team members were present.

Goals: Come up with a more solidified plan of tests we want to conduct and plan part of the outreach event.

Content:

- The Hydrocolloid bandages from ShopUW were a combination of half for fingers and toes, and half of the larger rectangles that we needed. We will plan to submit another request to order more dressing through Amazon.

- We did discuss also working on the subdermal design idea, however we believe that it is too late in the semester to work on a secondary design. We plan to consider with our protective adhesive method strictly.

- Methods for testing were discussed, and testing plans will be placed in the testing section of the notebook.

- Discussed methods for making an artificial sweat solution for the longevity test. There are pre-made solutions that can be bought online, however for out purposes we will plan to make our own mock sweat solution at a cheaper price.

- Testing of the adhesive will be done first, and then the securement methods will be decided after the adhesive is selected. This will minimize the amount of adhesive and securing materials we need to use, and will allow us to focus on one adhesive material.

- Team members worked on the outreach activity template, and will continue to work on it over the course of the week.

- Multiple emails were created to send to our advisor regarding opinions on materials ordering and contacting a Madison teacher to set up our outreach event.

Conclusions/action items:

We need to conduct our longevity test once we obtain approval to order more materials. We will continue working on the outreach activity as well. Once we gain approval to use the MTS machine, we will set up a time to test the adhesive materials in various aspects.

2022/11/14 - Preparation of Test Samples

ABDOULAHI BAH (anbah@wisc.edu)

Title: Preparation of Test Samples

Date: 11/14/2022

Content by: Abdoulahi Bah

Present: All team members were present.

Goals: create test samples to conduct MTS testing

Content:

- team members cut out templates for a dog bone shape

Figure 1: Sample template of dog bone shape

- We then attached the templates to the bandages using tape

Figure 2: Attached Template to hydrocolloid dressing

- Team members then traced the dog bone shape to use a guide when cutting out

Figure 3: Traced template onto silicone bandage

Figure 4a: Cut out silicone bandage in dog bone shape

Figure 4b: Cut out hydrocolloid bandage in dog bone shape

- this was done with three different types of bandage material (Hydrocolloid dressing, Elastic Therapeutic Tape, Silicone bandage, and Waterproofed Elastic Therapeutic Tap the elastic therapeutic tape, three samples had the dog bone shape parallel to fibers and the other three had the dog bone shape perpendicular to fibers.
- Three samples of dog bone shape for silicone bandage and hydrocolloid dressing
- Oscar created a document that contains the properties of each bandage material (Area, Thickness, Volume, Mass, Density, Elastic Modulus, Poisson's ratio, initial length, & Ultimate Strength)
    - was not able to use calipers to figure out the thickness of the bandage material, so compared to bandage that had a given thickness
    - Oscar used a scale in team labs to determine the weight of each bandage material

Bandage	Area (m^2)	Thickness (m)	Volume (m^3)	Mass (kg)	Density (kg/m^3)	Poisson's Ratio	Cross Sectional Area (m^2)	Initial Length (m)	Elastic Modu
Hydrocolloid	0.01	0.0005	0.000005	0.0072538	1450.76		0.000035	0.033	
Silicone	0.004284	0.0001	0.0000004284	0.0018286	4268.44071		0.000007	0.033	
Elastic Therapeutic Tape - parallel to fibers	0.003731	0.0001	0.0000003731	0.0010233	2742.696328		0.000007	0.033	
Elastic Therapeutic Tape - perpendicular to fibers	0.003731	0.0001	0.0000003731	0.0010233	2742.696328		0.000007	0.033	
Waterproof Elastic Therapeutic Tape - parallel to fibers	0.003731	0.0001	0.0000003731	0.0012411	3326.454034		0.000007	0.033	
Waterproof Elastic Therapeutic Tape - perpendicular to fibers	0.003731	0.0001	0.0000003731	0.0012411	3326.454034		0.000007	0.033	

Table 1: Collected Properties so far using given dimensions, scale, and mathematical formulas

Conclusions/action items: The team successfully created dog bone shape samples of each of the bandage materials we want to test. Tomorrow Lauren and Dana will begin co each sample to determine the elastic modulus and ultimate strength. This will help the team choose the final bandage material the team will use in the final prototype.

2022/11/18 - Preliminary Testing of Samples

ABDOULAHI BAH (anbah@wisc.edu)

Title: Preliminary Testing

Date: 11/18/2022

Content by: Abdoulahi Bah

Present: All Team Members

Goals: Conduct preliminary testing on various bandage samples to obtain their mechanical properties which will be important in determining which bandage material we should u

Content:

MTS Test:

- Lauren and Dana set up the MTS machine
- Problems w/ Testing:
  - Bandage can slip - done so 2 times
    - could be because of touching the adhesive multiple times - oil on fingers and adjusting it again after sticking it to the clamp
  - data was not exporting, so we will have to rely on the pictures we take
    - Solution: Saved to OneDrive
  - elastic modulus when testing for the hydrocolloid was not being calculated correctly - so had to retest the hydrocolloid to get the correct elastic modulus
  - elastic modulus was not being calculated correctly - we wanted only for the initial part until yielding in which the material had elasticity. However, since we ran the tes it calculated the elastic modulus from beginning of loading to failure.
  - **To See testing results from 1st try of preliminary testing go to Testing and Results section**
-

Poisson's Ratio Test:

- measure of how it deforms laterally when you stretch longitudinally
- if low there is a lot of lateral deformation when you stretch longitudinally
- if high there is not much lateral deformation
- All samples had a square drawn on them excluding the silicone bandage which had a rectangle due to lack of geometric space to draw one
- sample was then stretched longitudinally and measured the amount of deformation laterally and longitudinally
- Results from testing:
  - Silicone had the lowest lateral deformation (highest Poisson ratio), as we applied a longitudinal stretch
  - KT tape parallel fibers had the highest lateral deformation (lowest Poisson ratio) - Oscar said this could be because since fibers are in parallel there was no support i direction when it was stretched longitudinally

Bandage	Area (m^2)	Thickness (m)	Volume (m^3)	Mass (kg)	Density (kg/m^3)	Poisson's Ratio	Cross Sectional Area (
Hydrocolloid	0.01	0.0005	0.000005	0.0072538	1450.76	0.3333333333	0.0
Silicone	0.004284	0.0001	0.0000004284	0.0018286	4268.44071	0.375	0.0
Elastic Therapeutic Tape - parallel to fibers	0.003731	0.0001	0.0000003731	0.0010233	2742.696328	0.0555555556	0.0
Elastic Therapeutic Tape - perpendicular to fibers	0.003731	0.0001	0.0000003731	0.0010233	2742.696328	0.3333333333	0.0
Waterproof Elastic Therapeutic Tape - parallel to fibers	0.003731	0.0001	0.0000003731	0.0012411	3326.454034	0.2857142857	0.0
Waterproof Elastic Therapeutic Tape - perpendicular to fibers	0.003731	0.0001	0.0000003731	0.0012411	3326.454034	0.5	0.0

Table 1: Significance - Poisson's Ratio Results

Conclusions/action items: The team had conducted initial testing on the various bandage samples, however the MTS machine was not calculating the elastic modulus correctly load data collected from the MTS machine to calculate it correctly. However, the data did not export correctly and the team will meet on Saturday to re-conduct preliminary testing

2022/11/18 - Preliminary Testing of Samples Again

ABDOULAHI BAH (anbah@wisc.edu) - Nov 20, 2022, 9:46 PM CST

Title: Preliminary Testing of Samples Again

Date: 11/20/2022

Content by: Abdoulahi

Present: All Team

Goals: Conduct preliminary testing again so that we can do MATLAB and FEBio analysis

Content:

MTS Test:

- team created more samples to conduct testing again
    - Note: Was not able to conduct silicone test again because we ran out of the silicone bandages to produce more samples
- the solution to making sure the test exported correctly - is to delete the completed test after it was uploaded to OneDrive, otherwise we would keep uploading the same test results
- team members also noticed there was slipping happened frequently with the waterproofed KT Tape
- Oscar used MATLAB to calculate the elastic modulus of each sample tested:
    - Calculated stress and strain using the data outputted MTS Machine and properties collected of each sample initially
    - observed what the elastic region was and set boundaries
    - then MATLAB calculates the slope of the elastic region (using the stress and strain found before) to give us the elastic modulus of the bandage sample
- **Results from test can be found in Experimentation in the Test and Results folder**

Conclusions/action items: The team was successfully able to complete preliminary testing. The data collected from the MTS machine will be analyzed using MATLAB and FEBio, to help the team decide on a bandage material for the design.

2022/11/28 - Team Meeting

ABDOULAHI BAH (anbah@wisc.edu) - Nov 30, 2022, 11:34 AM CST

Title: Team Meeting

Date: 11/28/2022

Content by: Abdoulahi

Present: All Team

Goals: Discuss results from MATLAB and FEBio analysis, outreach activity and planning for our project

Content:

- Dana completed the rest of the outreach activity form. So the team took some time to look over it
    - As a team we have decided to reach out to our contact next semester, this will give us time to practice and decide on a time that works for our new schedules in the upcoming semester
- Oscar also discussed the some of the results from MATLAB and FEBio analysis
    - FEBio analysis was not helpful because there wasn't much difference in stress distribution depending on the shape
- Also looked at the circut device - the team could potentially use this device to cut out the bandage material for our final prototype
    - the UW makerspace has a Cricut Maker 3 which we can use to cut bandage materials
- Dana also modeled the designed clip
- Team will be meeting on Wednesday at UW-Makerspace to print out the clip and cut out using circut
- Team will also meet on Friday after our advisor meeting to test the printed clip

Conclusions/action items: The team will meet on Wednesday to print out the clip and cut out bandages. Then on Friday, we will meet to test the designed clip to see how well it works.

2022/11/30 - Fabrication of clip and cutting of hydrocolloids

Dana Stumpfoll - Nov 30, 2022, 4:55 PM CST

Title: 3D printing of clip design and cutting of hydrocolloid bandages

Date: 11/30/2022

Content by: Dana Stumpfoll

Present: Dana, Lauren, Beki, Abdoulahi

Goals: 3D print SolidWorks clip design and cut hydrocolloids using the Cricut machine at the makerspace.

Content:

- We were able to go into the makerspace and get our SolidWorks clip design started on the 3D printer.

- We then worked on creating cutouts of our hydrocolloid bandage using the Cricut machine.

- We started by using scrap material to ensure our design was correct and then we cut the correctly dimensioned design on our hydrocolloid bandages.

- We used the cardstock adhesive setting to ensure the Cricut would cut all the way through our hydrocolloids.

- We made 3 small hydrocolloid cutouts and one big one. (see images below)

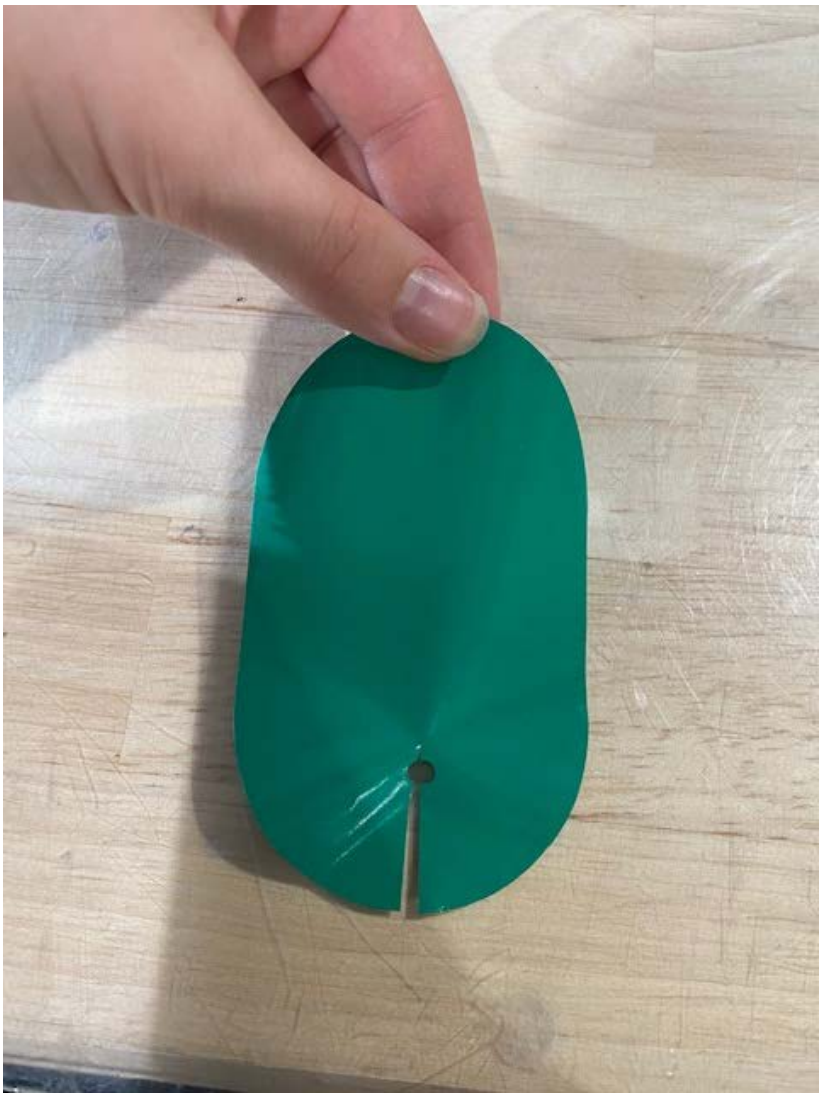


Figure 1: Example cut using vinyl scrap. The example was too wide so we reduced the width and we made the hole in the center bigger (0.6 cm x 0.6 cm).

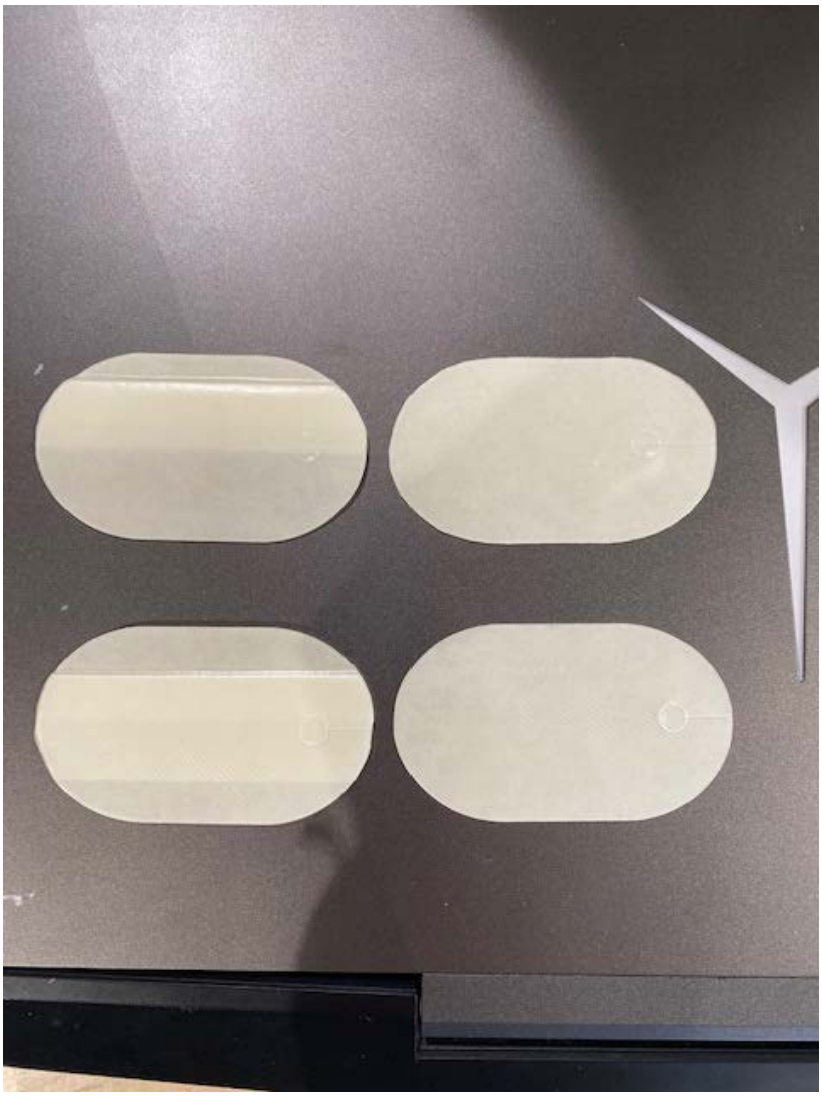


Figure 2: The smaller hydrocolloids cut using the Cricut machine. The holes were very close to the edge.

Figure 3: Our 4x2 inch hydrocolloid. It got a bit cut off on the right side edge.

Conclusions/action items:

Now that we know how to use the Cricut machine we will make more bandages if needed. We will also test our clip using weights and ensure this shape of the bandage is the best for the purposes of our design.

2022/12/2 - Cutting hydrocolloids and assembling griplok design

Dana Stumpfoll - Dec 02, 2022, 1:59 PM CST

Title: Cutting hydrocolloids and creating final design for testing

Date: 12/2/2022

Content by: Dana Stumpfoll

Present: Dana, Oscar, Beki, Abdoulahi

Goals: Create final prototypes and create testing protocol for final testing.

Content:

- After our advisor meeting we headed to the makerspace to create more hydrocolloid cutouts using the Cricut machine.
- We were able to use our remaining hydrocolloid bandages to create 8 more hydrocolloid bandages in the oval shape.
    - We adjusted the dimension to be 3.5 in x 1.75 in so we could create two bandages from our 4x4 in hydrocolloids.
- We then took 4 of them and glued griplok to them for our force testing.
- We created our force testing protocol.
- Our 3D printed clip was not finished so we were unable to attach those to the hydrocolloids.
- Oscar conducted some statistical analysis using the data he got from the FEBio simulations.
    - He found the shape of the bandages did not affect the stress distribution, but the material itself did.
    - This is what we deciphered before.
    - Because the elastic modulus is statistically different in the perpendicular and parallel direction for the kinesiology tape, it is valid that we modeled it as an orthotropic material in FEBio rather than an isotropic material.

Figure 1: Hydrocolloid bandages with griplok attached and four other hydrocolloids we will use to attach clips.

Conclusions/action items:

We will conduct force testing to determine whether the clip or the griplok holds the surgical drain in place better. We will continue to do statistical analysis for our testing and include these results in our final presentation and paper as we wrap up this semester.

2022/12/5 - Force testing

Dana Stumpfoll - Dec 05, 2022, 8:52 PM CST

Title: Force testing on griplok hydrocolloid

Date: 12/5/2022

Content by: Dana Stumpfoll

Present: Dana, Oscar, Beki, Abdoulahi, Lauren

Goals: Test griplok final prototypes.

Content:

- Our second print of our clips did not work out as the diameter of the hole for the clips was too big.
- Dana will reprint the clips tomorrow (12/6) with a 3 mm diameter.
- We still conducted force testing on the hydrcolloid bandages attached to the griplok.
- We attached the bandages to white board since this surface is uniform and will not affect the adhesion of the bandages.
- We first tested the griplok by just freely releasing the tube but ensuring not to drop it where it would add extra force to the griplok adhesive.
- We then added water into the surgical drain tube bulb, 10 mL at a time, or 10 grams at a time.
- Once the bulb was full, we dropped the full bulb to see if it would completely displace the tubing and it did.
- On our final trial we continued to add water until the the surgical drain was completely displaced by taping 50 mL conicals to the surgical drain bulb and adding water in 10 mL increments.
- Our results can be seen in the testing and results folder.
- Once the clip design has been printed we will add these results.

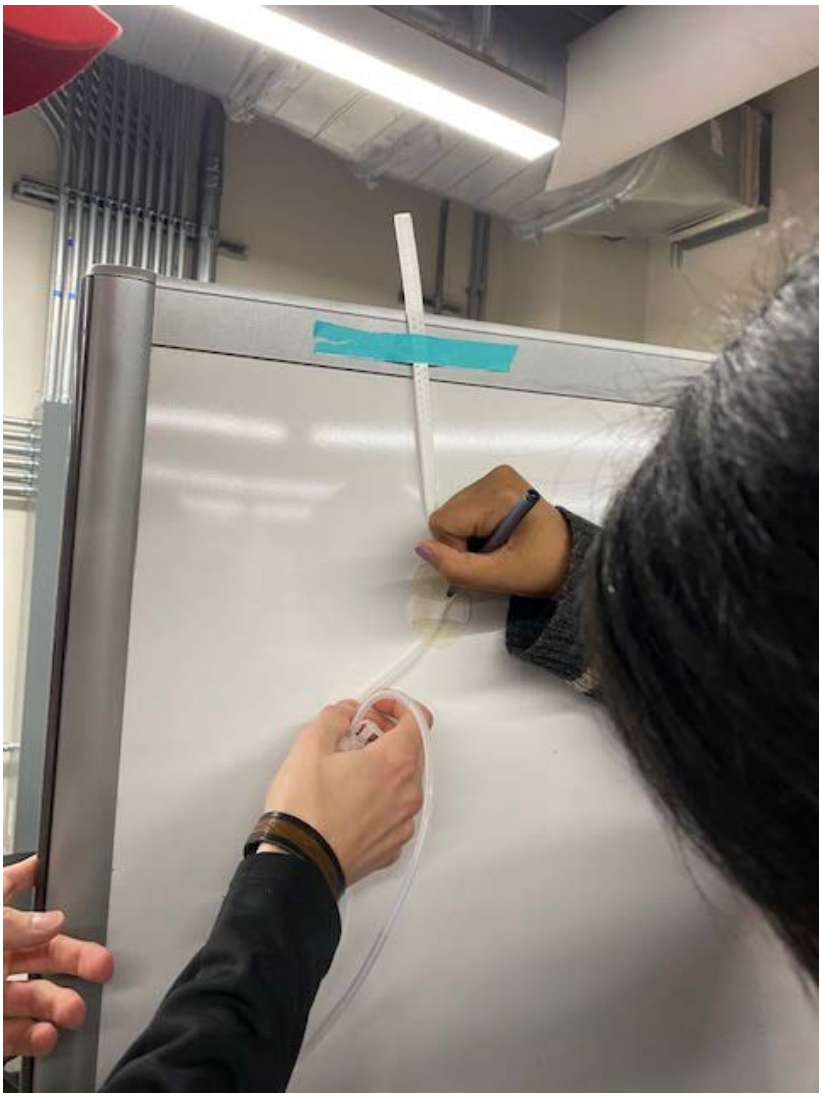


Figure 1: Marking the tubing for the testing setup.

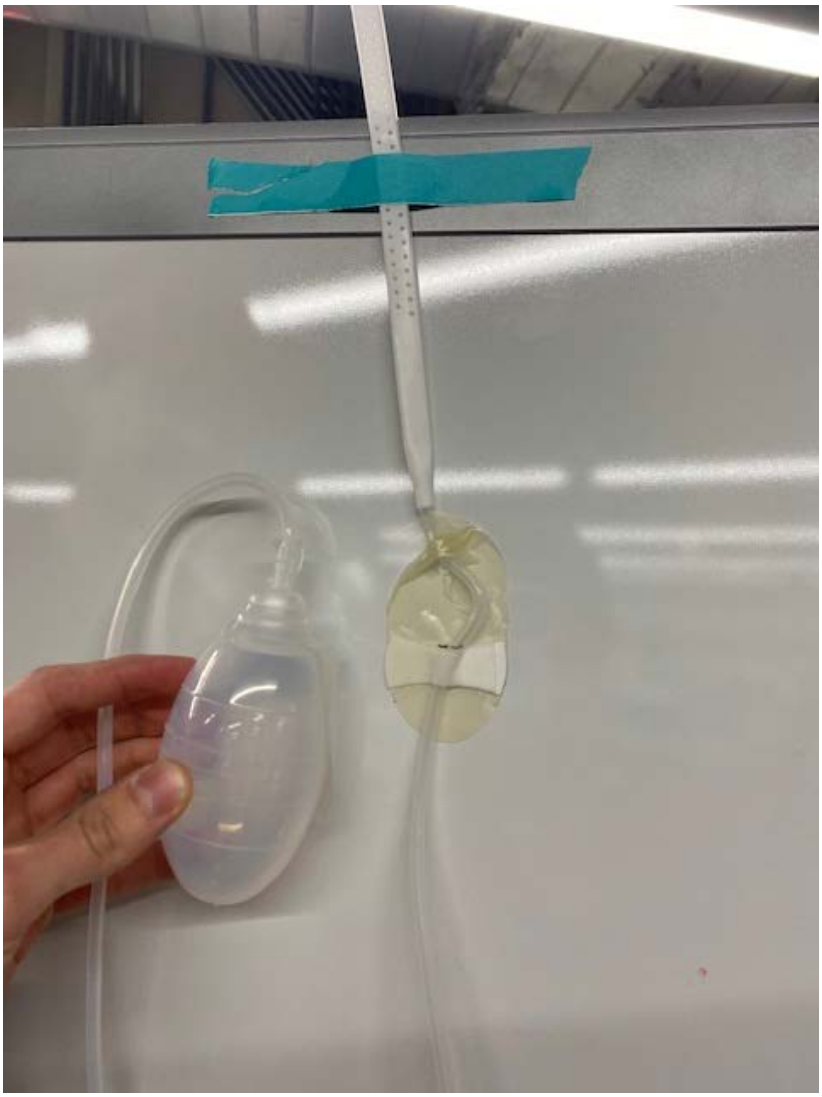


Figure 2: Testing setup. The tube is kinked to ensure that the weight is being concentrated at the griplok site.

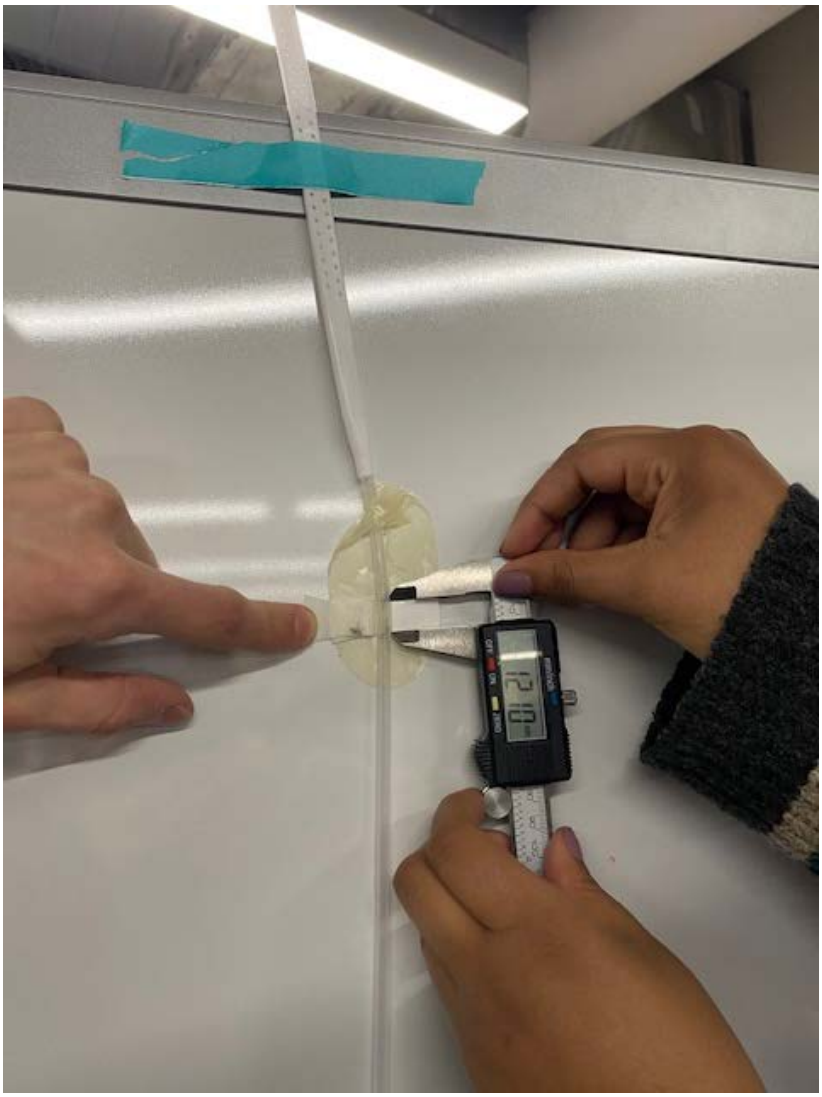


Figure 3: Measuring the displacement of the tubing once it has become completely detached from the griplok.

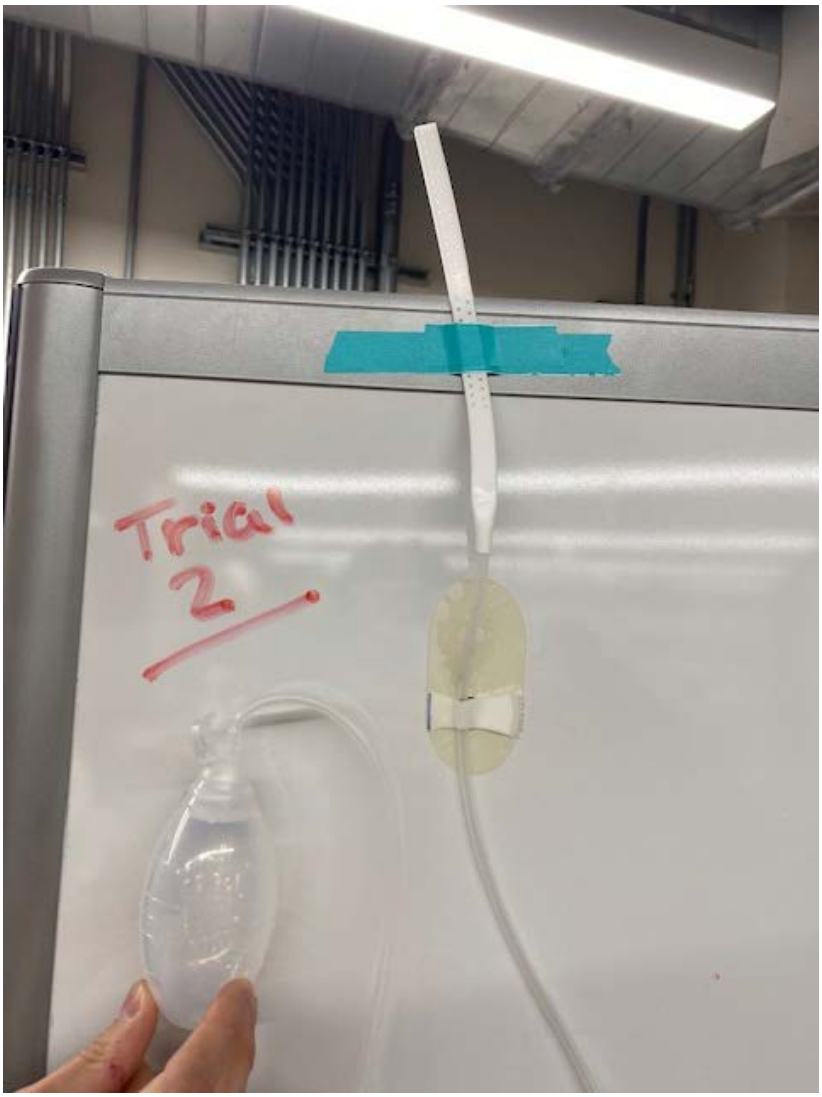


Figure 4: The setup for the second trial we conducted.

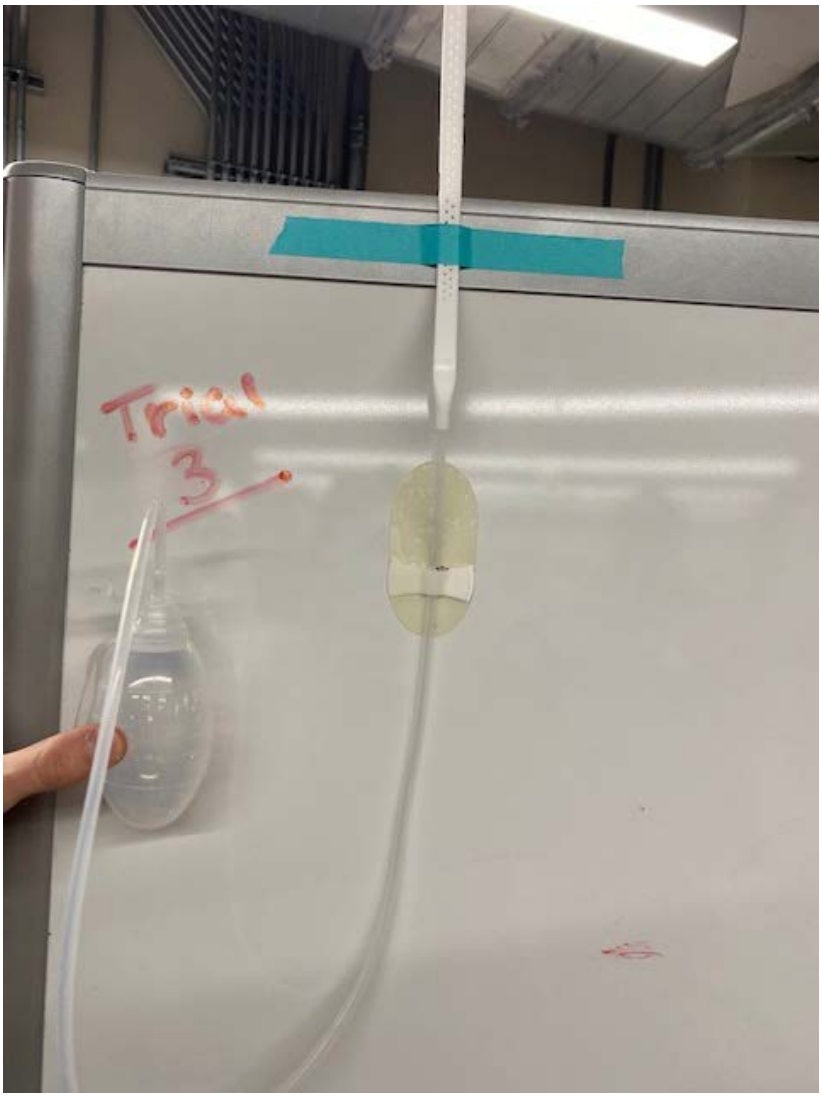


Figure 5: The setup for the third trial we conducted.

Conclusions/action items:

We will conduct force testing on the clip design once it has been printed and compare the results to this testing of the griplok to determine which design will be better for holding the drain in place.

2022/9/30 Completed Decision Matrices

Dana Stumpfoll - Oct 09, 2022, 1:16 PM CDT

Title: Preliminary Design Decision Matrices

Date: 9/30/22

Content by: Lauren Heller

Present: All team members were present.

Goals: Evaluate preliminary designs on a weighted set of criteria.

Content:

			Adhesive Bandage with Clip		Pressure Distributing Flaps Inside		Pressure distributing flaps outside	
	Attachment Site							
Rank	Criteria	Weight	Score (10 max)	Weighted Score	Score (10 max)	Weighted Score	Score (10 max)	Weighted Score
1	Effectiveness	30	8	24	6	18	8	24
2	Patient Comfort	25	8	20	3	8	9	23
3	Ease of Placement	20	7	14	9	18	6	12
4	Cost	15	8	12	9	14	6	9
5	Adaptability	10	10	10	7	7	8	8
	Sum	100	Sum	80	Sum	64	Sum	76

			Belt with Velcro		Kangaroo Pouch	
	Pouch Holder					
Rank	Criteria	Weight	Score (10 max)	Weighted Score	Score (10 max)	Weighted Score
1	Patient Comfort	25	8	20	5	13
2	Compactibility	25	6	15	8	20
3	Ease of Use	20	8	16	10	20
4	Compatibility	15	8	12	8	12
5	Safety	10	10	10	7	7
6	Cost	5	7	4	8	4
	Sum	100	Sum	77	Sum	76

Conclusions/action items:

Our designs were evaluated using two separate design matrices, as we thought that there were two distinct components to evaluate. There are aspects from each design that we think are useful, and plan to draw from other designs as needed to troubleshoot any initial fabrication/testing issues. For our attachment site design, we will proceed with the Adhesive bandage with clip design, and for our Pouch Holder we will proceed with the kangaroo pouch.

2022/9/29- Rough Bill of Materials

Rebekah Makonnen - Sep 30, 2022, 12:41 PM CDT

Title: Rough Bill of Materials

Date: 9/30/2022

Content by: Rebekah

Present: Rebekah

Goals: To make a tentative list of all materials and expenses

Content:

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link
Complete Sterile Suture Practice Kit for First Aid Field Emergency and Medical Students Training - Including Large Silicone Suture Pad and Sterilized Suture Tools Threads and Needles	Practice Suture Kit	NeoProMedical	MN-062719	9/29/2022	1	$27.99	$27.99	Practice Suture Kit
Jackson-Pratt Perforated Round Drains	Surgical Drain Jackson-Pratt® Perforated/Round End Perforation 7Fr Silicone Radiopaque	Cardinal Health	SU130-1320	9/29/2022	1	Free from Russ Johnson	Free from Russ Johnson	JP Drains

Conclusions/action items:

Once the team receives the practice suture kit and surgical drains, the team plans to meet with Dr. Wilke to have her attach the drain to the kit using sutures. Currently the team is working on finalizing the design matrix and choosing a design, starting to work on preliminary presentations, and determining the specific materials needed for the attachment site design.

2022/10/21 Updated Bill of Materials

Rebekah Makonnen - Oct 21, 2022, 1:06 PM CDT

Title: Rough Bill of Materials

Date: 10/21/2022

Content by: Team

Present: Rebekah

Goals: To make an updated list of all materials and expenses

Content:

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link
Complete Sterile Suture Practice Kit for First Aid Field Emergency and Medical Students Training - Including Large Silicone Suture Pad and Sterilized Suture Tools Threads and Needles	Practice Suture Kit	NeoProMedical	MN-062719	9/29/2022	1	$27.99	$27.99	Practice Suture Kit
Jackson-Pratt Perforated Round Drains	Surgical Drain Jackson-Pratt® Perforated/Round End Perforation 7Fr Silicone Radiopaque	Cardinal Health	SU130-1320	9/29/2022	3	Free from Russ Johnson	Free from Russ Johnson	JP Drains

SOULWIT Cable Clips	SOULWIT 50Pcs Adjustable Cable Management Clips, Adhesive Cable Organizers Sticky Wire Clips Cord Holder for TV PC Ethernet Cable Under Desk Wall Home Office	SOULWIT	B09VXNRJDN	10/21/2022	10	Free from Oscar Zarneke	Free from Oscar Zarneke	Cable Clips
Hydrocolloid Bandage	Bandage Hydrocolloid Blister White BX10 -19926	DUKAL CORPORATION	76407-780 (BX)	10/17/2022	1	$5.20	$5.20	Hydrocolloid Dressing
K-Tape	SB SOX Original Cotton Kinesiology Tape (16ft Uncut Roll) – Best Latex Free, Water Resistant Tape for Muscles/Joints – Perfect for Any Activity – Easy to Apply/Use, Works Great for Several Days!	SB SOX	B07L7NQN3V	10/17/2022	1	$12.30	$12.30	K-Tape
Adhesive Tape	100 Pieces Transparent Stretch Adhesive Bandages Waterproof Film Dressing Breathable Tape Clear Adhesive Skin Covers Shower Protective Patch for Bath Supplies Swimming (4 x 5 Inch)	Nuanchu	B099WJ4ZXJ	10/17/2022	1	$15.99	$15.99	Adhesive Tape

Silicone Adhesive Bandages	Curad Truly Ouchless Extra Large Silicone Bandages, Flexible Fabric, 8 Count Packaging May Vary	Medline	CUR5003V1H	10/17/2022	1	$11.98	$11.98	Silicone Adhesive Bandage
Velcro Tape	VELCRO Brand Extreme Outdoor Mounting Tape | 20Ft x 1 In, Holds 15 lbs | Strong Heavy Duty Stick on Adhesive | Mount on Brick, Concrete for Hanging, 30702	VELCRO Band	VEL-30702-AMS	10/21/2022	1	$19.99	$19.99	Velcro Tape
GripLok	TIDI Grip-Lok Small Securement Device — Pack of 10 — White — Flexible Material — Low-Profile Design for Comfort — Home Healthcare — Medical Supplies (3200S-10PK)	TIDI	3200S-10PK	10/21/2022	1	$30.25	$30.25	GripLok

Conclusions/action items:

Complete another funding request to order velcro tape and griplok devices for testing. Meet with Dr. Wilke on Monday (10/24/2022) to have her attach drains to suture kit

2022/11/28 - Updated Bill of Materials

Rebekah Makonnen - Nov 28, 2022, 7:27 PM CST

Title: Rough Bill of Materials

Date: 11/28/2022

Content by: Team

Present: Rebekah

Goals: To update the list of all materials and expenses

Content:

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link
Complete Sterile Suture Practice Kit for First Aid Field Emergency and Medical Students Training - Including Large Silicone Suture Pad and Sterilized Suture Tools Threads and Needles	Practice Suture Kit	NeoProMedical	MN-062719	9/29/2022	1	$27.99	$27.99	Practice Suture Kit
Jackson-Pratt Perforated Round Drains	Surgical Drain Jackson-Pratt® Perforated/Round End Perforation 7Fr Silicone Radiopaque	Cardinal Health	SU130-1320	9/29/2022	3	Free from Russ Johnson	Free from Russ Johnson	JP Drains

SOULWIT Cable Clips	SOULWIT 50Pcs Adjustable Cable Management Clips, Adhesive Cable Organizers Sticky Wire Clips Cord Holder for TV PC Ethernet Cable Under Desk Wall Home Office	SOULWIT	B09VXNRJDN	10/21/2022	10	Free from Oscar Zarneke	Free from Oscar Zarneke	Cable Clips
Hydrocolloid Bandage	Bandage Hydrocolloid Blister White BX10 -19926	DUKAL CORPORATION	76407-780 (BX)	10/17/2022	1	$5.20	$5.20	Hydrocolloid Dressing
K-Tape	SB SOX Original Cotton Kinesiology Tape (16ft Uncut Roll) – Best Latex Free, Water Resistant Tape for Muscles/Joints – Perfect for Any Activity – Easy to Apply/Use, Works Great for Several Days!	SB SOX	B07L7NQN3V	10/17/2022	1	$12.30	$12.30	K-Tape
Adhesive Tape	100 Pieces Transparent Stretch Adhesive Bandages Waterproof Film Dressing Breathable Tape Clear Adhesive Skin Covers Shower Protective Patch for Bath Supplies Swimming (4 x 5 Inch)	Nuanchu	B099WJ4ZXJ	10/17/2022	1	$15.99	$15.99	Adhesive Tape

Silicone Adhesive Bandages	Curad Truly Ouchless Extra Large Silicone Bandages, Flexible Fabric, 8 Count Packaging May Vary	Medline	CUR5003V1H	10/17/2022	1	$11.98	$11.98	Silicone Adhesive Bandage
Velcro Tape	VELCRO Brand Extreme Outdoor Mounting Tape | 20Ft x 1 In, Holds 15 lbs | Strong Heavy Duty Stick on Adhesive | Mount on Brick, Concrete for Hanging, 30702	VELCRO Band	VEL-30702-AMS	10/21/2022	1	$19.99	$19.99	Velcro Tape
GripLok	TIDI Grip-Lok Small Securement Device — Pack of 10 — White — Flexible Material — Low-Profile Design for Comfort — Home Healthcare — Medical Supplies (3200S-10PK)	TIDI	3200S-10PK	10/21/2022	1	$30.25	$30.25	GripLok
Hydrocolloid Bandage	Dimora Hydrocolloid Dressing 4" x 4" for Wound Care, 10 Pack Large Patch Bandages with Self-Adhesive for Bedsore, Burn, Blister, Acne Care, Super Absorbent for Fast Healing	Winner	B08F9Y9GBV	11/11/2022	1	$15.00	$15.00	Hydrocolloid Bandage

Kinesiology Tape	SpiderTech Therapeutic XXL Kinesiology Tape Roll (6 inch - 152 mm x 5 m) Reduce Inflammation, Preferred by Athletes, High-Grade Water-Resistant Material, Help Re-Train Muscles (Beige)	Spider Tech Inc.	B08JHCPQMK	11/11/2022	1	$29.99	$29.99	Kinesiology Tape

Conclusions/action items:

The team has completed mechanical testing using the most recent orders of the hydrocolloid bandage and kinesiology tape. Moving forward the team plans to create the final bandage design and fabricate it using the Cricut Maker 3, along with 3D printing the final clip design at the makerspace.

2022/9/28 -Tentative Fabrication Testing Apparatus

LAUREN HELLER - Sep 28, 2022, 11:15 PM CDT

Title: Tentative Fabrication Testing Apparatus

Date: 9/28/22

Content by: Lauren Heller

Present: All team members present

Goals: Construct an apparatus to test drain-site designs.

Content:

Given the nature of our design application, it is unreasonable to test our fabricated design on a patient with a surgical drain in place. Testing on a real site would pose concerns of drain dislodgement, infection, or constriction of the drainage tube during initial testing phases. To avoid this, we plan to fabricate a model similar to that of a patient with a sutured drain.

Materials:

- Practice sterile suture kit for first aid field emergency and medical student training [1]

- Jackson Pratt Flat Silicone Drain without Trocar, 100cc reservoir, 10mm drain, 3/4 perforations [2]

Methods:

- We will obtain a practice suture kit and drainage tube/reservoir kit from their respective distributors. The suture kit we use aims to best mimic the layering of skin, fat, and tissue without the need to use a real patient. The drain kit we are using is the same setup as the drain system our client

had placed in the past.

- Our suture kit and drain system will be brought to a meeting with our client's surgeon, where we will be able to have the drain sutured in using standard surgical practices to avoid any errors in securing the drain. This will help to remove one source of error if the drain becomes dislodged, and we can more confidently assume errors are arising from our design. We would ideally like to have a few drains sutured in, potentially using different suture shapes, to ensure that our design is versatile.

- Once our final design has been selected using the design matrix, we will be able to make design modifications and fabricate our first prototype. The on-site designs will be tested using this fabricated apparatus, and we can apply various stresses to the drain with our prototype in place.

Conclusions/action items:

This plan is only tentative, and will be modified as needed. Additionally, this only applies to the on-site portion of the design, which will ultimately be used in contact with the skin and the drain. Our drain bulb reservoir will be designed to be worn, and can likely be tested on our team members, since the main factors we want to ensure are related to comfort, ease of use, and that it does not restrict daily life/normal movement.

LAUREN HELLER - Sep 28, 2022, 11:18 PM CDT

[1] “Amazon.com: Complete Sterile Suture Practice kit for first aid field ...” [Online]. Available: https://www.amazon.com/Complete-Suture-Practice-Medical-Students/dp/B07TNRHKGW. [Accessed: 29-Sep-2022].

[2] “Jackson-Pratt flat silicone drain without trocar, 100cc, 10mm, 3/4,” *Medical Mega*. [Online]. Available: https://medicalmega.com/product/jackson-pratt-flat-silicone-drain-without-trocar-100cc-10mm-3-4?dfw_tracker=131483-43873&gclid=CjwKCAjw4c-ZBhAEEiwAZ105RbjHZMnBFQ_7ofyXHah5efLtAWXr0ZsC26Bg-NzRxXwg483gyK9XAhoCkQ8QAvD_BwE. [Accessed: 28-Sep-2022].

2022/12/09 - Final Prototype Fabrication

Dana Stumpfoll - Dec 14, 2022, 11:30 AM CST

Title: Final Prototype Fabrication

Date: 12/09/22

Content by: Dana Stumpfoll

Present: All team members present

Goals: Create the final prototype and instructions.

Content:

- The final prototype consists of a hydrocolloid bandage cutout using the Cricut Maker 3 machine at the makerspace.
- The clip design was used for the final prototype as it could hold the most weight to secure the drain in place.
- The clip was made in SolidWorks and was printed at the makerspace using the elastic resin material, to ensure the clip was flexible and yet still rigid enough to secure the 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 on top of the hydrocolloid bandage on the opposite side of the bandage, away from the opening for the drain.
- See the images below for detailed depictions of the assembled final design and the clip that was created in SolidWorks.

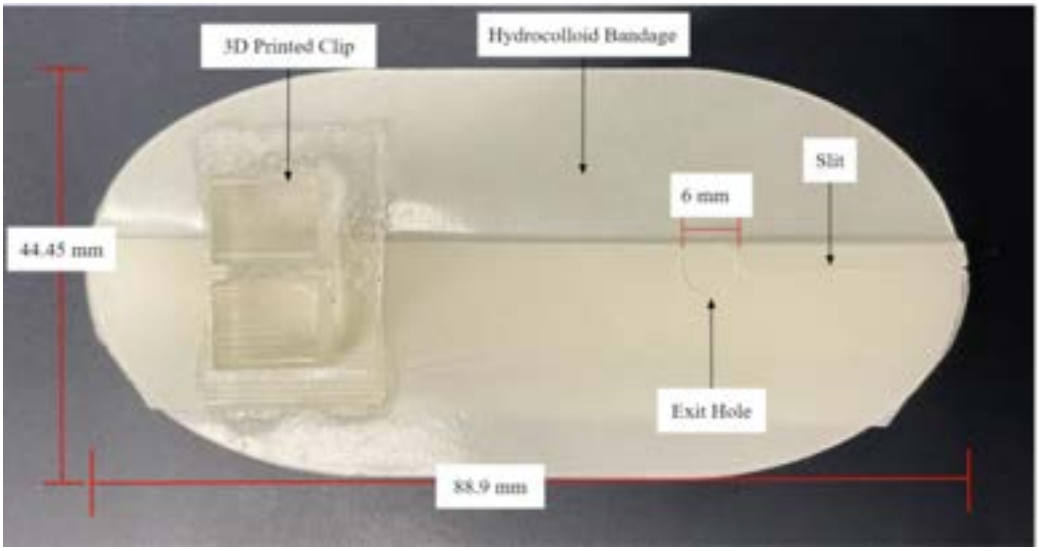


Figure 1: Top view with dimensions and highlighted features.

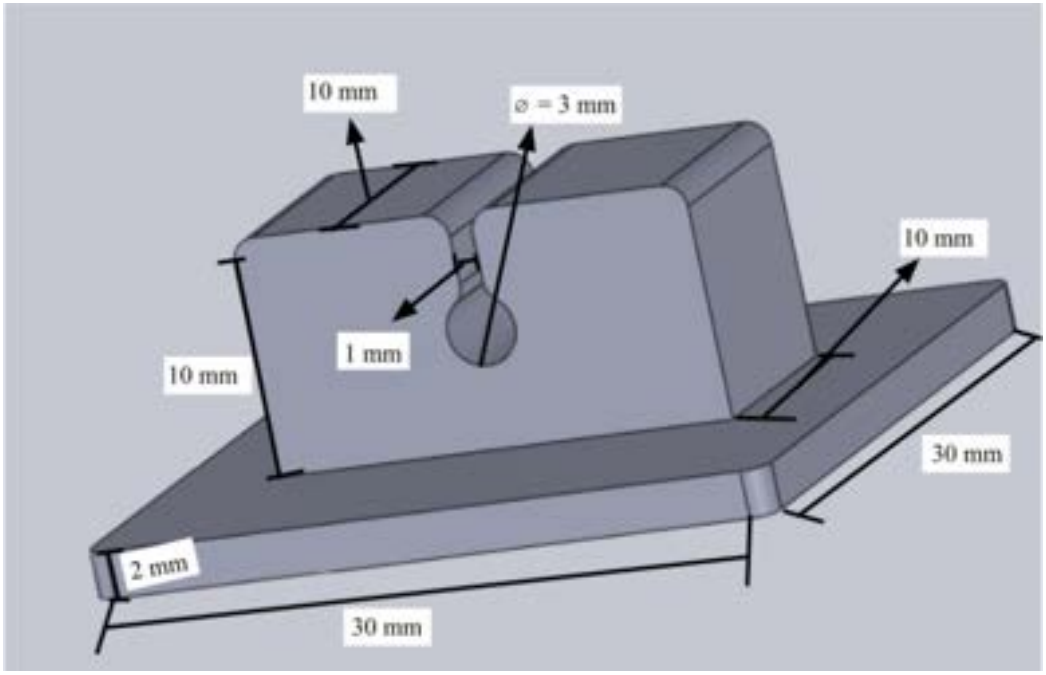


Figure 2: Final clip design with dimensions.

Conclusions/action items:

The final design needs to be modified and tested further for its effectiveness and comfortability. The clip is currently very bulky and may be uncomfortable for the patient. The diameter of the hole for inserting the surgical drain also needs to be modified since it currently compressing the drain tubing and may effect fluid flow through the drain. A double layer adhesive will be explored for better securement of the clip to the hydrocolloid bandage since the current method is super glue and this affects the stiffness of the bandage when it drys.

2022/11/10 - MTS Testing for Tensile Properties and Elastic Modulus

Dana Stumpfoll - Dec 02, 2022, 2:18 PM CST

Title: MTS Testing for Tensile Properties and Elastic Modulus

Date: 11/10/2022

Content by: Oscar Zarneke

Present: Lauren Heller, Dana Stumpfoll, Rebekah Makonnen, Oscar Zarneke

Goals: Develop various testing protocols to aid in materials decision-making.

Content:

Anticipated Findings: Tensile properties and Elastic Modulus

Date to be completed: 11/17/2022 (Subject to Availability)

Team Members testing: Lauren Heller, Rebekah Makonnen, Oscar Zarneke, Abdoulahi Bah, Dana Stumpfoll

Detailed Steps of testing:

1. Set up the MTS machine for tensile testing.
    a. Use __ load/tensile cell.
2. Obtain the bandages for testing (elastic therapeutic tape, hydrocolloid bandage, silicone bandage, elastic therapeutic tape with waterproofing).
3. Load a bandage, note the direction of the bandage (will be loading with the fibers and against the fibers).
4. Perform a tensile test to failure.
5. Record the elastic modulus.
6. Repeat steps 3-5, loading the bandage with fibers in the opposite direction.
7. Repeat steps 3-6 using the next bandage.

Conclusions/action items:

This testing protocol will be submitted with our request to use the MTS machine for testing. Following the anticipated approval, several team members will go to test and collect data. This information will allow us to pick the material that has the most elastic properties, as well as the generation of a stress strain curve. Elastoplastic properties for each material will be observed. We can determine the bond strength from the range of elastic moduli, and compare to literature values.

2022/11/10 - MTS Testing for Poisson's Ratio and Shear Modulus

Dana Stumpfoll - Dec 02, 2022, 2:18 PM CST

Title: MTS Testing for Poisson's Ratio and Shear Modulus

Date: 11/10/2022

Content by: Oscar Zarneke

Present: Lauren Heller, Dana Stumpfoll, Rebekah Makonnen, Oscar Zarneke

Goals: Develop various testing protocols to aid in materials decision-making.

Content:

Anticipated Findings: Poisson’s Ratio and Shear Modulus

Date to be completed: 11/17/2022 (Subject to Availability)

Team Members testing: Lauren Heller, Rebekah Makonnen, Oscar Zarneke, Abdoulahi Bah, Dana Stumpfoll

Detailed Steps of testing:

1. Draw or stamp on a perfect square onto the bandage. Record its dimensions.
2. Stretch the bandage using a uniaxial load. Record the square’s dimensions.
3. Repeat step 2 with the load applied in the perpendicular direction.
4. Calculate Poisson’s ratio ($^{\text{lateral deformation}}/_{\text{longitudinal deformation}}$) in both directions.
5. Assume elastic modulus and Poisson’s ratio is the same in either perpendicular direction.
6. Calculate the shear modulus in three directions ($E=2G(1+v)$).

Conclusions/action items:

This testing protocol will be submitted with our request to use the MTS machine for testing. Following the anticipated approval, several team members will go to test and collect data. This information will allow us to analyze the stretch in multiple directions, and we will be able to determine geometries for the adhesive bandage to maximize benefits from the determined data.

2022/11/10 - FEBio Simulation

LAUREN HELLER - Nov 10, 2022, 5:31 PM CST

Title: FEBio Simulation

Date: 11/10/2022

Content by: Oscar Zarneke

Present: Lauren Heller, Dana Stumpfoll, Rebekah Makonnen, Oscar Zarneke

Goals: Develop various testing protocols to aid in materials decision-making.

Content:

Anticipated Findings: Ideal bandage geometries for the purpose of distributing force away from the drainage site/sutures.

Date to be completed: 11/28/2022

Team Members testing: Oscar Zarneke

Detailed Steps of testing:

1. Create different geometries of the bandage in SolidWorks. Export as .STEP files.
2. Open the model in FEBio.
3. Set the material (orthotropic elastic) and its properties (density, elastic modulus in three directions, shear modulus in three directions, and Poisson's ratio in three directions).
4. Set the boundary condition to be on the adhesive surface, constrained in all directions.
5. Set the load at the clip location as a pressure surface load. Set the scale (as a stress).
6. Optimize the mesh to find the one that has the best performance with the fewest elements.
7. Analyze the stress distribution using the optimized mesh.
8. Repeat steps 2-7 using each geometry.
9. Compare the distributions and the maximum stresses in each geometry. Choose the geometry that minimizes the maximum stress.

Conclusions/action items:

This analysis will be done after the two types of MTS testing are done. The MTS findings will allow us to put the properties of each material into FEBio and gather information about which geometries optimize the distribution of forces the best. This is ideal, as it will help to alleviate the tugging sensation that is felt at the drain/skin interface, which can lead to discomfort or unintentional drain dislodgement.

2022/12/02 - Force Testing Protocol

Dana Stumpfoll - Dec 02, 2022, 2:22 PM CST

Title: Force Testing to determine the best securement mechanism for the surgical tubing.

Date: 12/2/2022

Content by: Dana Stumpfoll

Present: Dana Stumpfoll, Rebekah Makonnen, Oscar Zarneke, Abdoulahi Bah

Goals: Develop various testing protocols to aid in securement mechanism decision making.

Content:

Testing Plans

Team Name: Drain Pain

Team Members: Dana Stumpfoll, Lauren Heller, Rebekah Makonnen, Oscar Zarneke, Abdoulahi Bah

Project Name: Improved Method for Securing Surgical Drains

Testing Details

Anticipated Findings: Whether the clip or the Griplok design works better to secure the surgical drain tube.

Team Members testing: Lauren Heller, Rebekah Makonnen, Oscar Zarneke, Abdoulahi Bah, Dana Stumpfoll

Detailed Steps of testing:

1. Gather eight hydrocolloid bandages, four with griplok and four with the clip attached to them.
2. Gather uniform weights.
3. Adhere the bandage to a clean vertical surface with the hole with the slit facing up.
4. Secure the surgical drain tube to the bandage using either the griplok or the clip.
5. Draw a line on the surgical drain tube relative to the top edge of the mechanism holding it in place.
6. Attach the weight to the surgical drain tubing using tape.
7. Release the weight and allow it to hang freely.
8. Record the weight and displacement of the surgical drain.
    a. Measure the displacement from the line on the tubing to the top edge of the mechanism holding the drain in place.
9. Repeat steps 3-8 using an increased amount of weight until failure (bandage falls, tube falls out of attachment device, or something tears/breaks) and record the results.
10. Repeat steps 3-9 using another bandage.

Conclusions/action items:

This testing protocol will be used to determine whether the clip mechanism or the Griplok mechanism will be better for securing the surgical drain in place. Edit the protocol as needed.

Dana Stumpfoll - Dec 12, 2022, 11:57 AM CST

Title: Updated force testing protocol based on how we used uniform weights.

Date: 12/12/2022

Content by: Dana Stumpfoll

Present: Dana Stumpfoll

Goals: Update force testing protocol.

Content:

1. **Force Testing Protocol**

Detailed Steps of testing:

1. Gather eight hydrocolloid bandages, four with Grip - Lok and four with the clip attached to them.
2. Gather uniform weights.
3. Adhere the bandage to a clean vertical surface with the hole with the slit facing up.
4. Secure the surgical drain tube to the bandage using either the Grip - Lok or the clip.
5. Draw a line on the surgical drain tube relative to the top edge of the mechanism holding it in place.
6. Attach the weight to the surgical drain tubing using tape.
    a. If no weights are available, fill the surgical bulb with 10 ml of water at a time by pipetting it into the opening of the bulb.
    b. If additional weights are needed 50 ml centrifuge tubes can be taped onto the bulb and 10 ml can be added at a time.
7. Release the weight and allow it to hang freely.
8. Record the weight and displacement of the surgical drain.
    a. Measure the displacement from the line on the tubing to the top edge of the mechanism holding the drain in place.
9. Repeat steps 3-8 using an increased amount of weight until failure (bandage falls, tube falls out of attachment device, or something tears/breaks) and record the weight of failure.
    a. Determine the weight added by using the density conversion of water.
        i. 1 g/ ml x 10 ml = 10 g for every 10 ml added.
10. Repeat steps 3-9 using another bandage.

Conclusions: Add the updated protocol into the final report.

2022/11/18 - Preliminary Testing Results

ABDOULAHI BAH (anbah@wisc.edu) - Nov 20, 2022, 10:39 PM CST

Title: Preliminary Testing Results

Date: 11/18/2022

Content by: Abdoulahi

Present: All Team

Goals: Conduct Preliminary Testing to obtain necessary properties for analysis using MATLAB and FEBio

Content:

Perpendicular KT Tape:

Figure 1: Perpendicular KT Tape Trial 1

Figure 2: Perpendicular KT Tape Trial 2

Figure 3: Perpendicular KT Tape Trial 3

Hydrocolloid:

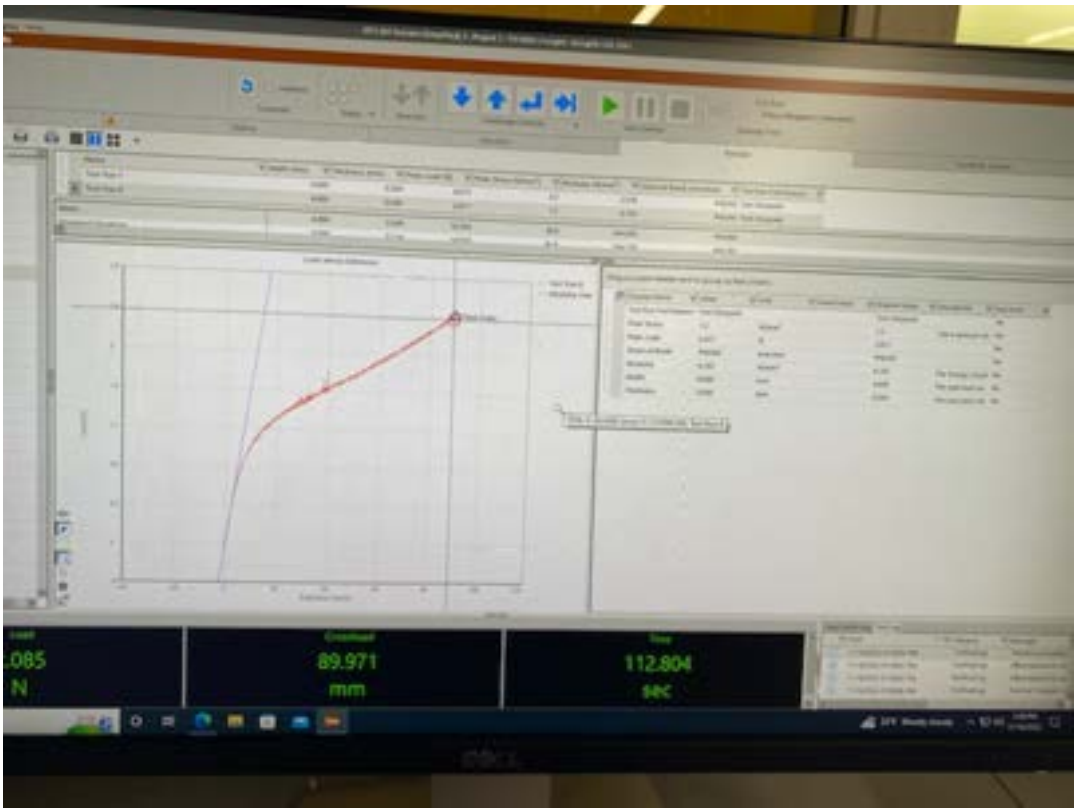


Figure 4: Hydrocolloid Trial 1

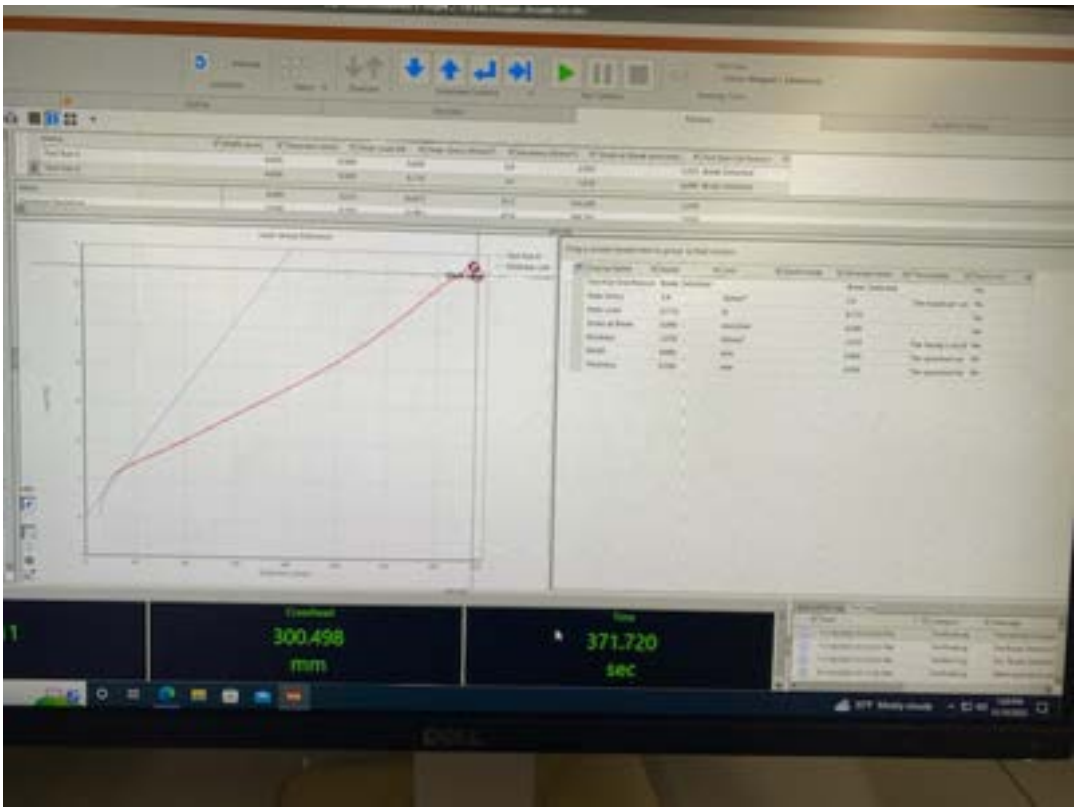


Figure 5: Hydrocolloid Trial 2

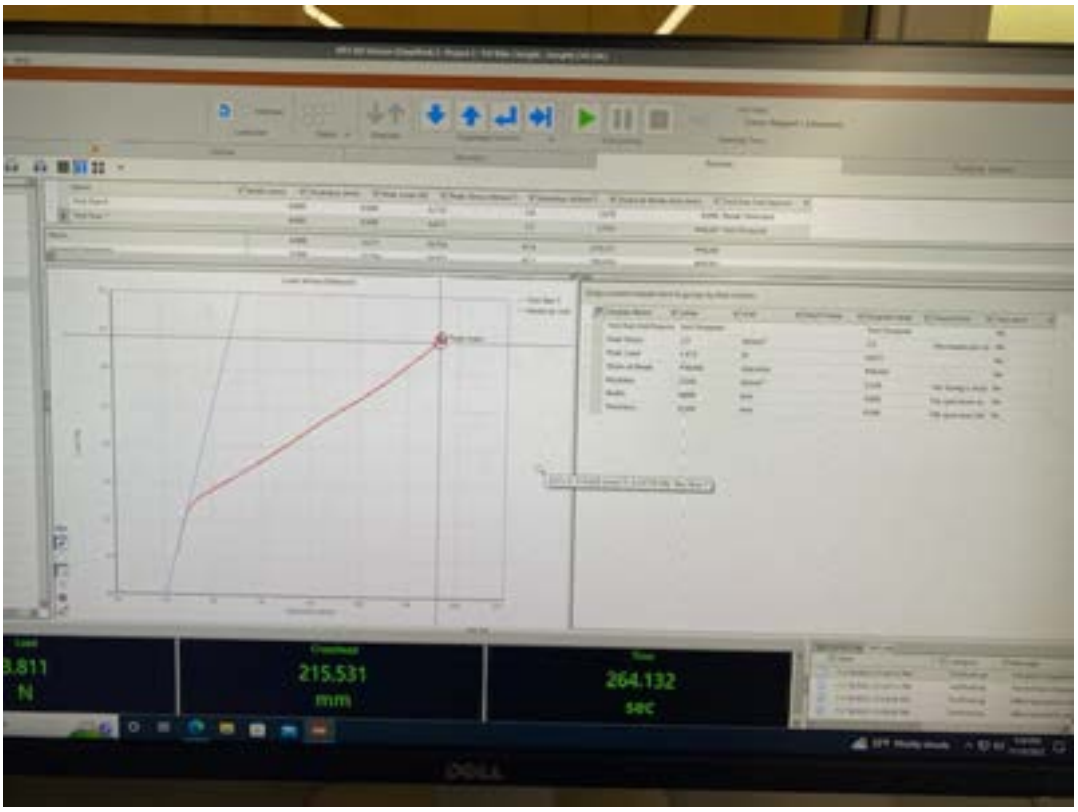


Figure 6: Hydrocolloid Trial 3

Parallel KT Tape:

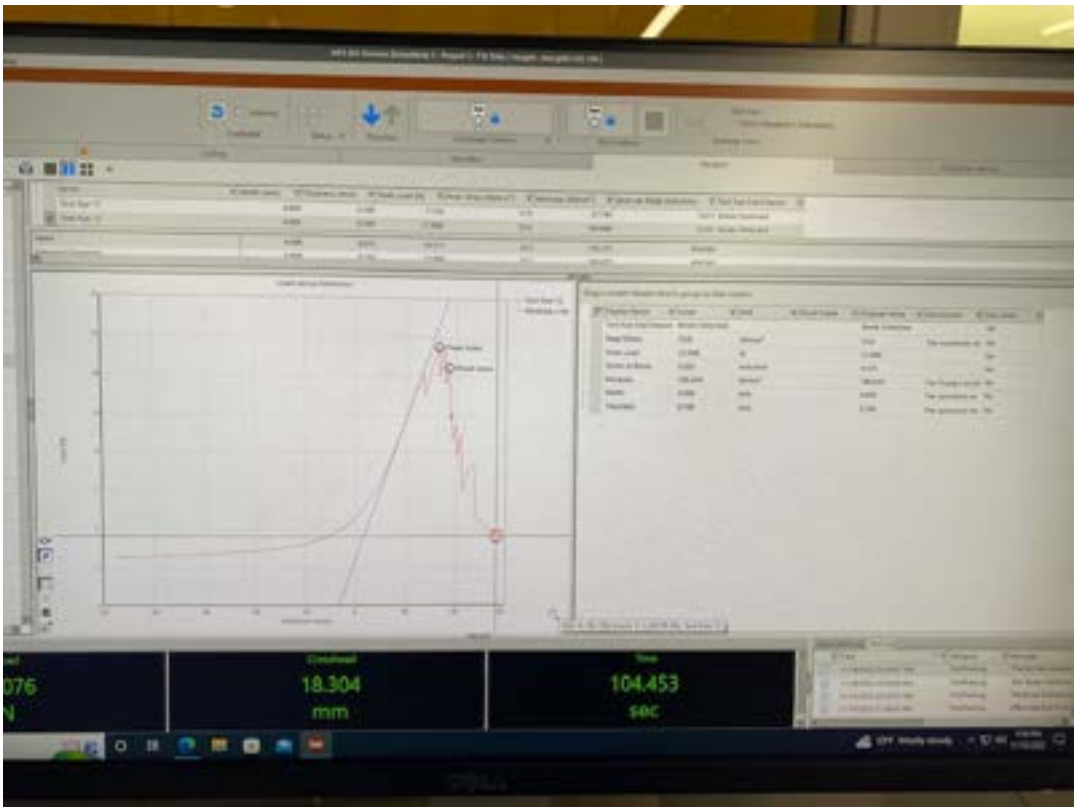


Figure 7: Parallel KT Tape Trial 1

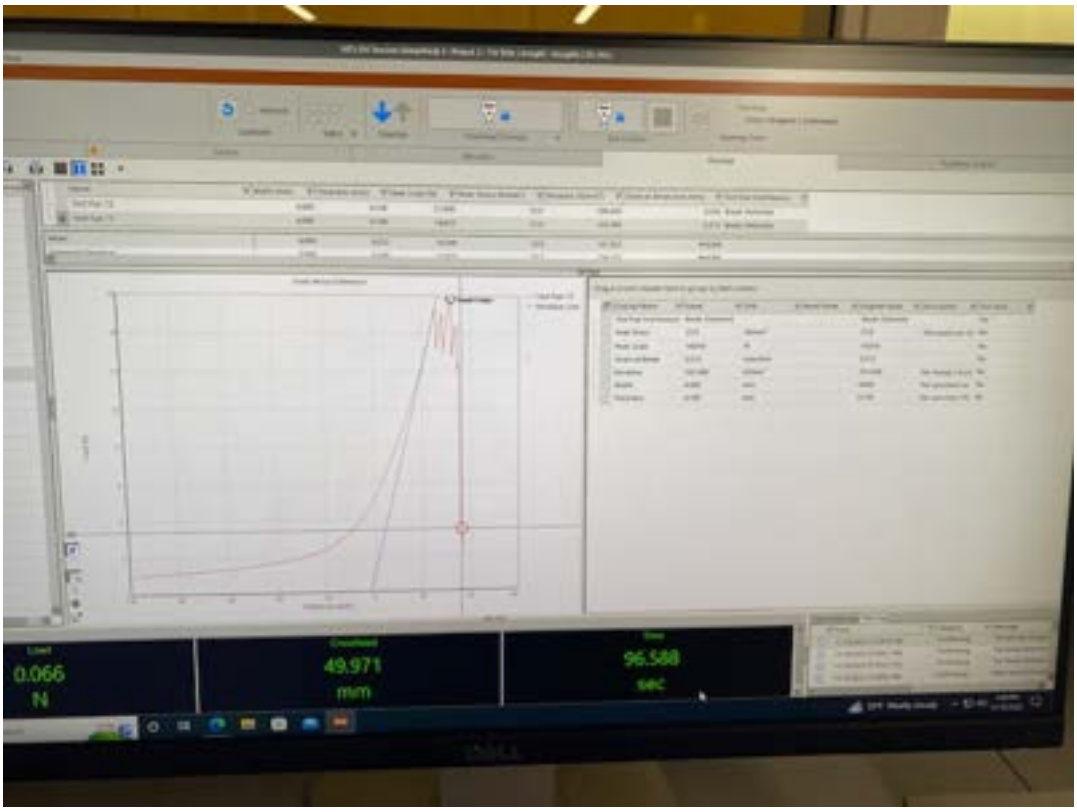


Figure 8: Parallel KT Tape Trial 2

Figure 9: Parallel KT Tape Trial 3

Perpendicular Waterproof KT Tape:

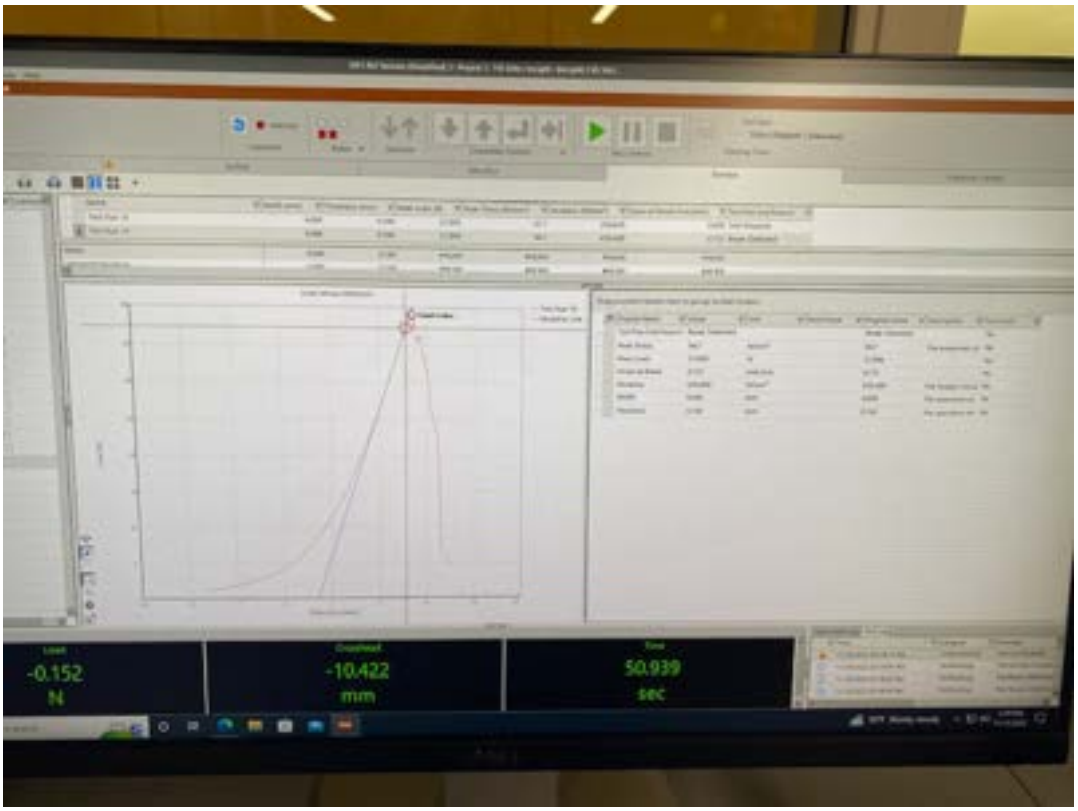


Figure 10: Perpendicular Waterproof KT Tape Trial 1

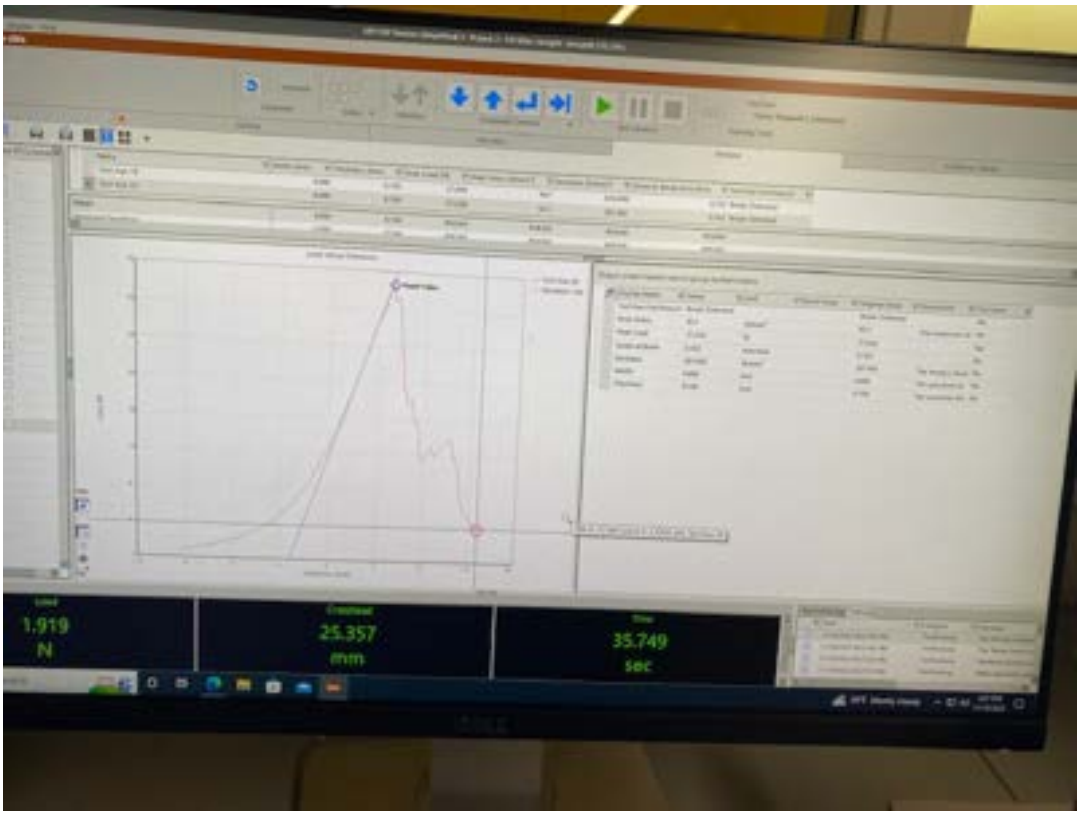


Figure 11: Perpendicular Waterproof KT Tape Trial 2

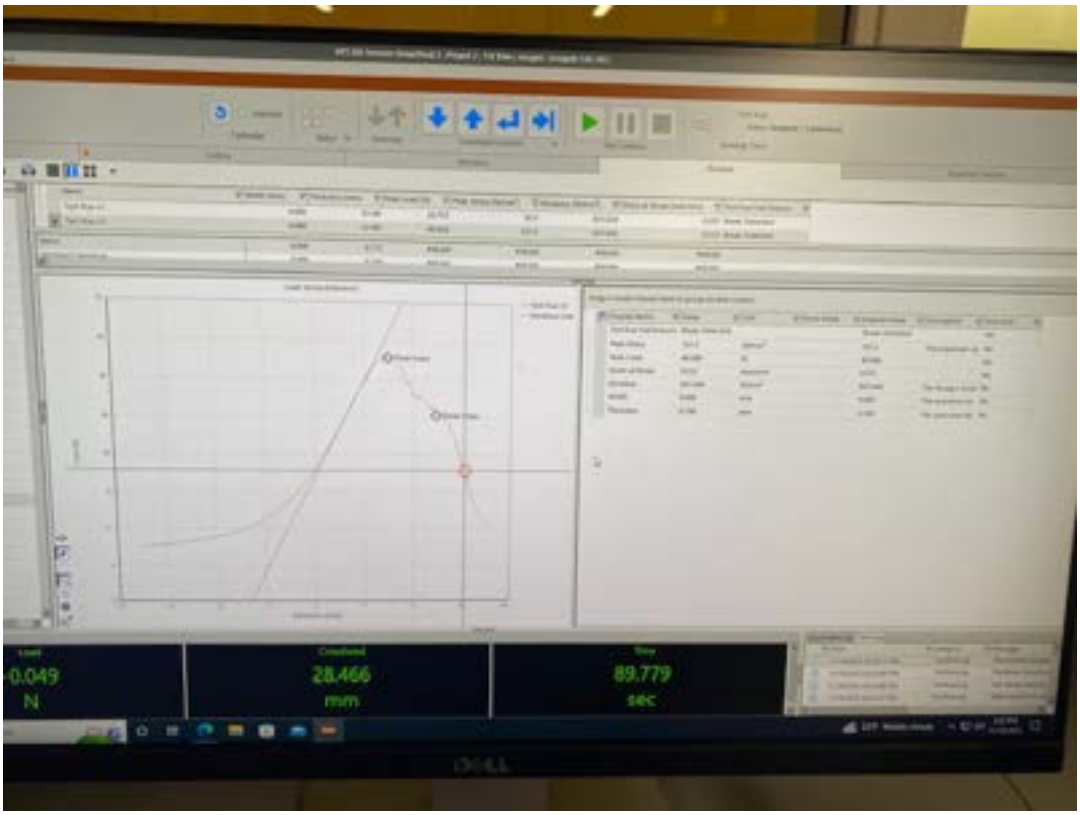


Figure 12: Perpendicular Waterproof KT Tape Trial 3

Parallel Waterproof KT Tape:

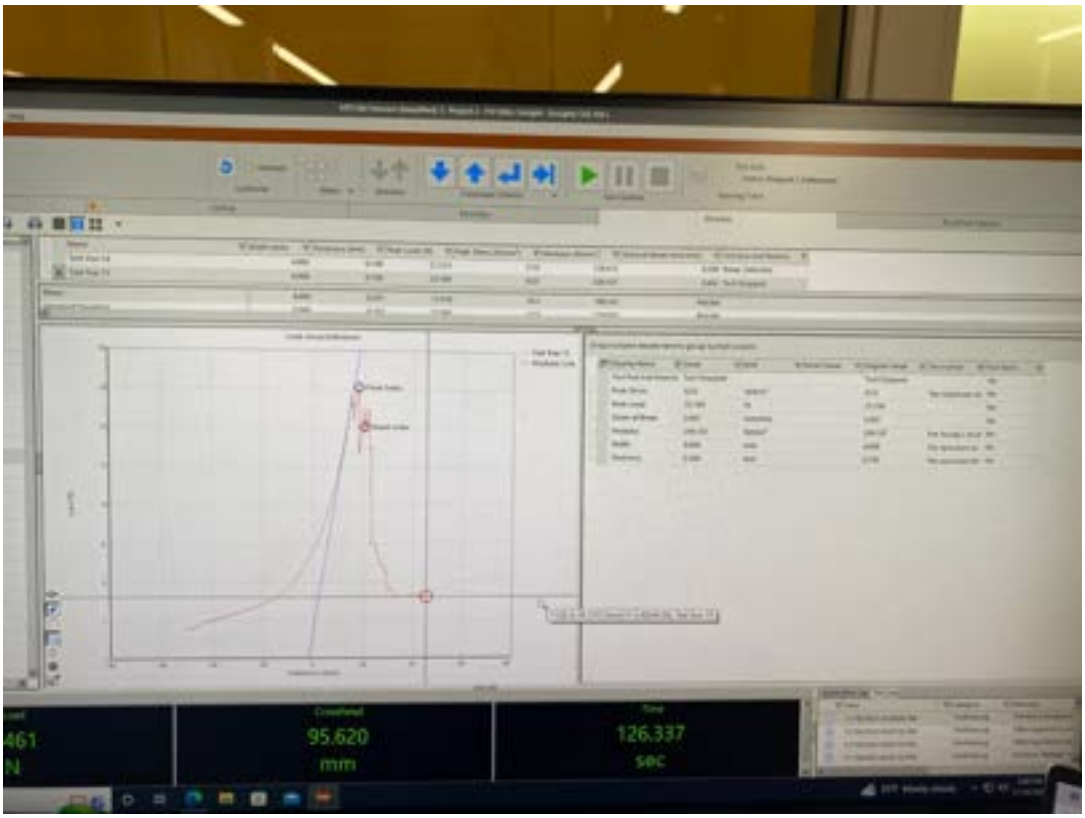


Figure 13: Parallel Waterproof KT Tape Trial 1

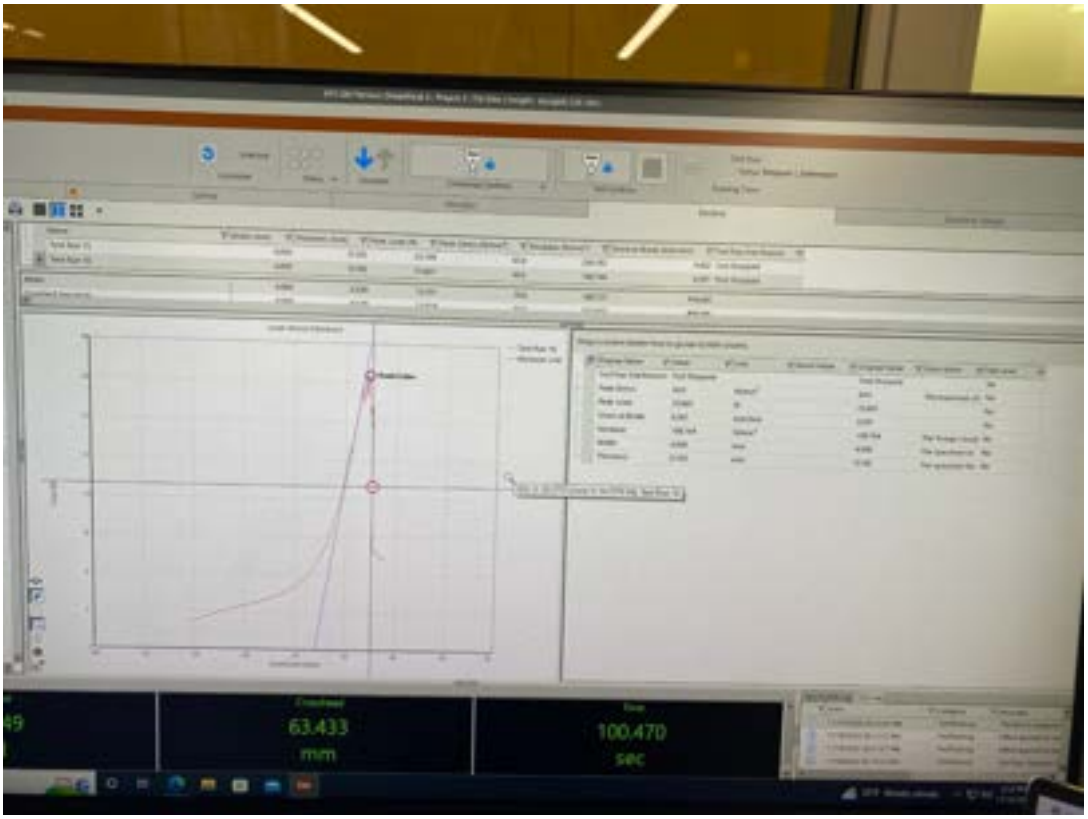


Figure 14: Parallel Waterproof KT Tape Trial 2

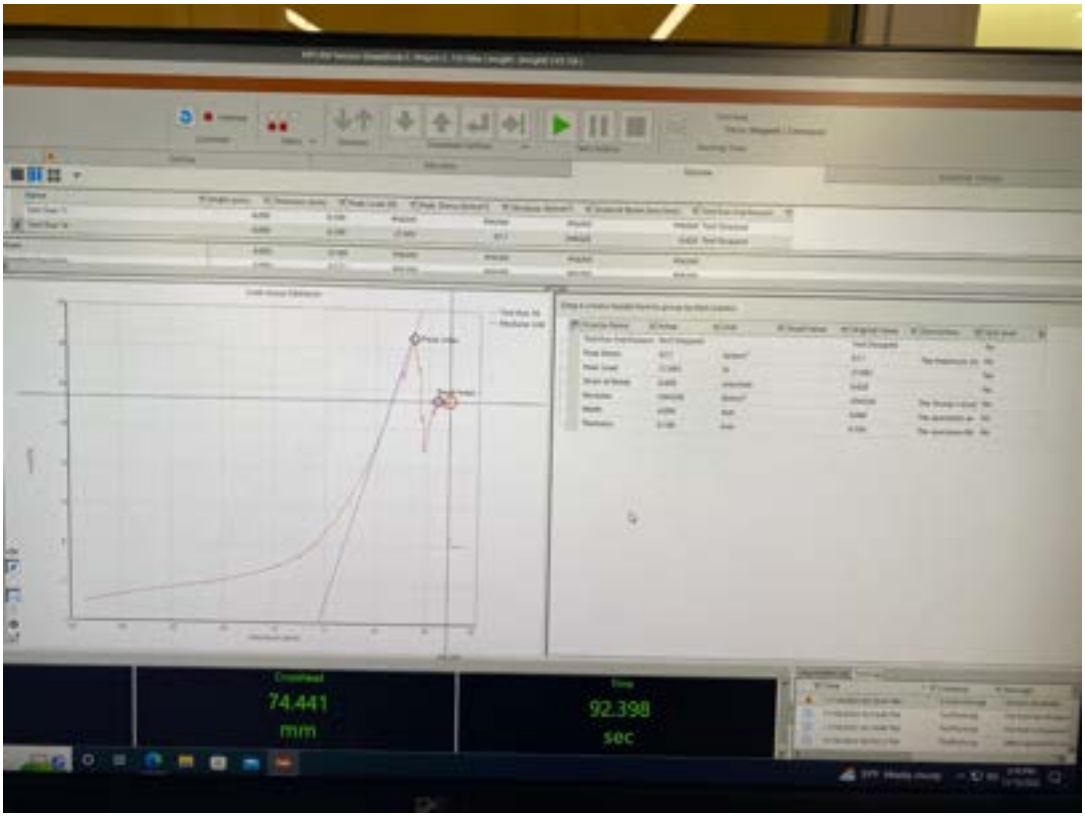


Figure 15: Parallel Waterproof KT Tape Trial 3

Silicone:

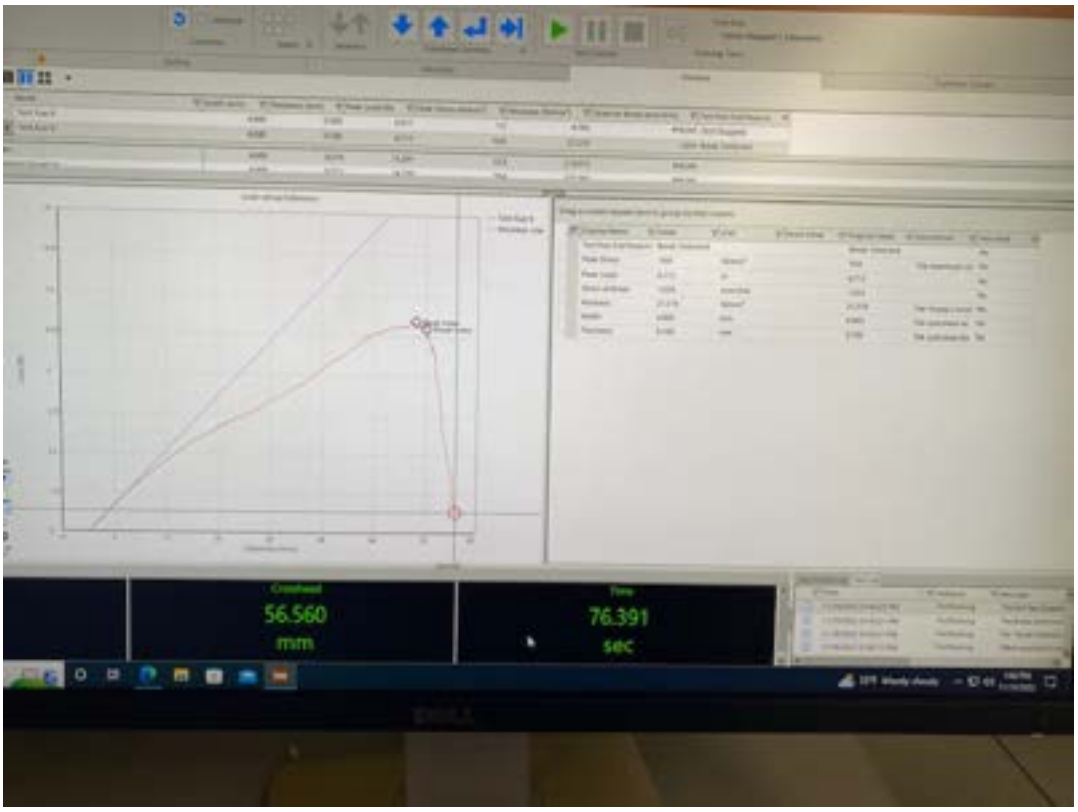


Figure 16: Silicone Trial 1

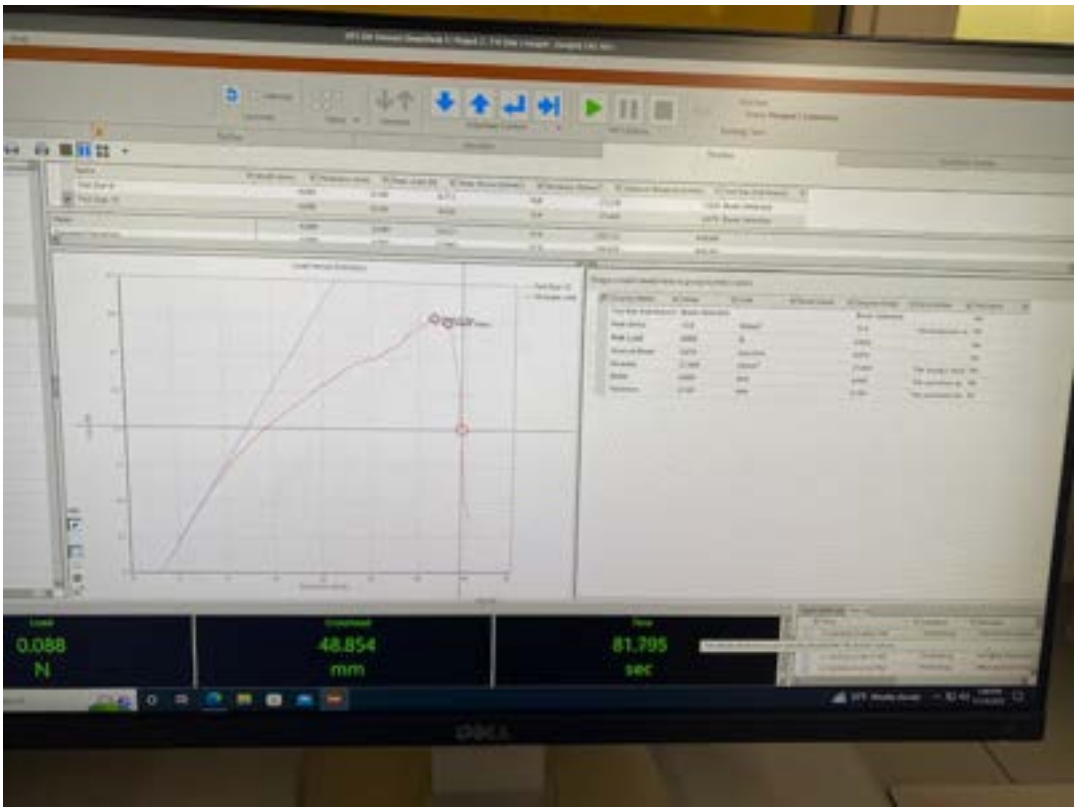


Figure 17: Silicone Trial 2

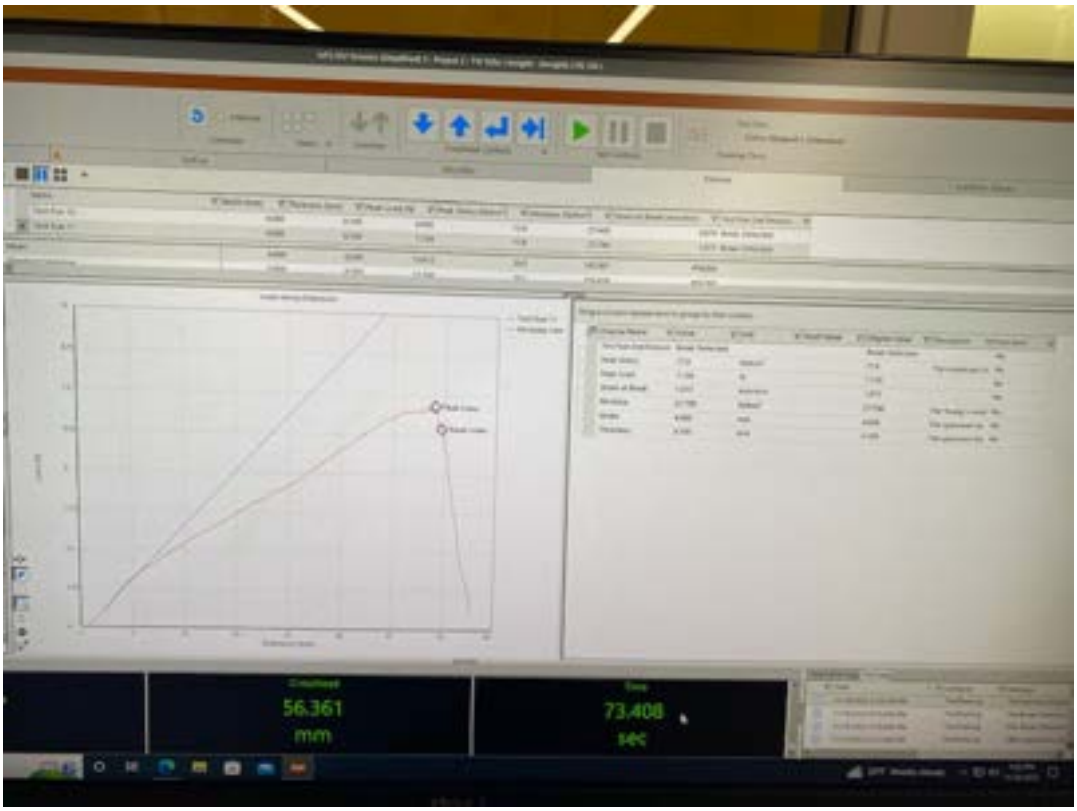


Figure 18: Silicone Trial 3

Conclusions/action items: These were the results from the preliminary test. However, the elastic modulus was not being calculated correctly so it had to be calculated using MATLAB instead and because the data did not save to calculate it manually we had to conduct the preliminary test again.

2022/11/20 - Preliminary Testing Again

ABDOULAHI BAH (anbah@wisc.edu) - Nov 20, 2022, 11:08 PM CST

Title: Preliminary Testing Results

Date: 11/20/2022

Content by: Abdoulahi

Present: All Team

Goals: Conduct Preliminary Testing to obtain necessary properties for analysis using MATLAB and FEBio

Content:

Perpendicular KT Tape:

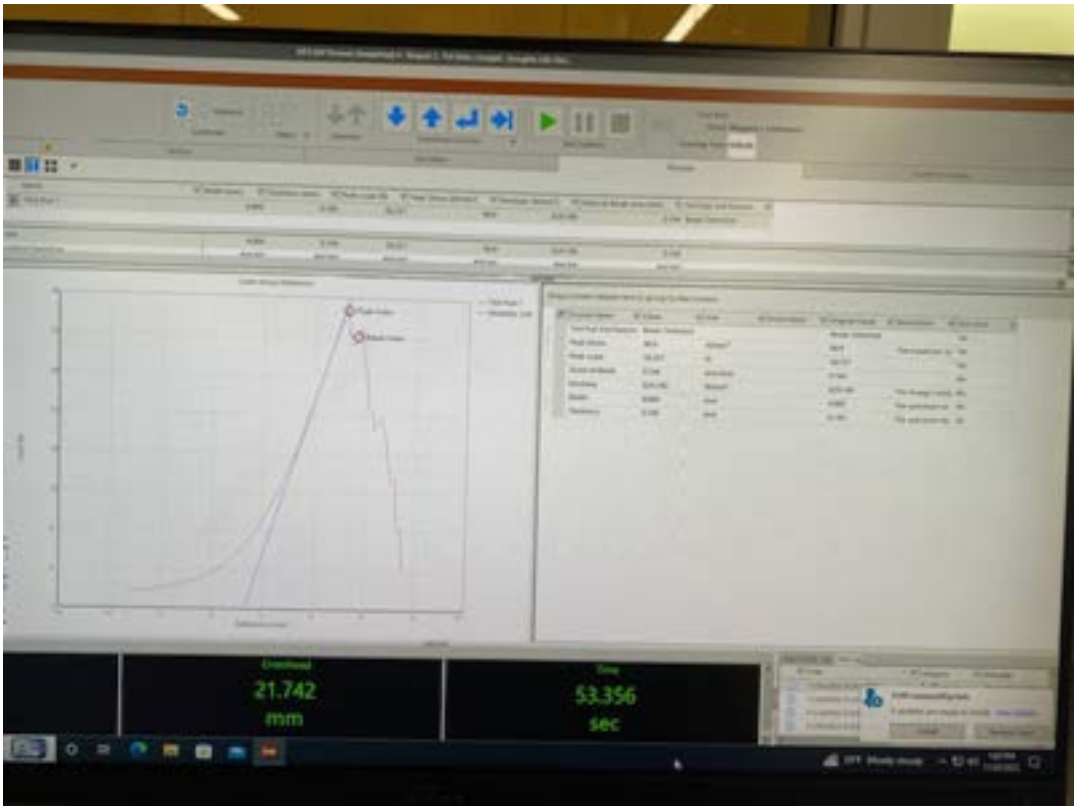


Figure 1: Perpendicular KT Tape Trial 1

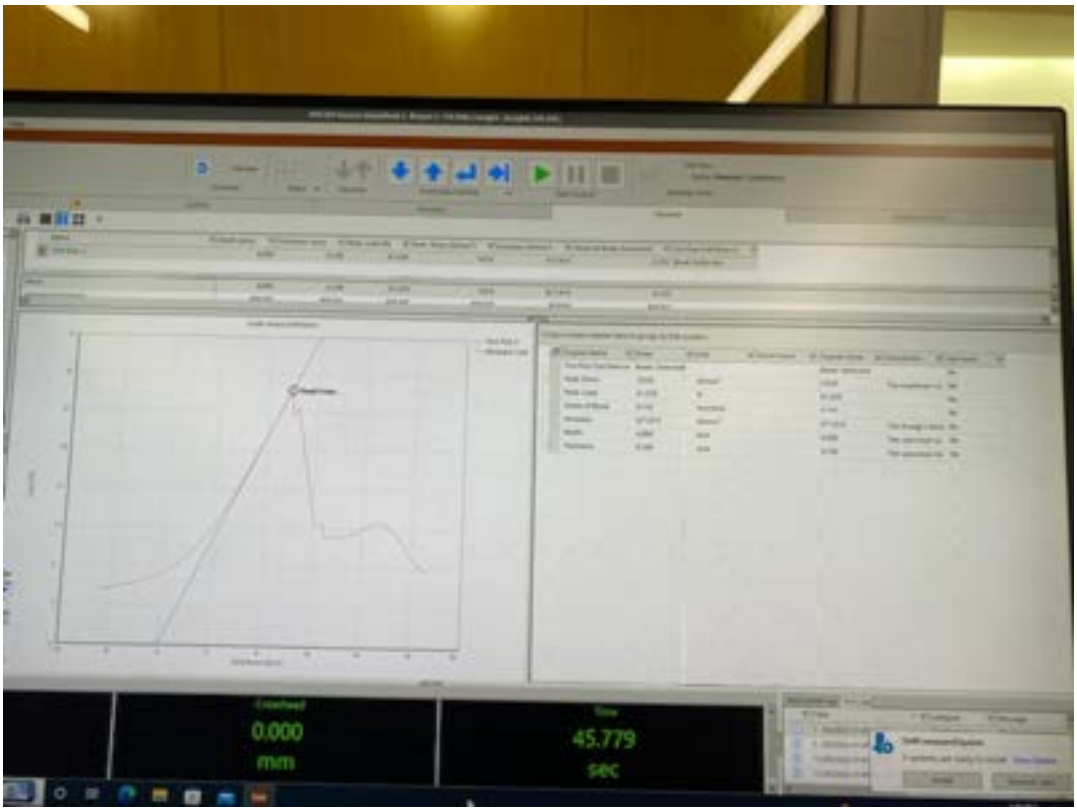


Figure 2: Perpendicular KT Tape Trial 2

Figure 3: Perpendicular KT Tape Trial 3

Parallel KT Tape:

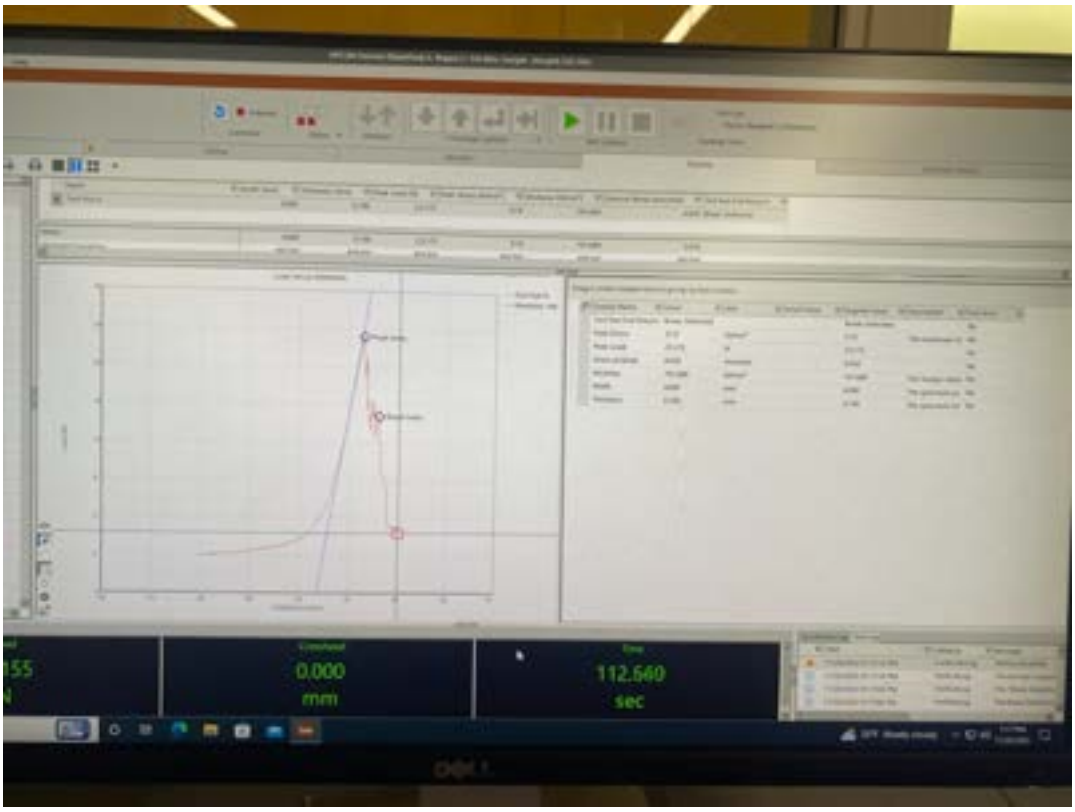


Figure 4: Parallel KT Tape Trial 1

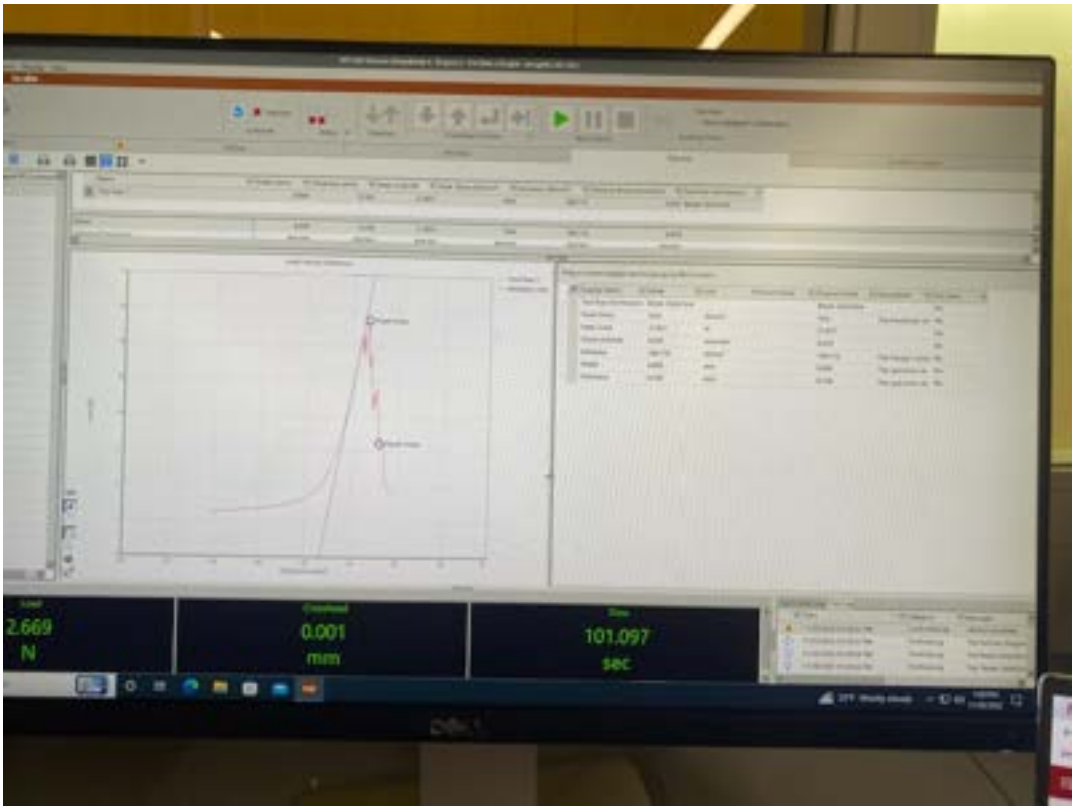


Figure 5: Parallel KT Tape Trial 2

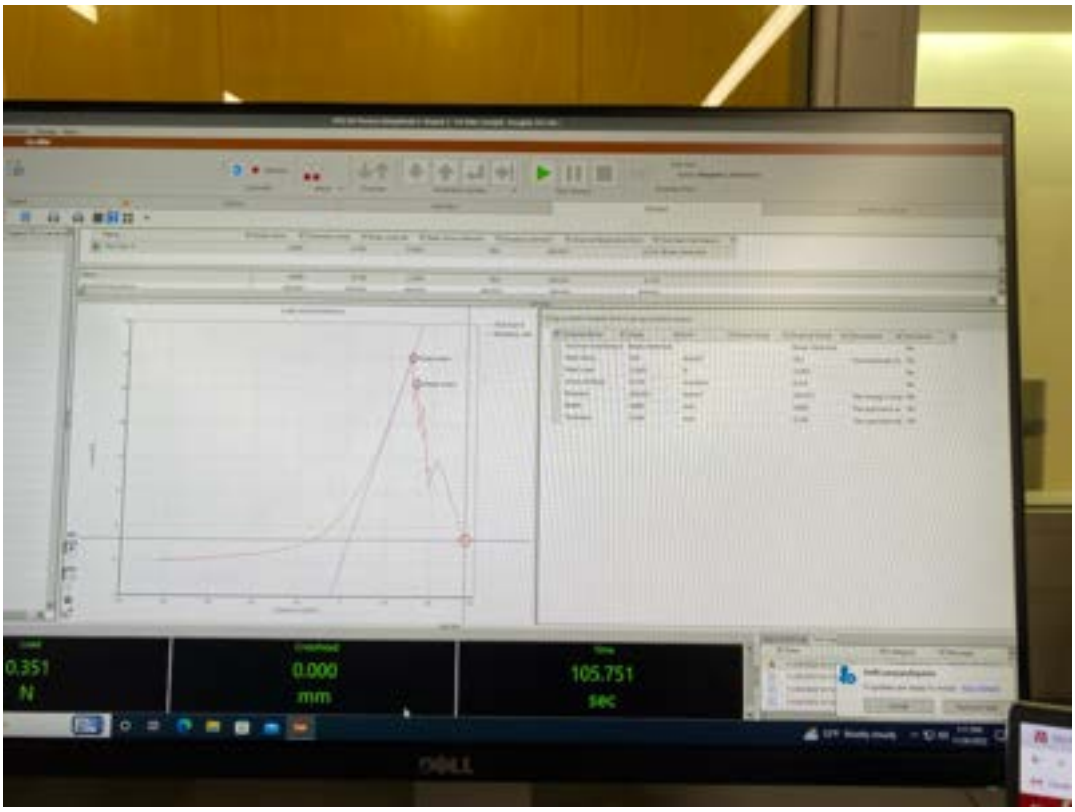


Figure 6: Parallel KT Tape Trial 3

Hydrocolloid:

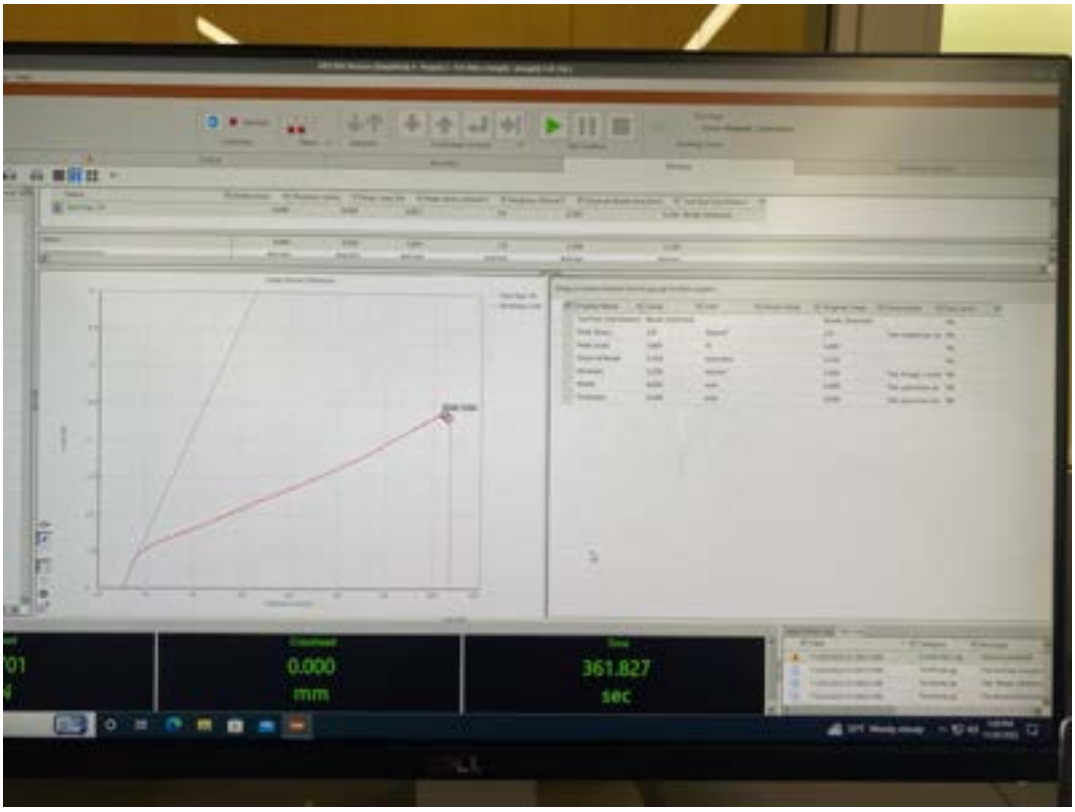


Figure 7: Hydrocolloid Trial 1

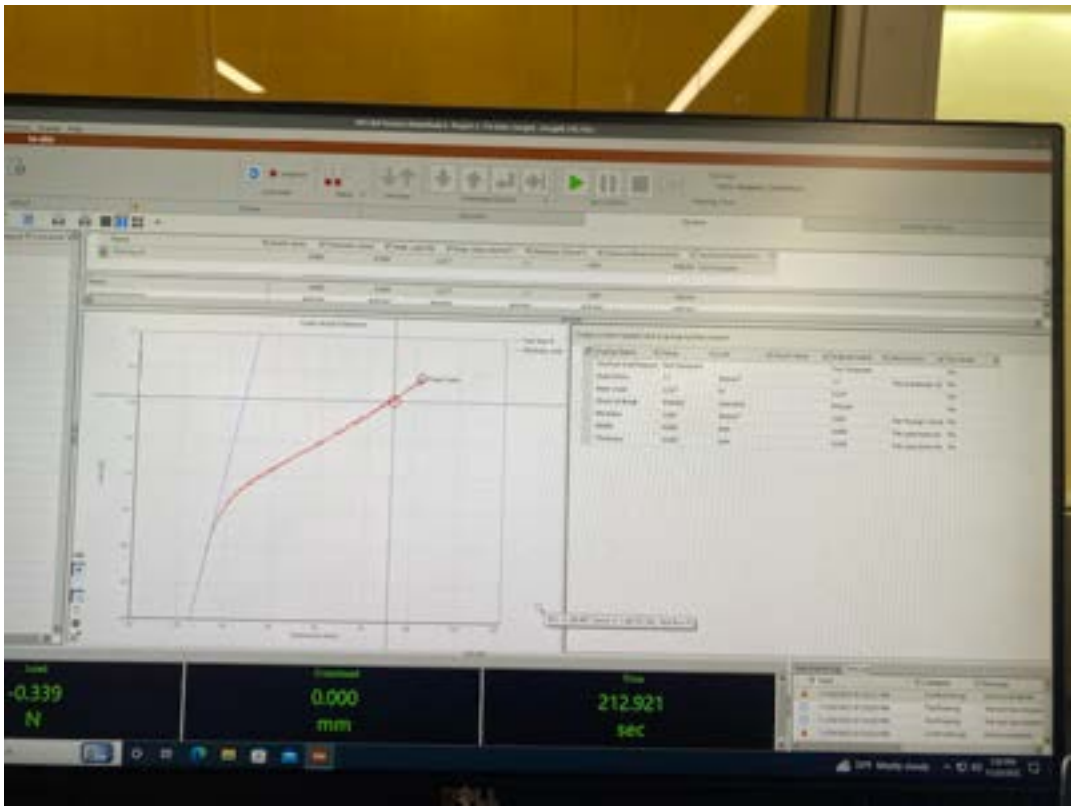


Figure 8: Hydrocolloid Trial 2

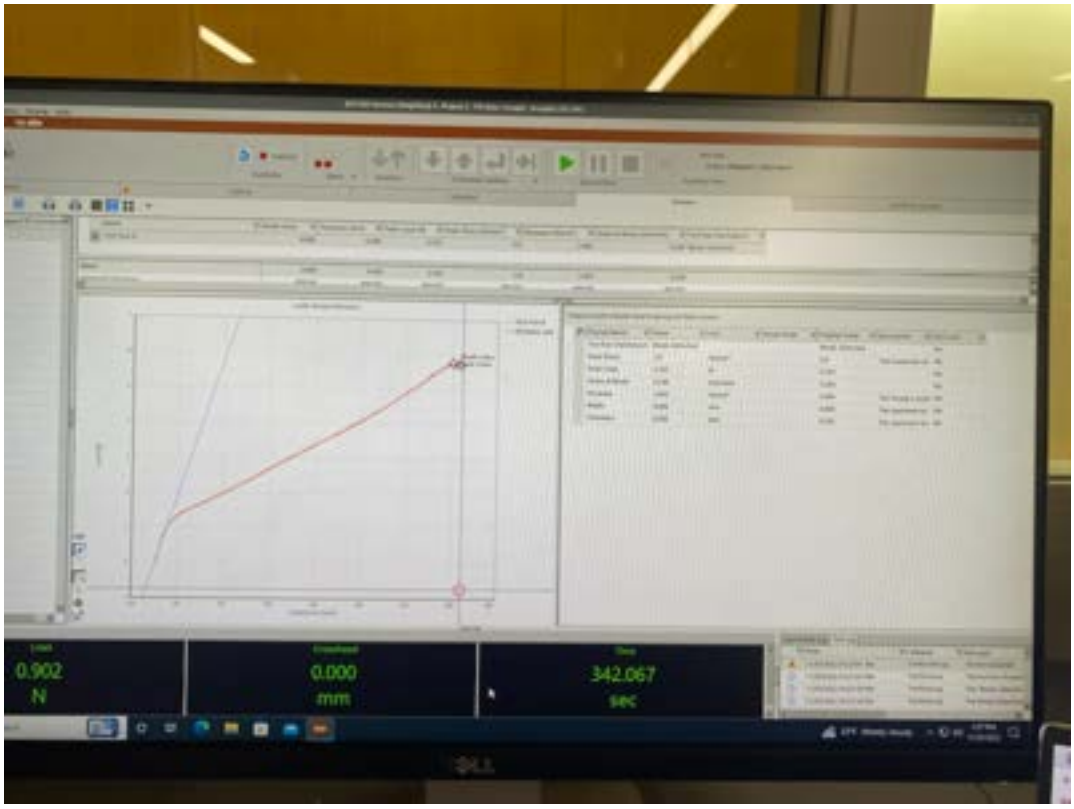


Figure 9: Hydrocolloid Trial 3

Perpendicular Waterproof KT Tape:

Figure 10: Perpendicular Waterproof KT Tape Trial 1

Figure 11: Perpendicular Waterproof KT Tape Trial 2

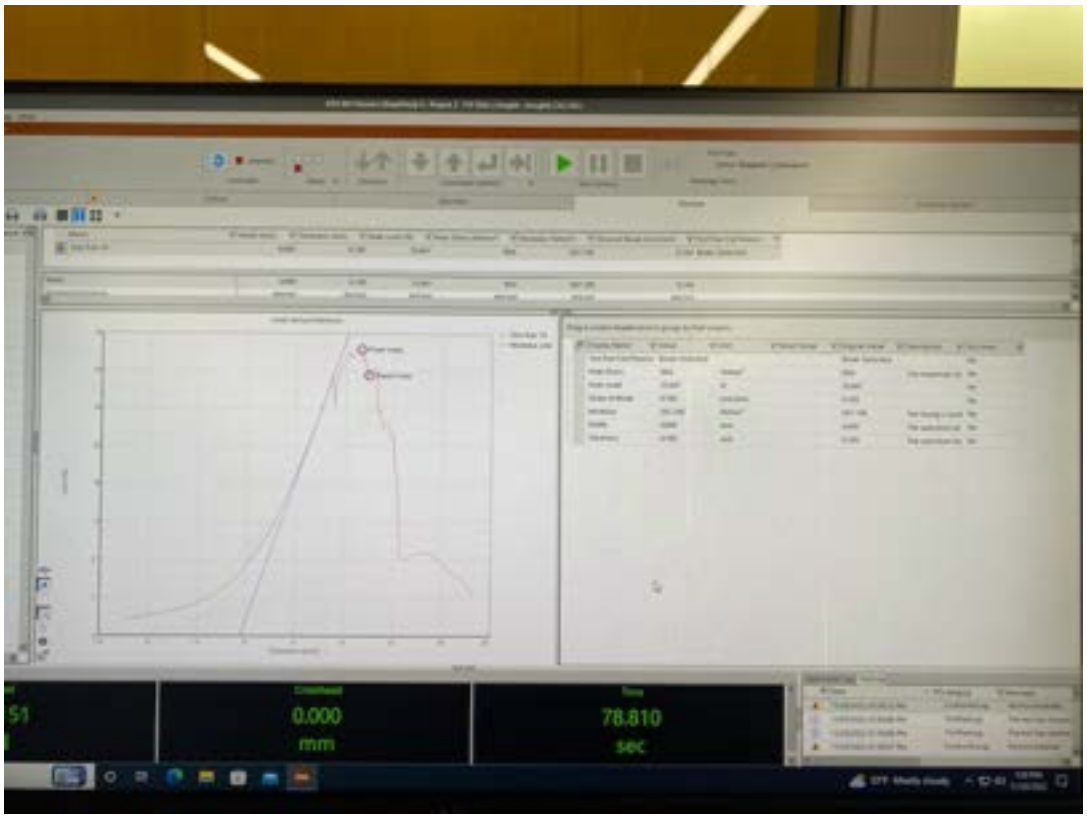


Figure 12: Perpendicular Waterproof KT Tape Trial 3

Parallel Waterproof KT Tape:

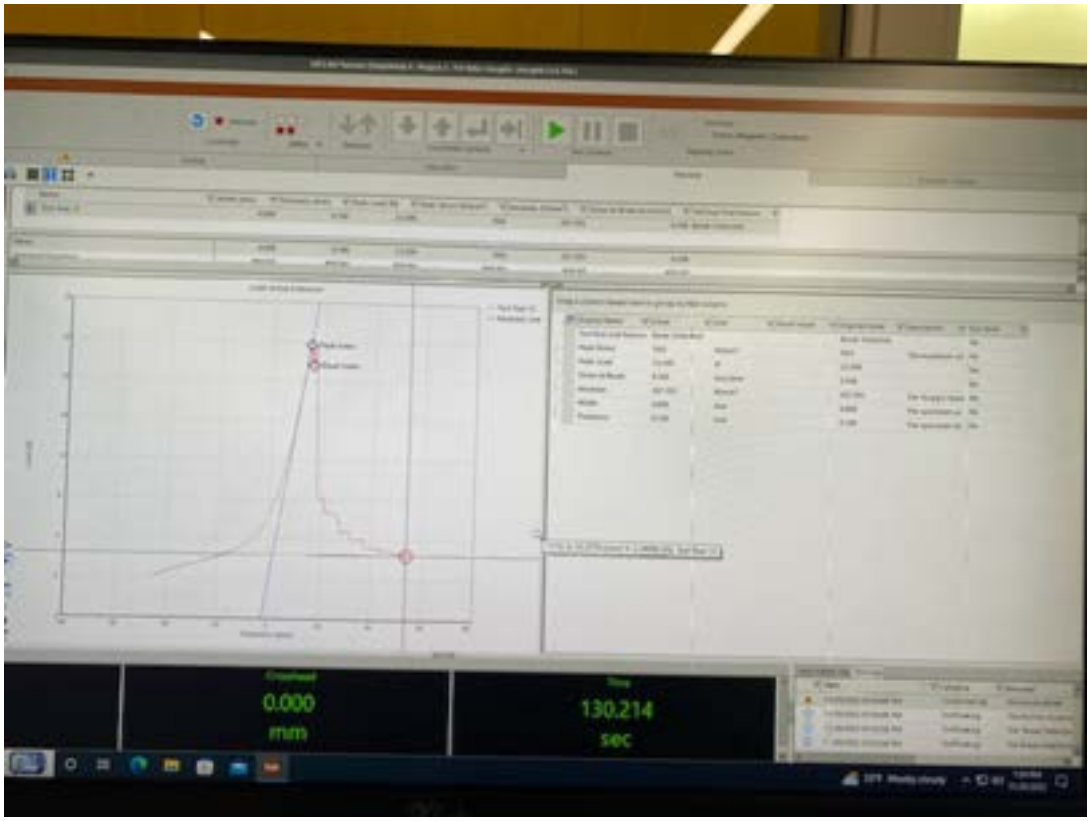


Figure 13: Parallel Waterproof KT Tape Trial 1

Figure 14: Parallel Waterproof KT Tape Trial 2

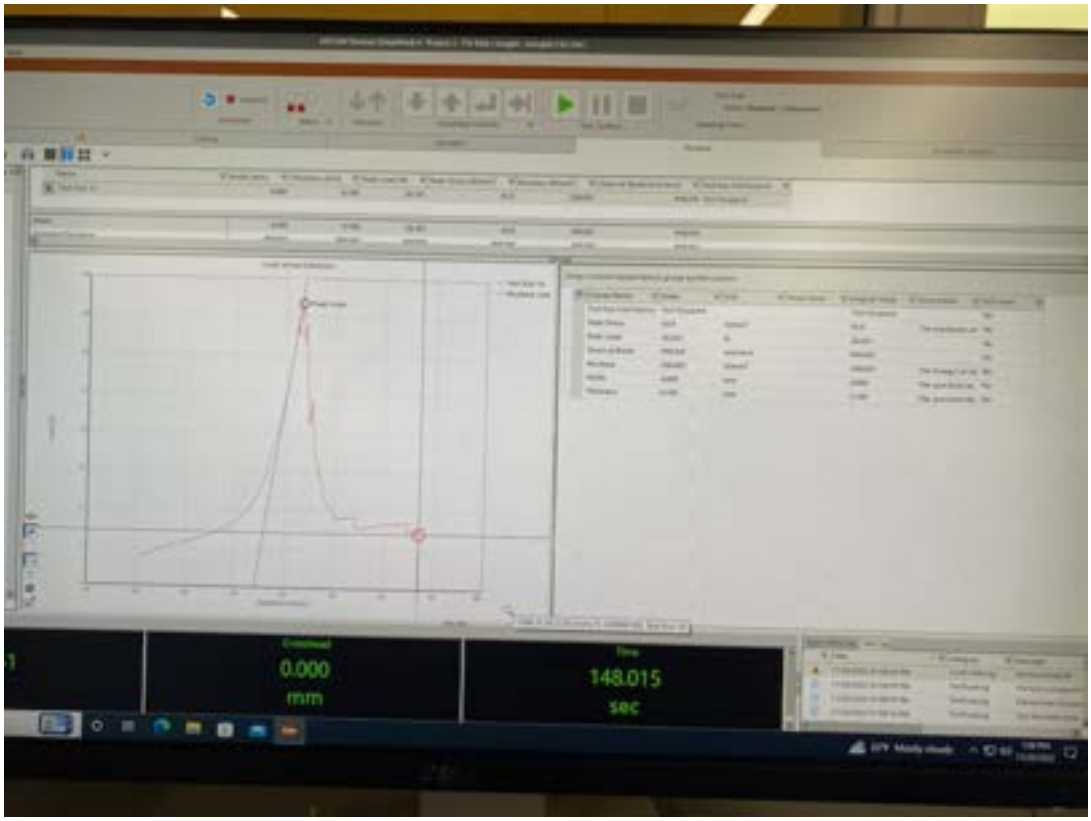


Figure 15: Parallel Waterproof KT Tape Trial 3

Conclusions/action items: The team met again to conduct preliminary testing again. We were not able to re test silicone because we did not have anymore. Otherwise, from the data we do have Oscar has already calculated the elastic modulus of bandage samples and will continue analyzing the data using MATLAB and eventually FEBio.

2022/11/21 - Mechanical Properties of Adhesive Bandages

Oscar Zarneke - Nov 21, 2022, 12:11 PM CST

Title: Mechanical Properties of Adhesive Bandages

Date: 11/21/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To record the results of mechanical testing

Content:

The results of mechanical testing are included in the table below. We were not able to complete the silicone bandage testing because we did not have enough bandages. The published MATLAB script that analyzed the MTS data is included below.

Bandage	Area (m^2)	Thickness (m)	Volume (m^3)	Mass (kg)	Density (kg/m^3)	Poisson's Ratio	Cross-Sectional Area (m^2)	Initial Length (m)	Elastic Modulus (Pa)	Yield Strength (Pa)	Shear Modulus (Pa)
Hydrocolloid	0.01	0.0005	0.000005	0.0072538	1450.76	0.3333333333	0.000035	0.033	169130	21290	63423.75
Silicone	0.004284	0.0001	0.0000004284	0.0018286	4268.44071	0.375	0.000007	0.033			
Elastic Therapeutic Tape - parallel to fibers	0.003731	0.0001	0.0000003731	0.0010233	2742.696328	0.0555555556	0.000007	0.033	110890	78339	52526.84211
Elastic Therapeutic Tape - perpendicular to fibers	0.003731	0.0001	0.0000003731	0.0010233	2742.696328	0.3333333333	0.000007	0.033	1071800	234140	401925
Waterproof Elastic Therapeutic Tape - parallel to fibers	0.003731	0.0001	0.0000003731	0.0012411	3326.454034	0.2857142857	0.000007	0.033	572100	132170	222483.3333
Waterproof Elastic Therapeutic Tape - perpendicular to fibers	0.003731	0.0001	0.0000003731	0.0012411	3326.454034	0.5	0.000007	0.033	1484700	349040	494900

Conclusions/action items:

Begin running simulations to identify the best geometry for our design.

Oscar Zarneke - Nov 21, 2022, 12:11 PM CST

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Hydrocolloid

Download

MTSAnalysis.pdf (327 kB)

2022/12/05 - Force testing

Dana Stumpfoll - Dec 07, 2022, 10:53 PM CST

Title: Force testing on griplok hydrocolloid

Date: 12/5/2022

Content by: Dana Stumpfoll

Present: Dana, Oscar, Beki, Abdoulahi, Lauren

Goals: Test griplok final prototypes.

Content:

- Our second print of our clips did not work out as the diameter of the hole for the clips was too big.
- Dana will reprint the clips tomorrow (12/6) with a 3 mm diameter.
- We still conducted force testing on the hydrcolloid bandages attached to the griplok.
- We attached the bandages to white board since this surface is uniform and will not affect the adhesion of the bandages.
- We first tested the griplok by just freely releasing the tube but ensuring not to drop it where it would add extra force to the griplok adhesive.
- We then added water into the surgical drain tube bulb, 10 mL at a time, or 10 grams at a time.
- Once the bulb was full, we dropped the full bulb to see if it would completely displace the tubing and it did.
- On our final trial we continued to add water until the the surgical drain was completely displaced by taping 50 mL conicals to the surgical drain bulb and adding water in 10 mL increments.
- Our results can be seen in the testing and results folder.
- Once the clip design has been printed we will add these results.

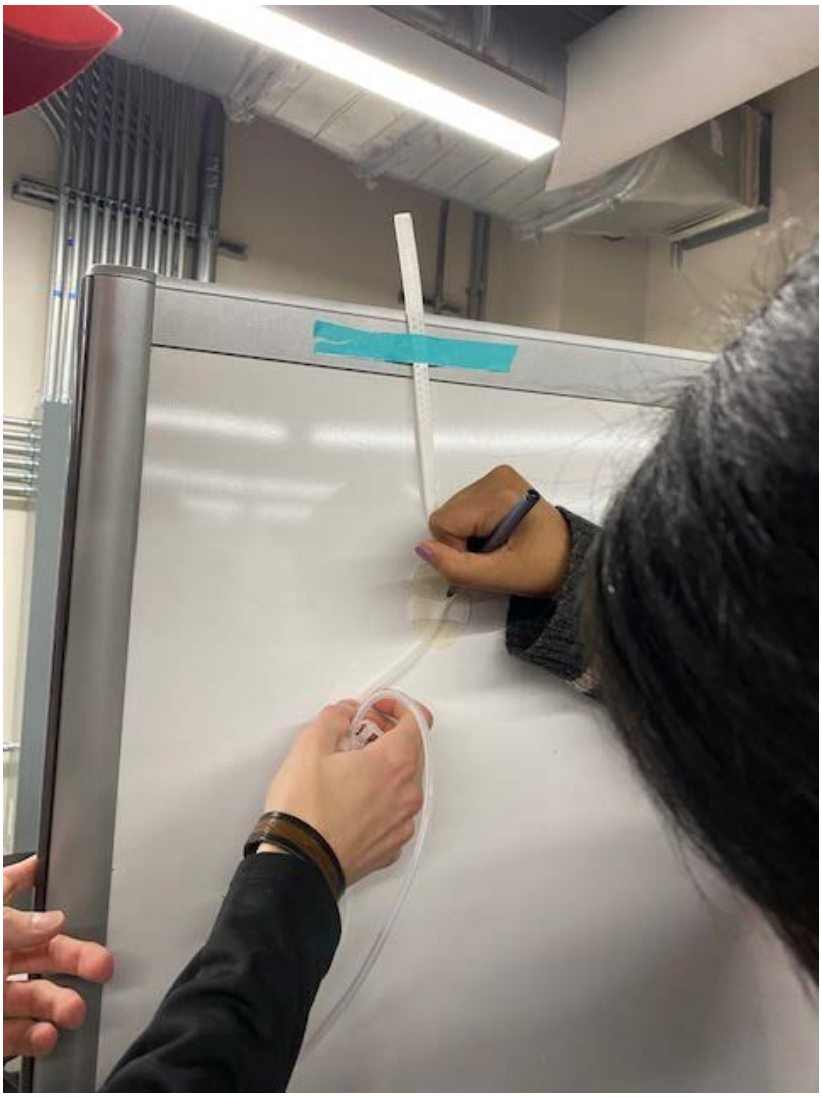


Figure 1: Marking the tubing for the testing setup.

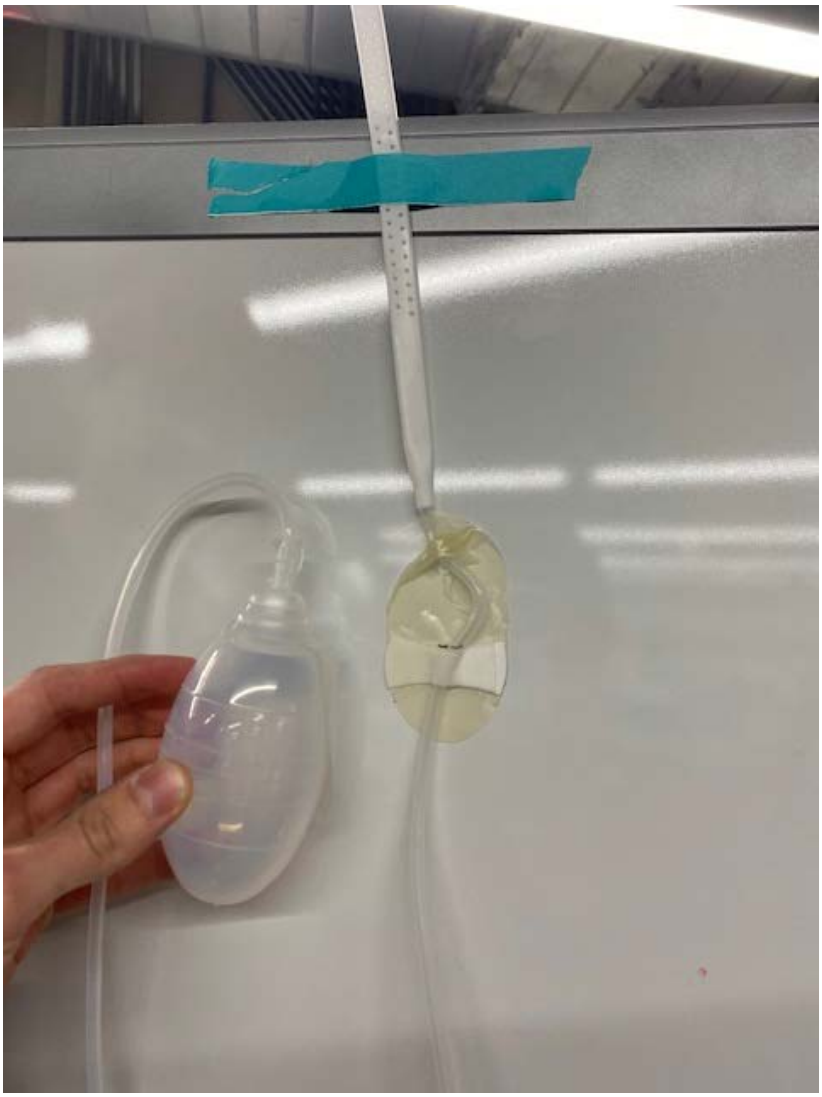


Figure 2: Testing setup. The tube is kinked to ensure that the weight is being concentrated at the griplok site.

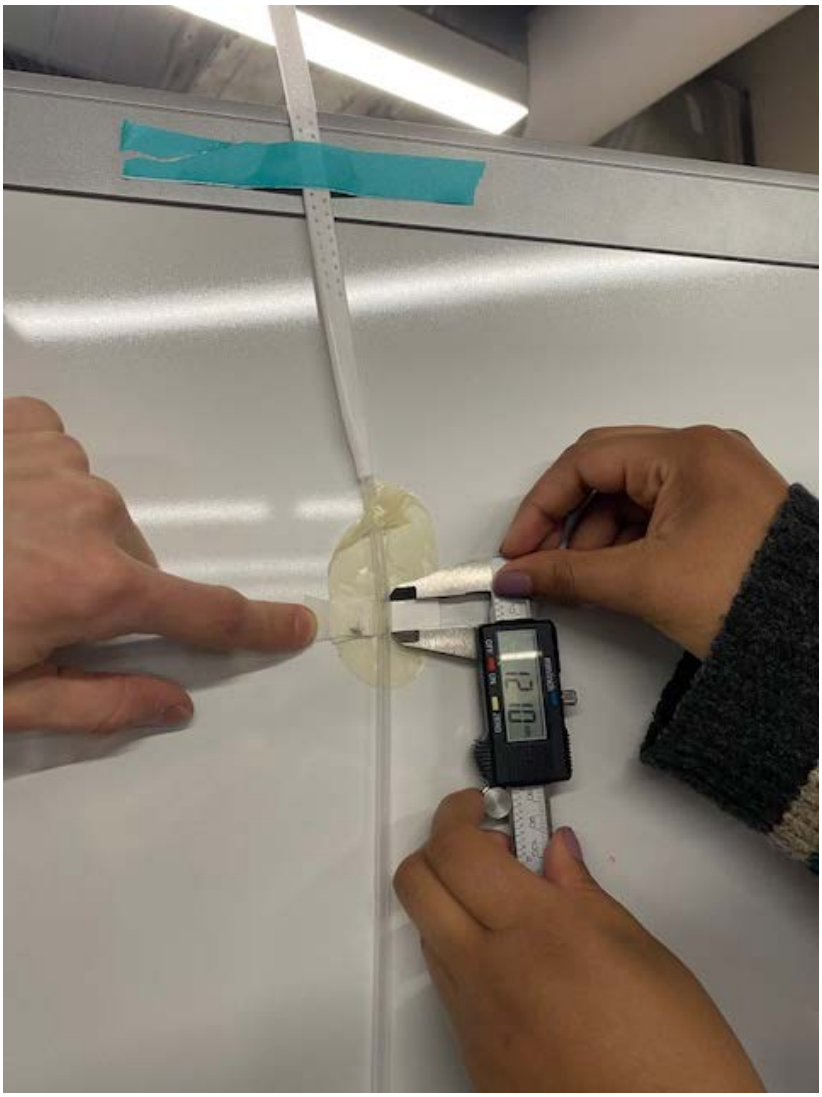


Figure 3: Measuring the displacement of the tubing once it has become completely detached from the griplok.

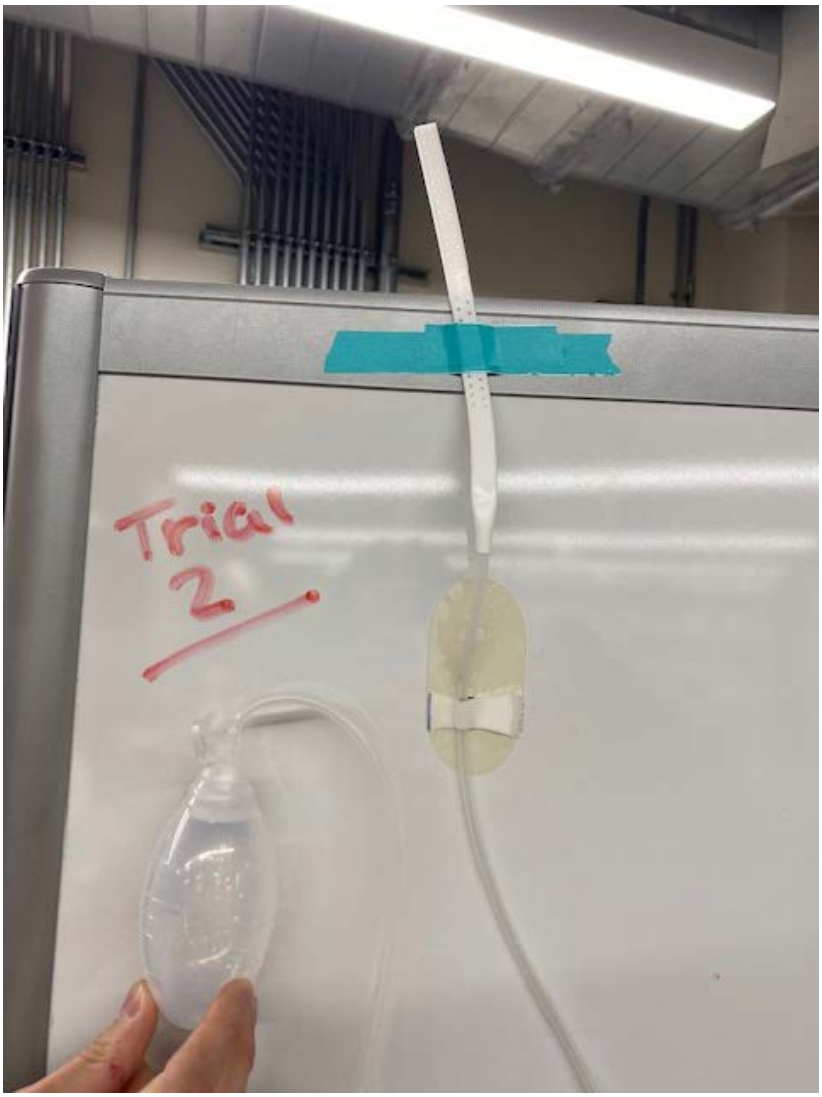


Figure 4: The setup for the second trial we conducted.

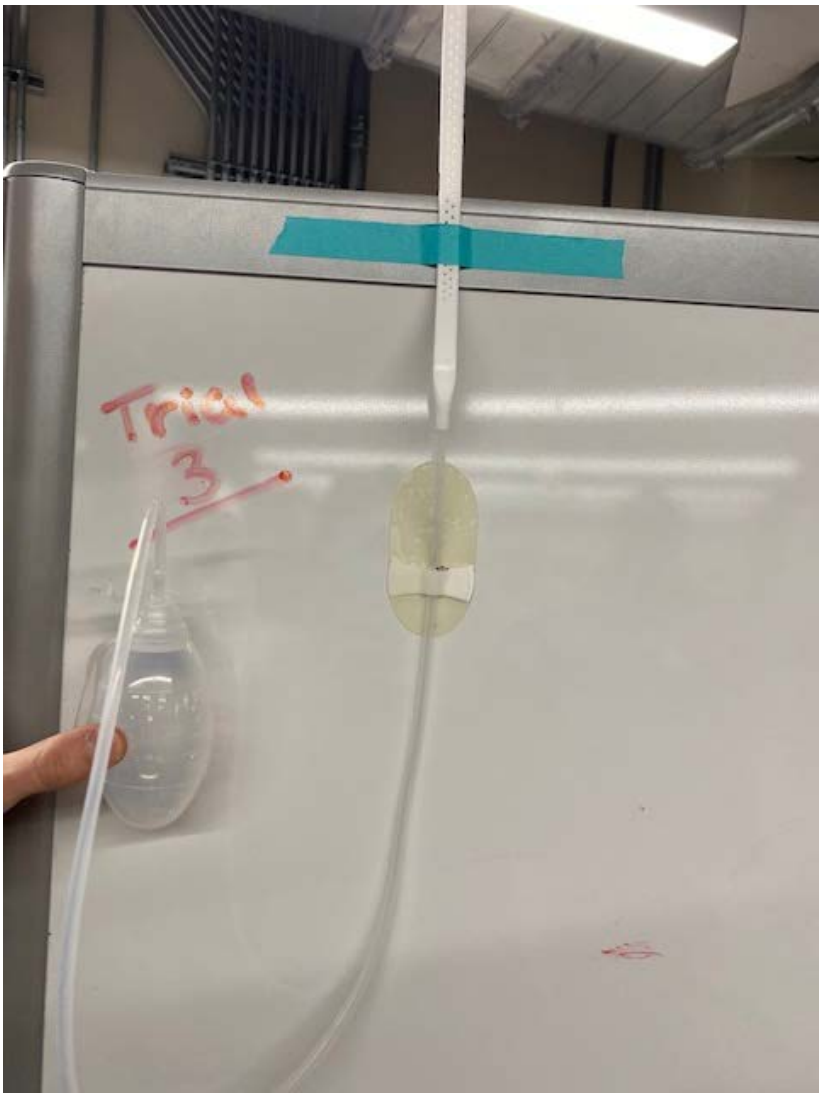


Figure 5: The setup for the third trial we conducted.

Conclusions/action items:

We will conduct force testing on the clip design once it has been printed and compare the results to this testing of the griplok to determine which design will be better for holding the drain in place.

2022/12/07 - Force testing on clips

Dana Stumpfoll - Dec 07, 2022, 11:19 PM CST

Title: Force testing on clip design

Date: 12/7/2022

Content by: Dana Stumpfoll

Present: Dana, Oscar, Beki, Lauren

Goals: Test clip design final prototypes.

Content:

- We performed the same test on the clip design that we did with the Grip-Lok design.
- Extra weight was added by using 50 ml centrifuge tubes and adding 10 ml of water each time.
- We calculated the weight added each time by using the density of water.
    - MATH: 10 ml x 1 g/ml = 10 grams each time

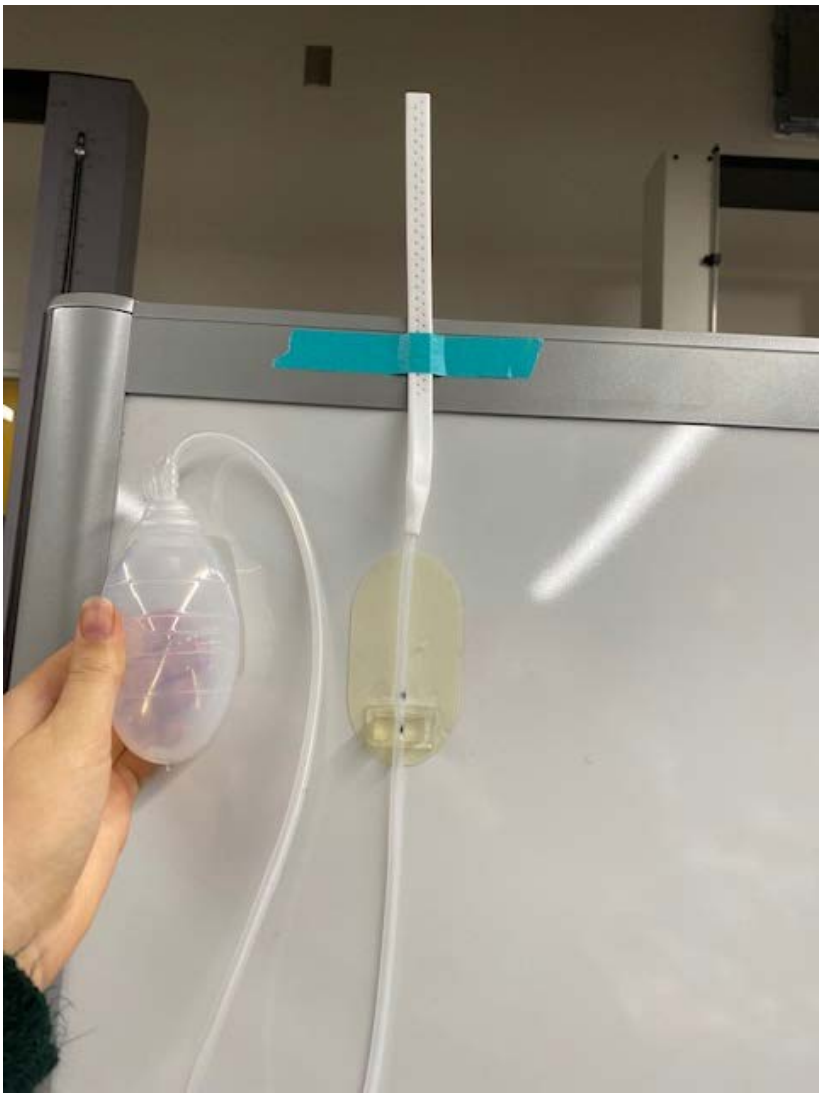


Figure 1: Test setup for the hydrocolloid with the clip attached.

Conclusions/action items:

We will use the data collected from testing the clip to show that the clip design holds the drain in place better than the Grip-Lok.

2022/12/07 - Force testing results

Dana Stumpfoll - Dec 12, 2022, 11:52 AM CST

Title: Force testing results

Date: 12/07/2022

Content by: Dana Stumpfoll

Present: Dana Stumpfoll

Goals: To upload an organized table of force testing results

Content:

Attachment type	Trial	Failure weight (g)
Grip-Lok	1	468.92
	2	487.14
	3	467.14
Clip	1	519.35
	2	611.40
	3	601.40

These results show the failure of the two mechanisms for securing the surgical drain tubing. It is apparent that the clip mechanism could hold more weight than the Grip-Lok mechanism.

Conclusions/action items:

Create final final prototype and final deliverables. Create statistical analysis from this data to show that the clip design is better.

2022/12/11 - Statistical Results

Oscar Zarneke - Dec 11, 2022, 10:34 AM CST

Title: Statistical Results

Date: 12/11/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To record the results of all the statistical analyses

Content:

Note - the MATLAB script with all analyses and statistical results is attached below

MTS analysis:

We needed the mechanical properties to model the bandages in FEBio, and we needed to know how to model the elastic therapeutic tape: either as an isotropic or anisotropic (orthotropic) material. Therefore, we ran a two-tailed T-test with a significance level of 0.05 between the elastic moduli of the parallel and perpendicular directions of both the waterproofed and non-waterproofed elastic therapeutic tape. Both the waterproofed and non-waterproofed showed significance (tstat=-10.933, df=4, p=0.000398 and tstat=-3.141, df=4, p=0.0348, respectively), proving that they needed to be modeled as orthotropic materials.

FEBio analysis:

The goal of this testing was to identify what bandage geometry if any, best-distributed stress. After running the FEBio simulations using a 20 N load, we could visually see that the stress distribution did not change across any trial. Therefore, we looked at the maximum effective stress (effective stress is the stress calculated by the Von Mises stress equation). We ran an ANOVA test between both the geometries and the materials of the bandages. Bandage geometry made no difference in the maximum effective stress (F=0.754, df=4, p=0.583), but the material did have a significant difference (F=6.098, df=2, p=0.0246). *Note - the document with FEBio results is attached below*

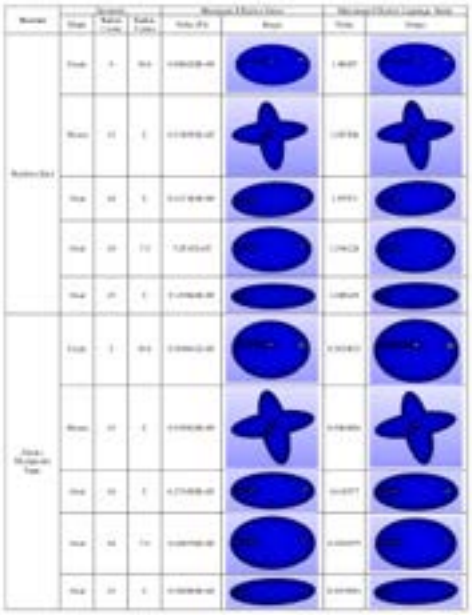
Force testing analysis:

We wanted to know what attachment device, clip or Grip-lok, could support more weight. Therefore, we conducted a two-tailed T-test between the maximum supported weight of the clip and Grip-lok. Using a significance level of 0.05, we found the clip supported significantly more weight than the Grip-lok (tstat=3.450, df=4, p=0.0261).

Conclusions/action items:

Complete final prototypes and deliverables.

Oscar Zarneke - Dec 11, 2022, 10:39 AM CST



Download

FEBio-Results.pdf (256 kB)

Oscar Zarneke - Dec 11, 2022, 10:39 AM CST

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BME400_TestingAnalyses.pdf (363 kB)

2022/10/07 - Preliminary Design Presentation

Dana Stumpfoll - Oct 12, 2022, 11:04 AM CDT

Title: Preliminary Presentation

Date: 10/10/2022

Content by: Dana

Present: Rebekah, Lauren, Oscar, Abdoulahi, Dana

Goals: Upload the preliminary design presentation

Content:

- See attachment for preliminary presentation slides.

Conclusions/action items:

Continue to upload project files.

Dana Stumpfoll - Oct 12, 2022, 11:04 AM CDT

Download

Drain_Pain_Preliminary_Presentation.pdf (648 kB)

2022/10/11 - Product Design Specifications

Dana Stumpfoll - Oct 11, 2022, 11:33 PM CDT

Title: Product Design Specifications

Date: 10/10/2022

Content by: Dana

Present: Rebekah, Lauren, Oscar, Abdoulahi, Dana

Goals: Upload the product design specifications

Content:

- See google document attachment for product design specifications.

Conclusions/action items:

Continue to upload project files. Continue to edit the product design specifications.

Improved Method of Securing Surgical Drains

Preliminary Product Design Specifications

Team: Dana Stumpfoll, Rebekah Makonnen, Lauren Heller, Oscar Zarneke, Abdoulahi Bah

Client: Dr. Katie Kalscheur

Advisor: Dr. Tracy Jane Puccinelli

Date: September 23, 2022

Function:

Surgical drains are used to keep certain fluids and air from accumulating in a dead space that is created during surgery [1]. These are attached to patients using sutures which are stitches that attach and hold the tube in the patient's skin [1]. However, these sutures cause pain and discomfort due to tension at the suturing site [2][3]. The created device will address this problem by reducing the amount of tension produced at the suturing site. This problem will be addressed with two approaches. One approach will be to develop a device that improves the attachment of the surgical drains to the skin. The other approach will be to create a housing for the drain tubing and bulb. As a result, the patient will have a much more comfortable and painless experience with the surgical drains.

Client requirements:

- 5cfThe device will need to work effectively in various environments including hot and cold temperatures as well as exposure to water.
- 5cfThe device should be able to work for any type of surgical drain and be placed in any location.
- 5cfThe device should maintain function and provide comfort when the patient is performing various movements and daily activities including walking, sleeping, stretching, and exercising.
- 5cfThe drainage wound site should be accessible for sanitizing using alcohol or various soaps.

Design requirements:

1. Physical and Operational Characteristics

a. *Performance requirements*:

The device should be replaceable and removable for sanitary reasons until the surgical drain collects less than 25 - 30 cc of fluid, which can take 1 to 5 weeks [2][4]. Once the drainage amount is consistently below 25 - 30 cc of fluid, the drain can be removed. The device should also prevent displacement of the surgical drain tube, especially during patient movement or when pulled on. In addition, the device should relieve the tension created at the attachment site of the surgical drain tube. It will also be necessary that the device is biocompatible with the skin to avoid irritation when in use. Lastly, the device will need to follow certain FDA protocols highlighted in section 3a.

b. *Safety*:

This attachment device should not cause any additional irritation or inflammation to the patient. It should not inhibit drainage flow or cause the tube to be displaced. The site should also be able to be cleaned to ensure that it is sanitary and will not cause any infections.

c. *Accuracy and Reliability*:

The attachment device should be able to hold the surgical drain in place without irritating the patient's skin. This device should not allow for displacement greater than 3.16 +/- 1.0 mm [5]. It should also be adjustable to ensure it is adequately secured and for patient comfort.

d. *Life in Service*:

This product should be able to last for the duration that the surgical drain is attached to the patient, up to one week. This device should be able to withstand all of the activities that accompany a normal life without any impact on its function or how secure it is.

e. *Shelf Life*:

While not in use, this device will be stored in a standard healthcare storage closet at room temperature. If properly stored, the attachment device should be able to be kept for 36 to 40 months [6].

f. *Operating Environment*:

The attachment device will be placed near the exit site of a surgical drain and will have to maintain its function while exposed to body temperatures, cleansing and showering, and stripping of the drain to ensure the drain does not become clogged. The design will likely be attached to the patient's skin and should be able to maintain its function at body temperatures ranging from 98.3 +/- 4.0°F [7]. This range accounts for the temperatures the patient's body might get to if they are instructed to do light exercises while the drains are still in place. Patients are instructed to shower while their surgical drains are in place so the design should not lose its integrity when exposed to water [8]. Drains also need to be regularly stripped to ensure they remain functional, so the design should not detach or displace during this process [2].

g. *Ergonomics*:

The design should not detach from the patient's skin after accidental tugging or movement [2]. The housing design should allow the patient to move around and attend their daily activities without interruption. The housing design will incorporate a way to easily hide or wrap this extra tubing. The patient should also be able to access their drain site for the duration they need the drain which can range from 1 to 5 weeks [9].

h. *Size*:

Most surgical drain diameters range from 0.25 inches to 1 inch and are 14-18 inches long [4][10]. The attachment device will be able to accommodate this range of diameters.

i. *Weight*:

The design should weigh less than 1 oz as this competes with current devices on the market and will not cause increased discomfort on the patient's skin [11].

j. *Materials*:

The design must use sterile materials that do not interfere with natural wound healing. The materials should not evoke an immune response at the drainage site. Water-soluble materials cannot be used, as the site must be washed frequently [12]. The material should not notably expand or contract. The design must also use durable materials to withstand use for up to several weeks, but must be easy to remove in as little as a few days [13]. Drains are used for varying durations of time, and the design must be versatile to represent this.

k. *Aesthetics, Appearance, and Finish*:

The final design must have a smooth finish to avoid any unnecessary catching on clothing [2]. In addition to this, it should conceal the appearance of the drains. Ideally, the design will have patterned options as well as various skin tone options for a more discreet appearance [14]. The design should also incorporate a method of securing tubing and drainage bulbs so that the design accounts for all portions of the drainage process, not just at the drain-skin contact point [15].

2. Production Characteristics

a. *Quantity*:

Only one or two units will be needed to show proof of concept. The design should be easily scalable to large quantities to match the rapidly growing need for surgical drains [16].

b. *Target Product Cost*:

Various other products on the market typically fall in the range of $25 to $35 [14]. Our design should fall within this range, however, it will ideally be lower in cost than similar products on the market. If scaled up to match market demand, the price will ultimately be lower than the initial cost of production.

3. Miscellaneous

a. *Standards and Specifications*:

The FDA classifies surgical sutures [17], topical adhesives [18], and surgical drains [19] as class II medical devices. Therefore, new attachment methods must follow the FDA's general and special controls. All equipment must be sterilized following FDA sterilization guidelines [20].

b. *Customer*:

The housing device should prevent tugging on the drain, a source of pain and discomfort for the patient. Additionally, it should be concealed under normal clothing or be designed to appeal to all customers.

c. *Patient-related concerns*:

New attachment methods must be sterilizable prior to use and must allow visual access to the insertion site. The housing device should be machine washable and avoid kinking the drain tube.

d. *Competition*:

Many variations of surgical drain bulb holders have been patented including:

5cfMedical drainage pouch [21]

5cfPost-surgical drainage bulb support sling [22]

5cfPost-surgical drainage container carrier [23]

5cfDrain tube belt and shower pack kit [24]

5cfSurgical recovery brassiere [25]

5cfDrainage reservoir support assembly [26]

5cfSurgical drainage device [27]

5cfAbdominal binder with improved drainage bulb holding system [28]

5cfApparatus and method for carrying and storing medical drains [29]

5cfDrain pouch caddy [30]

5cfPost-operative compression bra and drain apron [31]

5cfSurgical drain management apparatus [32]

5cfDrain tube holder system [33]

5cfOstomy pouch holding system [34]

5cfSurgical drainage reservoir support [35]

5cfMedical drain carrier [36]

5cf** This is a non-exhaustive list **

Methods for surgical drain attachment include:

5cfSutures with Tie-Lok [37]

5cfAdhesive device [38]

5cfProlene suture with beads [39]

5cfCenturion sandal [5]

5cfCenturion sandal with two locking plastic ties [5]

5cfCenturion sandal with Steristrips [5]

5cfDouble loop sutures [5]

5cfMultiple loop sutures [5]

5cfClassical suture loop and knot [40]

5cfRoman Gaiter suture technique [40]

5cfLocking-Turns suture technique [40]

5cf** This is a non-exhaustive list **

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2022/10/21 - SolidWorks Designs

Dana Stumpfoll - Oct 23, 2022, 6:44 PM CDT

Title: SolidWorks Designs

Date: 10/21/22

Content by: Dana

Present: Everyone

Goals: Model each design in Soliworks

Content:

See attached files for models of each design. The files consist of a velcro design, an adhesive double layer design and a clip design using a premade clip that Oscar found.

Conclusions/action items: Work on adding dimensions to the model and make them look better if we need them for final presentations.

Dana Stumpfoll - Oct 23, 2022, 6:46 PM CDT

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Dana Stumpfoll - Oct 23, 2022, 6:46 PM CDT

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Dana Stumpfoll - Oct 23, 2022, 6:46 PM CDT

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Clip_design.SLDPRT (159 kB)

Dana Stumpfoll - Oct 27, 2022, 6:34 PM CDT

Title: SolidWorks Designs

Date: 10/27/22

Content by: Dana

Present: Everyone

Goals: Add the drawings for each design that are dimensioned

Content:

See attached files for drawing of models with dimensions for each design.

Conclusions/action items: Add images of each design.

Dana Stumpfoll - Oct 27, 2022, 6:57 PM CDT

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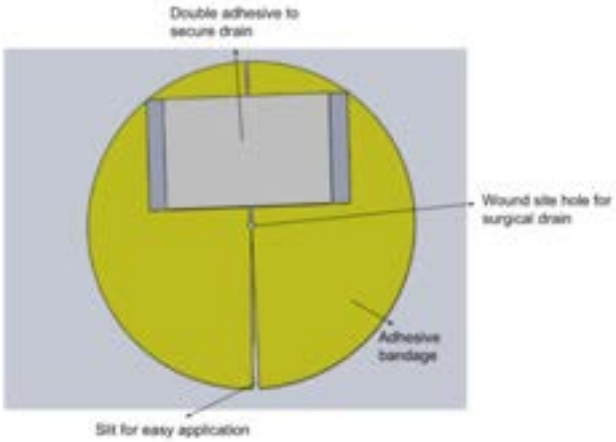

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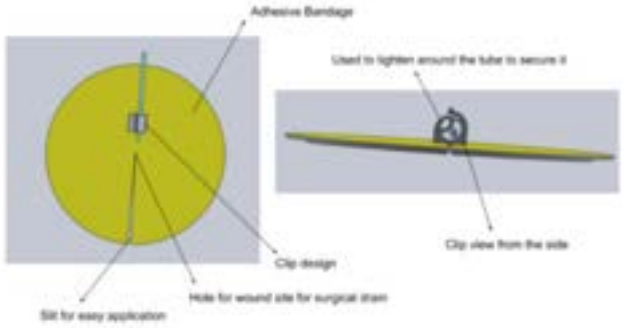

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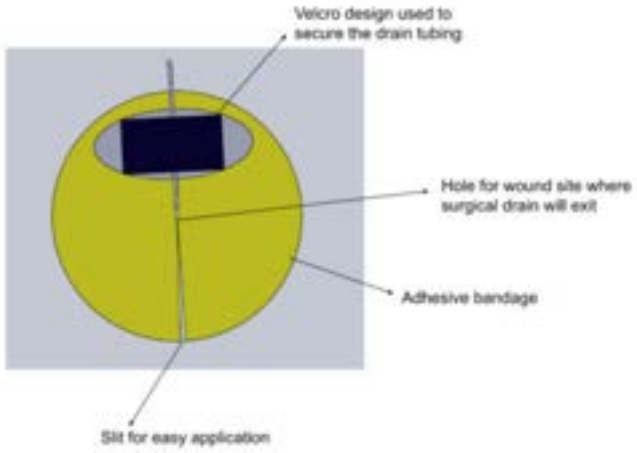

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2022/11/21 - Mechanical Properties of Adhesive Bandages

Oscar Zarneke - Nov 21, 2022, 12:12 PM CST

Title: Mechanical Properties of Adhesive Bandages

Date: 11/21/22

Content by: Oscar

Present: Everyone

Goals: Record the MTS testing data and the MATLAB script that analyzed it.

Content:

See the attached files for the raw MTS data. The MATLAB script that analyzed the data for the elastic modulus and yield strength is also included.

Conclusions/action items: Begin working on the simulations to determine the best bandage geometry.

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2022/11/28 - SolidWorks Files of Adhesive Bandages

Oscar Zarneke - Nov 28, 2022, 7:04 PM CST

Title: SolidWorks Files of Adhesive Bandages

Date: 11/28/22

Content by: Oscar

Present: Everyone

Goals: Record the SolidWorks files used for geometry testing in FEBio.

Content:

See the attached files. Both SolidWorks and .step files (format used in FEBio) are included.

Conclusions/action items: Run the geometries through FEBio.

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2022/11/28 - FEBio Part & Job Files of Adhesive Bandages

Oscar Zarneke - Nov 28, 2022, 7:11 PM CST

Title: FEBio Part & Job Files of Adhesive Bandages

Date: 11/28/22

Content by: Oscar

Present: Everyone

Goals: Record the FEBio part and job files used for geometry testing.

Content:

See the attached part and job files.

Conclusions/action items: Analyze the results of geometry testing.

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Oscar Zarneke - Nov 28, 2022, 7:16 PM CST

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Water_KT_Oval_D30cm-10cm.feb (17.9 MB)

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Water_KT_Oval_D30cm-10cm.log (30.4 kB)

Oscar Zarneke - Nov 28, 2022, 7:16 PM CST

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Water_KT_Oval_D30cm-10cm.xplt (57.3 MB)

2022/11/28 - SolidWorks Clip Design

Dana Stumpfoll - Nov 28, 2022, 7:47 PM CST

Title: SolidWorks Clip Design

Date: 11/28/22

Content by: Dana

Present: Everyone

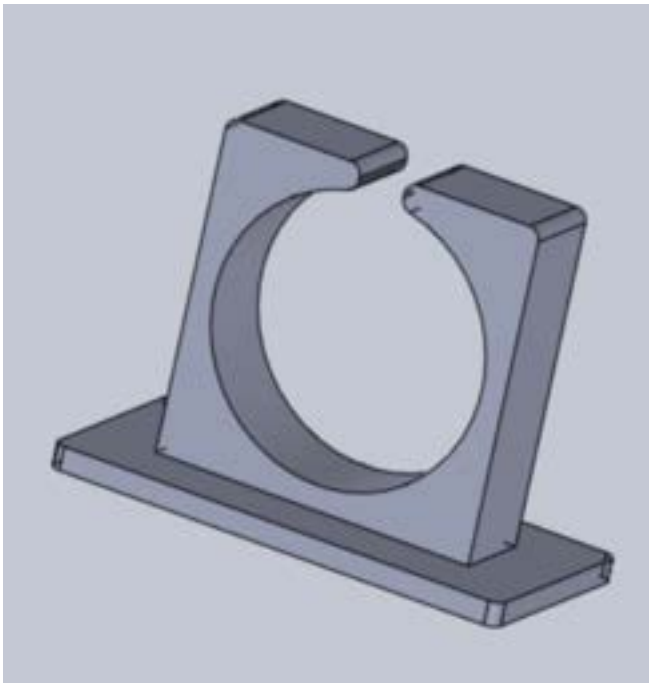
Goals: Model a clip in SolidWorks

Content:

See attached files for clip design. We will be printing it at the Makespace on Wednesday 11/30.

Conclusions/action items: Print the clip design and test it to determine how much force it takes to displace the tube from its original position.

Dana Stumpfoll - Dec 07, 2022, 11:02 PM CST



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Screenshot_78_.png (50.2 kB)

Dana Stumpfoll - Dec 07, 2022, 11:03 PM CST

Download

clip_design_1_.SLDPRT (101 kB)

2022/12/01 - SolidWorks Clip Design Iterations

Dana Stumpfoll - Dec 07, 2022, 11:10 PM CST

Title: SolidWorks Clip Design

Date: 12/01/22

Content by: Dana

Present: Everyone

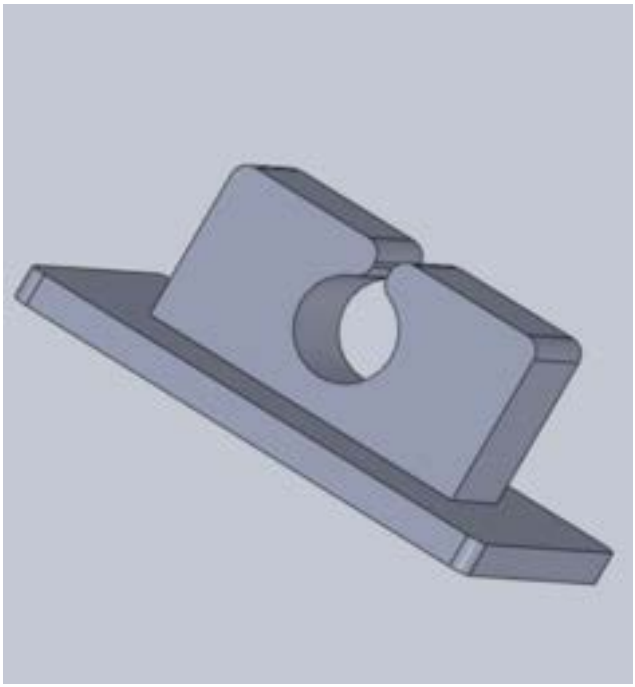
Goals: Model a clip in SolidWorks

Content:

See attached files for clip design. First clip design did not turn out as expected so Dana recreated it and printed it at the makerspace. This clip's hole has a diameter of 6mm.

Conclusions/action items: Print the clip design and test it to determine how much force it takes to displace the tube from its original position.

Dana Stumpfoll - Dec 07, 2022, 11:10 PM CST



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clip2.png (69 kB)

Dana Stumpfoll - Dec 07, 2022, 11:11 PM CST

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2022/12/06 - SolidWorks Clip Design Iteration 2

Dana Stumpfoll - Dec 07, 2022, 11:12 PM CST

Title: SolidWorks Clip Design

Date: 12/06/22

Content by: Dana

Present: Everyone

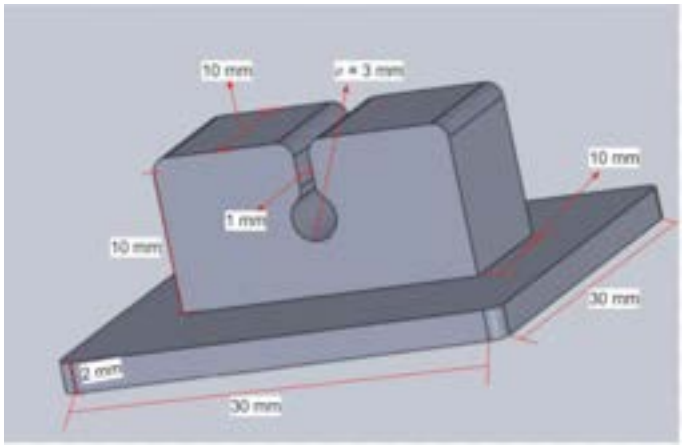
Goals: Model a clip in SolidWorks

Content:

See attached files for clip design. First clip design did not turn out as expected so Dana recreated it and printed it at the makerspace. This clip's hole has a diameter of 3 mm since the first clips diameter was too big.

Conclusions/action items: Print the clip design and test it to determine how much force it takes to displace the tube from its original position.

Dana Stumpfoll - Dec 07, 2022, 11:12 PM CST



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Screenshot_20221207_091711.png (125 kB)

Dana Stumpfoll - Dec 07, 2022, 11:13 PM CST

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clip_design_3.SLDPRT (86.3 kB)

2022/12/09 - Final Poster

Dana Stumpfoll - Dec 14, 2022, 12:02 PM CST

Title: Final Presentation

Date: 12/09/2022

Content by: Dana

Present: Rebekah, Lauren, Oscar, Abdoulahi, Dana

Goals: Upload the preliminary design presentation

Content:

- See attachment for final poster presentation pdf.

Conclusions/action items:

Continue to upload project files.

Dana Stumpfoll - Dec 14, 2022, 12:04 PM CST

Download

Final_Poster_Drain_Pain.pptx_2_.pdf (1.31 MB)

2022/12/13 - Final Report

Dana Stumpfoll - Dec 14, 2022, 12:06 PM CST

Title: Final Report

Date: 12/13/2022

Content by: Dana

Present: Rebekah, Lauren, Oscar, Abdoulahi, Dana

Goals: Upload the final report

Content:

- See attachment for final report pdf.

Conclusions/action items: NONE

Dana Stumpfoll - Dec 14, 2022, 12:06 PM CST

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Drain_Pain-Final_Report.pdf (8.45 MB)

2022/10/10 - Biocompatibility of silicone implants

Dana Stumpfoll - Oct 10, 2022, 9:51 PM CDT

Title: Silicone as a biomaterial

Date: 10/10/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Research implantable materials

Content:

- Silicone has a repeated unity of monomer with polydimethylsiloxane (PDMS).
- It has been used in applications such as:
    - Breast implants
    - Contact lenses
    - Lubricants
    - Artificial cardiac tubes
    - Catheters
- Based on the foreign body reaction to the material, the implant should not be toxic and should resist fragmentation when implanted.
- It is generally normal for a fibrous capsule to form around an implant.
- Many breast implantation tend to need to be removed within 10 years of implantation due to the increased side effects from the implants the longer they are implanted.
- The material Silicone gel was implanted into animal models using a control and experimental group.
    - The sites were then closed where the implant was injected and monitored at 7-days, 15-days, and 30-days.
    - After the monitoring was finished the animals were euthanized and the silicone implants were inspected.
- After 7 days post-op the incision showed a reparative epithelial layer and there was a discrete layer of granulation tissue consistinging mostly of inflammatory cells.
    - The nearest band of cells near the implant showed intense cellularity where mesenchymal and mononuclear inflammatory cells were present.
- After 15 days post-op the epithelial regneration was complete in the control group and the experimental group.
    - The subjacent connective tissue showed fibroblasts and few mononuclear inflammatory cells.
- After 30 days, all materials were enclosed by newly formed tissue in a collagenized matrix.
- This experiement concluded that silicone gel based products have a resonable assurance of safety when implanted in the body.
    - The material causes an acceptable inflammatory reaction, but follow up appointments should be made with implants in case of rejection to the implants and other adverse side effects.

Conclusions/action items:

Silicone works well as an implantable material as it is widely used for breat surgeries. Symptoms should be monitored to ensure its efficacy and to monitor the body foreign body reaction to the implant. Silicone would be a good material for our design, especially the implantable design if we ever decide to go that route.

Citation: D. C. C. França, A. L. de Castro, A. M. P. Soubhia, S. M. H. C. Á. de Aguiar, and M. C. Goiato, “Evaluation of the biocompatibility of silicone gel implants - histomorphometric study,” Acta Inform. Med., vol. 21, no. 2, pp. 93–97, 2013.

2022/10/10 - Why are surgical drains necessary?

Dana Stumpfoll - Oct 10, 2022, 10:50 PM CDT

Title: Why are surgical drains necessary?

Date: 10/10/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Biology and physiology research

Content:

- Surgical drains are used to prevent the accumulation of fluid in the body post surgery.
    - They prevent the accumulation of blood, pus, or other infected fluids.
    - They prevent the accumulation or air or dead space.
    - They characterize the collected fluid by color and amount.
- An accumulation of fluid can form an abscess that can lead to an infection.
- Surgical drains change the physiochemical and spatial environment of abscesses.
    - This helps to disturb the biome of the baterial environment.

Conclusions/action items:

Surgical drains are important to prevent the accumulation of fluid in the body post surgery. This is important for preventing infection and buildup of fluid in the body.

Citation: S. H. Dougherty and R. L. Simmons, “The biology and practice of surgical drains part I,” *Curr. Probl. Surg.*, vol. 29, no. 8, pp. 567–623, 1992.

2022/09/14- A clinical comparison of sutures versus a drain/tube attachment device

Dana Stumpfoll - Sep 14, 2022, 10:04 PM CDT

Title: A clinical report on the comparison of a drain /tube attachment device with conventional suture methods in securing percutaneous tubes and drains

Date: 09/14/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: A comparison of sutures versus a drain/tube attahcment device

Content:

- This study was conducted to compare the methods of drain/tube attachment device (DTAD) versus the normal suture attachment.
- The parameters for comparison included:
    1. The ability to maintain the drain/tube in the desired position
    2. Patient comfort
    3. Incidence of obstruction, dislodgement and infection around the site
- The second test was conducted solely on the DTAD device and tested for:
    1. Ease of use
    2. Adherence of the material to the skin
    3. Accessiblity of the site for inspection and care
    4. Wear time of the device
- A DTAD is a device that consists of a plastic clamp with serated jaws fixed to a foam skin barrier.
    - The device adheres to the skin and the tube from the drain is placed in the clamp of the clip.
    - The clamp can then be opened and closed as necessary.
    - The materials used were tested for biocompatibility and safety.
- Suture material and technique were up to the physicians descretion and were not controlled for the purposes of the study.
- General care for the sites were based on usual standard practices of care.
- Study sites included 5 hospitals, 3 nursing homes, and 1 at home agency.
- 71 patients were observed for this study.
- DTADs were expected to be in place for 7 days before changing and maximum participation was limited to 14 days.
    - No more than 3 DTADs per patients were permitted.
- Condition of the site was recorded for records before the study was conducted.

Table 2. Comparison on selected parameters of DTAD versus suturing

Parameter	Percent of total responses in each category			
	Study group		Control group	
	%	cf	%	cf
Security of tube position				
Excellent	51	51	25	25
Very good	30	81	33	58
Good	12	93	8.5	66.5
Fair	2	95	8.5	75
Poor	5	100	25	100
Incidence of problems				
Occlusion/dislodgment	0	0	17	17
Infection (site)	0	0	8	25
Interference with clothing/linens	5	5	25	50
Comfortable for patient	98	98	50	50
Need for additional items to secure tube position	3	3	50	50

Figure 1: A direct comparison of the suturing and DTAD techniques based on the criteria of security of tube position, frequency of problems with tube management, patient comfort, addition tools needed to secure the tube and for general site care.

- This table shows that that the DTAD was much better at securing the drains compared to the control group, sutures.
- The DTAD seemed to have less incidents of movement and dislodgement compared to sutures and also less infection.
- It was also found to be quite more comfortable as well.
- Overall the DTAD was rated good to excellent 93% of the time for securing the drain compared to 67% for sutures.
- In 50% of cases solely using sutures, additional adhesives were required to keep the tube/drain in place.
- One issue with the DTAD was that the starter hole in the adhesive was too large for the tube and resulted in pooling of fluid around the drainage site.
    - This was fixed by providing a smaller starting hole for the device to prevent this issue.
- The DTAD was found to be preferable to sutures in 97% of cases.
- The DTAD was found to be easy to remove, easy to apply, and decreased the necessity for extra adhesive items such as tape, in turn reducing the cost for keeping the drain/tube in place.
- Patient comfort was increased by not having to suture the device through the patients skin and providing protection to the skin from the irritating effects of drainage.

Conclusions/action items:

The DTAD device seems to be a great alternative to sutures for securing drains/tubes. This design may be useful for brainstorming ideas for developing a new method. I will continue to look into the DTAD device and see what other methods may be used to provide comfort to the patient while keeping the drain/tube secure in place.

Citation: Powers, M. L. , Myers, R. B. , Bryant, R. , Aeschliman, L. , Anderson, M. E. , Moore, K. & Kissil, M. T. (1988). A clinical report on the comparison of a drain /tube attachment device with conventional suture methods in securing percutaneous tubes and drains. *Journal of Enterostomal Therapy, 15* (5), 206-209.

2022/10/23- Grip-Lok IV and Catheter Securement

Dana Stumpfoll - Oct 26, 2022, 8:58 PM CDT

Title: Grip-Lok

Date: 10/23/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Look into Grip-Lok Suggested by Dr. Russ Johnson

Content:

- Designed to improve patients safety and comfort while they need an IV or cather.
- Easy to apply and secure method using adhesives.
- Avoids dislodgement while increasing patient comfort.
- Developed with a medical grade, hypoallergenic adhesive that promotes skin integrity.
- Hook and loop deisgn allows for access to the catheter after securement.
- Low-profile design keeps the device close to the skin while promoting patient comfort.
- Adhesion is 4.9x stronger than the typical tape.
- Instructional videos are provided to show the step by step adhesion process.

Figure 1: The device works by using an adhesive to adhere to the patients skin. Then another adhesive is used on top of the bandage to adhere the tubing to the bandage.

Conclusions/action items: We will develop a design similar to this for the purposes of securing the surgical drain away from the wound site. Dr. Russ Johnson showed us this device and it has been helpful in coming up with a simpler idea. We would also like to try a velcro design in stead of an adhesive.

Citation: L. L. C. TIDI Products, “Grip Lok: IV and catheter securement device: Tidi Products,” Grip Lok | IV and Catheter Securement Device | TIDI Products. [Online]. Available: https://www.tidiproducts.com/product-listing/grip-lok-securement-devices

2022/10/27- Vacuum - Assisted Closure of a Wound

Dana Stumpfoll - Oct 27, 2022, 12:37 PM CDT

Title: Wound Vac

Date: 10/27/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Look into Vacuum Assisted Closure of a Wound based off of the advice from Dr. Wilke

Content:

- Vacuum assisted closure of is used to heal wounds faster.
- By decreasing the air pressure in the wound it allows the wound to heal more quickly.
- The pressure from the air puts pressure on the wound.
- To remove this, the wound vacuum can pull fluid from the wound over time.
    - This reduces swelling and can clean the wound by also removing bacteria.
- A wound vacuum also pulls the edges of the wound together to allow it to heal.
- A foam or gauze padding is placed directly at the wound site.
- Then an adhesive bandage is placed over the wound and dressing.
- A drainage tube then leads from a connection to the foam from underneath the adhesive to a pump that removes the air pressure over the wound.
    - It does this constantly or it may do it in intervals over time.
- The dressing needs to be changed every 24 to 72 hours and the pump needs to be carried with the patient at all times.
- This device can be used for large wounds and other chronic wounds that won't heal.
- It works to heal a wound faster by:
    - Draining excess fluid from the wound
    - Reducing swelling
    - Reducing bacteria in the wound
    - Keeping your wound moist and warm
    - Helps to draw together the wound edges.
    - Increases blood flow to the wound
    - Reducing redness and inflammation
- It may also decrease the overall discomfort since the dressings need to be changed less often.
- Some risks with Wound Vac include:
    - Bleeding
    - Wound infection
    - Enteric Fistula (abnormal connection between intestinal tract and skin)
- Certain factors increase the risk of complications:
    - Exposed organs or blood vessels
    - High risk of bleeding from another issue
    - Wound infection
    - Nearby bone infection
    - Dead wound tissue
    - Cancerous tissue
    - Fragile skin, allergies to adhesives
    - Poor blood flow to the wound
    - Wounds close to joints that may reopen with movement

- Dead or damaged tissue may need to be removed before this device can be used.

Conclusions/action items: To understand how vacuum assited wound closure works, we may be able to develop an entirely different bulb system to assist in healing the wounds faster. The bulb system currently doesn't vacuum the wound close and allow it to heal faster, so a new system may need to be created to address this problem. For now we will continue working on our topical adhesive device.

Citation: “Vacuum-assisted closure of a wound,” *Hopkinsmedicine.org*, 14-Aug-2019. [Online]. Available: https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/vacuumassisted-closure-of-a-wound.

2022/10/27- G-tubes

Dana Stumpfoll - Oct 27, 2022, 9:40 PM CDT

Title: G-Tubes

Date: 10/27/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Research how G-Tubes work

Content:

- A gastrostomy tube is a surgically placed device used to give access to someone's stomach for supplemental feeding, hydration, or medication.
- G-Tubes are commonly used to for feedings to endhance children's nutrition intake.
    - Typically used when the child is unable to eat.
- One of the most common G-Tubes is the low-profile tube sometimes called the "button".
    - This tube uses a water-filled balloon on this inside of the stomach to hold it in place.
    - A special extension tube is added when administering medications or for feeding.

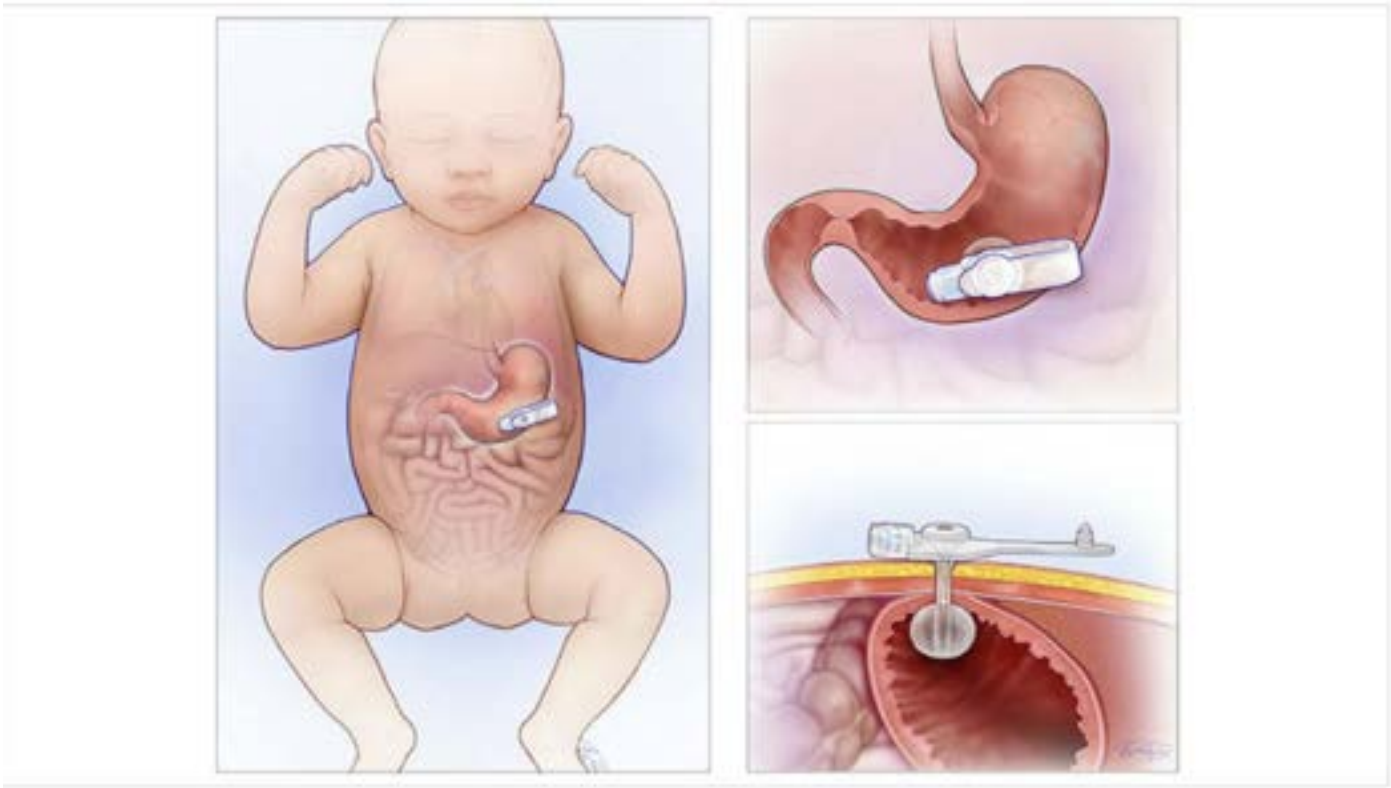


Figure 1: This shows how the G-Tube is held in place by the water-filled balloon.

- These devices remain in place for a long amount of time and this is a common mechanism used to keep them in place.
- Sometimes a hollister dressing is used to keep the dressing in place.
    - This is like a ziplcok-type design to keep the G-Tube in place.
- To place the device a small incision called a stoma is created to place the device.
- G-Tubes commonly leak and a dressing is normally added under the tube.

Conclusions/action items: Understanding how G-tubes work is important if we plan to work on a device that would be under the skin. This would be considered if our adhesive skin device does not work.

Citation: The Children's Hospital of Philadelphia, "Gastrostomy Tubes (G-Tube)," *Chop.edu*, 12-May-2014. [Online]. Available: https://www.chop.edu/treatments/gastrostomy-tubes.

2022/09/22 - PDS Research- Most common procedures

Dana Stumpfoll - Sep 22, 2022, 8:48 PM CDT

Title: Surgical Drains

Date: 09/22/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: PDS Research

Content:

- Surigical Procedures that typically require a drain:
  - Chest surgery
  - Lymph node clearance
  - Breast surgery
  - Abdominal surgery
  - Thyroid surgery
  - Plastic surgery flap procedures
- This list shows how useful our design would be and the multitude of surgies it could be used for.
- Two common drainage bulbs are the low negative pressure bulb and the high negative pressure bulb.
  - These are two passive drains where the low pressure bulb collects a small amount of fluid while the high pressure bulb collects significantly more fluid.
- The drain has a sharp end (a trocar) that is inserted into the patient.
- An anchoring suture is placed to secure the drain in place.
- Negative pressure is built up inside the bulb to suck the fluid out by squeezing the bulb and flattening it.
- After drain is removed dressing and tape are added over the open wound to allow it to heal.

Conclusions/action items:

This article helped me determine the common surgeries that require surgical drains. This gives us an idea of the different types of drains we will need to consider to make our design universal. It also helps us consider the area of the body this device may need to be attached to such as the abdomen or chest, allowing us to make the device easy to manipulate for these positions.

Citation: Ramesh BA, Evans JT, BK J. Suction Drains. [Updated 2022 Jul 7]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK557687/

2022/09/22 - PDS Research- Medline Drain

Dana Stumpfoll - Sep 2

Title: Medline Sterile Silicone Round Wound Drains with Trocars

Date: 09/22/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: PDS Research

Content:

Figure 1: Surgical drain from Medline typically used in breat surgies.

- The diameter of this drain is 0.25".
  - This was helpful for determining the width we would need to incorporate into our design for breast drains specifically.
- This drain costs $250.
- It is made from silicone, a material our team is considering using in our attachment design.
- It is inert and biocompatible in the body.

Conclusions/action items:

This Medline drain helped me determine the diameter of the drains for determining how big we will need to make our design. The drain is 0.25" and is used in surgies such as neu surgies, breast augmentation surgies, and orthopedic procedures. We plan to incorporate a range of 0.25" diameter drains to 1" diameter drains. I will conduct more research on l device universal for all drain sizes and how to make it adjustable.

Citation:

"Medline sterile silicone round wound drains with trocars - silicone ev," *Devine Express*. [Online]. Available: https://www.devineexpress.com/products/medline-sterile-silicone-ro with-trocars-silicone-evaluator-and-wound-drain-round-kit-with-trocar-radiopaque-100cc-evac-19-fr-14-full-fluted-dynjwe2265?variant=40074691510315&cmp_id=17327877329&adg_id=136737181853&kwd=&device=c&gclid=CjwKCAjwyaWZBhBGEiwACslQo0lr1xnqWRHh3NkVnKdqes2l2Fzp251Vr8ZS pxoCDOsQAvD_BwE.

2022/09/13- Care for Surgical Drains

Dana Stumpfoll - Sep 14, 2022, 9:10 PM CDT

Title: Care for Surgical Drains

Date: 09/13/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Understand surgical drains and how patients have to care for them

Content:

- Surgical drains are placed to help treat a collection of fluid or to prevent a collection of fluid from building up inside the body.
- The site should be cleaned but not tugged at in case it becomes loose.
- Let soap and water run over the drain but do not soak the wound.
- Look at the drain site and look for signs of infection if you are not showering daily.
- Do a regular dressing change to decrease chance of infection.
- The drain will also need to be stripped at home to keep it open and working.
- For stripping it is important to be careful as to not pull the drain out of place.
    - Since drains are typically held in by stitches only it is difficult to do this without pulling the drain out.
- Emptying the drain is important for measuring the amount of fluid that is being released so the doctor can determine when the drains can be removed.
- The color of the fluid can range from dark red to straw like in color and can help the patient determine if they have an infection if it changes to a pus like color or becomes thick.
- It is also important to keep the suction in the drains so they continue to drain.

Conclusions/action items:

Overall, surgical drains are important for patient care after surgery. This care routine helps me understand the importance of the project and the steps the patient will have to take to clean their drain and empty it. This will be important to consider when we start prototyping.

Citation: “Care of your surgical drain at home,” *Uwhealth.org*. [Online]. Available: https://patient.uwhealth.org/healthfacts/4603.

Dana Stumpfoll - Sep 13, 2022, 10:05 PM CDT

UWHealth Health Facts *for you*

Care of Your Surgical Drain at Home

Download

4603.pdf (529 kB) Our client's surgical drain care at home post procedure.

2022/09/15 - Dr. Li's Guide to Getting Drains

Dana Stumpfoll - Sep 15, 2022, 5:57 PM CDT

Title: Dr. Li's Guide to Getting Drains After Surgery

Date: 09/15/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Read the suggested article from the client and understand tips for taking care of drains after surgery

Content:

- Essential functions of drains:
  - prevent fluid build-up after surgery
  - need to be emptied and fluid volume should be measured
  - fluid color will change from pinkish to yellow
  - very uncomfortable for the patient especially if they are tugged on
  - once drain volume is consistently low they can be removed
- The drains prevent fluid from forming an abscess and infection.
- How do drains work?
  - The work like a vacuum.
  - The bulb of the drain needs to be squeezed to generate negative pressure which will slowly, but gently remove fluid from the area.
  - Drains are typically sutured to the skin to prevent them from coming out.
- Drains need daily care to avoid infection.
  - Washing hands and wearing gloves is important when handling the drains.
  - The drains must be stripped by milking the tubing and pushing the fluid into the bulb of the drain.
  - The bulbs should be emptied 2-3 times a day or when they are half full.
  - The fluid should be measure in milliliters and this amount and the color should be recorded for the doctor.
- Minimizing drain pain:
  - Wear clothing that can secure the drain in place or that it can be pinned to.
  - Give the tubing a little slack to avoid skin irritation and tugging.
  - If the stich comes out, contact your doctor and get it fixed as this can cause the drain to displace and lead to infection.
  - Tape the tube to the skin near the exit site, although this may cause skin irritation.
- The longer the drain stays in the higher the risk for infection.
  - The color of fluid should go from a redish/pink to a yellow and may have clots.
- The drains are typically removed when there is less than 30cc of fluid for two consecutive days.
- The drains will then be pulled out by cutting the stich and a dressing will be placed over the wound until it heals.
  - This takes about 48 hours.

Conclusions/action items:

Tips and tricks for a less painful surgical drain experience are important to consider. These tips can be taken into consideration as we are designing to ensure the patients have a more comfortable experience. I will continue to look into how long drains are in place and tips for securing them comfortably.

Citation: W.-Y. Li, “Dr. Li’s guide to getting drains after surgery,” *Surgical Seecrets*, 07-Oct-2020. [Online]. Available: https://surgicalseecrets.com/blogs/articles/guide-to-getting-drains-after-surgery.

2022/09/22 - PDS Research- How long is surgical drain tubing?

Dana Stumpfoll - Sep 22, 2022, 7:57 PM CDT

Title: Surgical Drain Care After Breast Surgery

Date: 09/22/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: PDS Research

Content:

- The most-common drainage system for breast surgeries is the Jackson-Pratt drainage system.
- The flexible surgical tubing is stitched to the patients skin.
- Some drains are only left in for 2 to 3 weeks but they can be left in longer.
    - Risk for infection increases after 21 days.
- You may have only one drain post surgery but you can have up to five depending on the type of breast surgery and if both breasts need to be removed or reconstructed.
- Another drainage tube may be placed if a lymph node dissection also has to take place.
    - This is important to consider because more than one drain means the patients skin is being pulled on in more than one spot causing more discomfort.
- The drains tubing outside of the body is typically 14-18 inches long and tends to get tangled in IV cords and tugged on from regular daily activites.
    - This can be annoying as this will tug on the patient more.
    - It is important to consider this in our design as we can make the drain tubing get out of the way of everyday functions and also to make it not visible.
    - The article suggests having a special drain management garment to keeps the drains secure so they don't pull on the wound site.
    - It can be difficult for the patient to pull clothing over their head post surgery.
        - This is important to consider for our housing design for the tubing and surgical bulbs.

Conclusions/action items:

The JP drain is one of the most common drains used in breast surgeries. The drain is typically sutured to the patients skin which if tugged too harshly will cause the drain to fall out. This article also suggests some sort of clothing to hold the surgical tubing and bulbs in place so they don't tug on the wound site. Our team is considering incorporating this into our design or coming up with an additional method to the attachment device to ensure the tubing does not get in the way.

Citation: M. S. Jean Campbell, “How to take care of your drains after breast surgery,” Verywell Health,05-Apr-2016. Available: https://www.verywellhealth.com/managing-your- surgical-drains-following-breast-surgery-4021630.

2022/09/22 - PDS Research- After Surgical Procedure Instructions

Dana Stumpfoll - Sep 22, 2022, 7:42 PM CDT

Title: After surgical procedure instructions for JP Drain and Surgical Incision

Date: 09/22/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: PDS Research

Content:

- One of the most common surgical drains is the Jackson-Pratt closed suction system.
- On average JP drains continue to drain for 1 to 5 weeks.
    - This is helpful for determining the ergonomics of our design.
        - The patient should be able to access their drain site for the duration they need the drain which can range from 1 to 5 weeks.
- The flat end of the drain is placed inside the body to allow for excess fluid to be collected in the bulb of the drain.
- The JP drain requires daily milking of the drain to ensure the fluid is being drained out of the tubing.
    - The tube is milked by holding it with your thumb and index finger and sliding foward on the tubing toward the bulb.
    - The guide suggests to milk the drain 3x a day.
        - This is important to consider for our design since the patient will need access to the drain to milk it.
- The artciel suggests keeping the bulb secure by fastening it to the clothing of the pateint with a safety pin.
    - There is a specific tab on the bulb for attaching a safety pin.
- Hands should be cleaned before and after handling the drainage site.
- It explicitly states that it is okay to shower with the surgical drain in.
    - 48 hours after surgery the wound should be rinsed over with soapy water.
    - The JP drain is typically help to the body by a suture.
- Moderate excercise such as a 10 minute walk is recommended for a faster recovery.
    - The patient is directed to avoid household chores and lifting heavy weights for about a 2 to 8 week period.

Conclusions/action items:

The JP drain is one of the most common drains used in procedures that require a drain after surgery. The main takeaway from this article was that drains are kept in place for 1 to 5 weeks. This provides a timeline for how long our design will need to remain in use.

Citation: “After surgical procedure instructions for JP drain and surgical incision,” Ucdavis.edu. Available: https://health.ucdavis.edu/surgery/specialties/oncologic/jp_instructions.pdf.

2022/09/14- A modified technique for securing surgical drains to the skin

Dana Stumpfoll - Sep 14, 2022, 9:08 PM CDT

Title: A modified technique for securing surgical drains to the skin

Date: 09/14/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: A technique for securing surgical drains to the skin

Content:

- Surgical drains are used for a variety of surgical procedures.
- It is important to ensure they remain in their correct position until removal.
- Sugical knots are a typical technique used to secure drains to the skin of the patient.
    - This method poses issues such as tissue damage and accidental displacement of the drain.
- Securing the drain by knots should not disrupt the flow of fluid through the drain.
- A braided suture known as the "Roman sandal" is the most used suture knot technique.

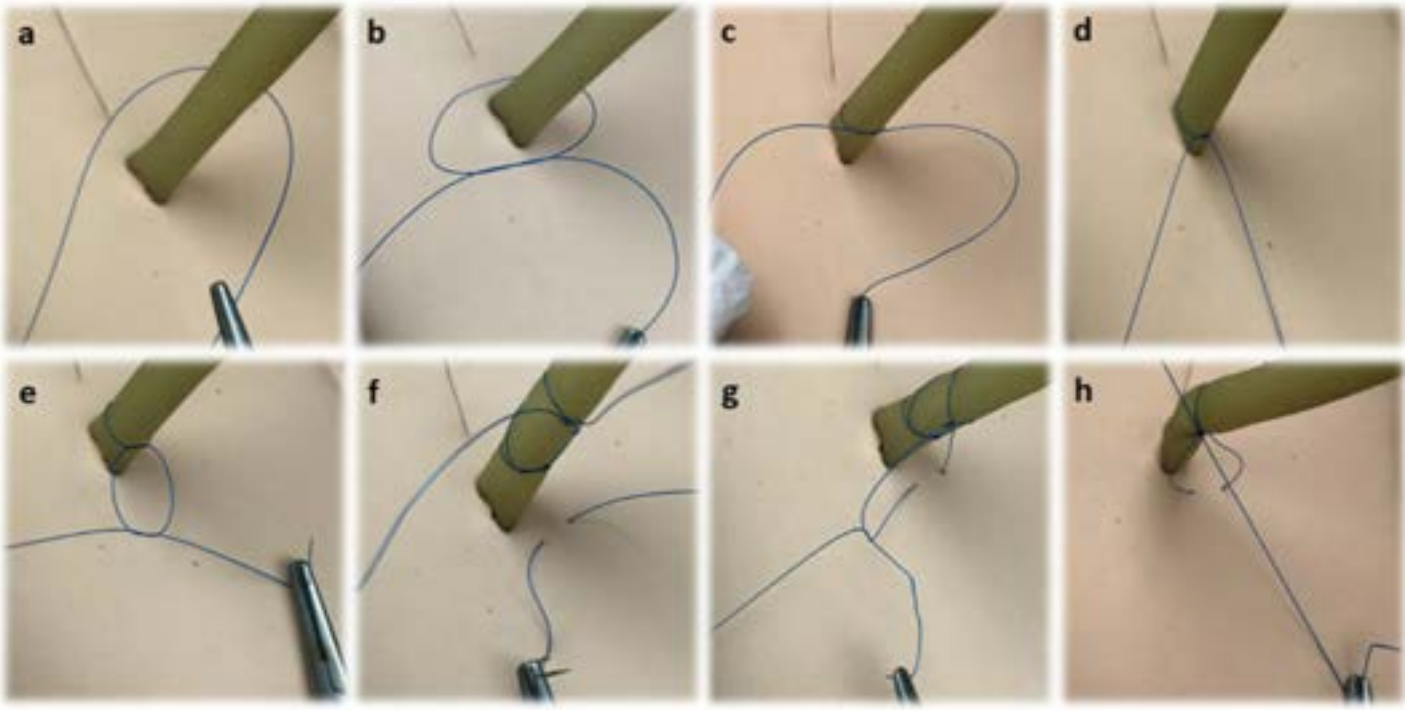


Figure 1: In this article the researchers decribe specific steps for their technique of securing the drain to the patient.

- The process begins by first tying a series of knots as demonstrated in steps a-e.
- Next the long end of the suture connected to a needle is passed through under the skin and tied into a knot again as shown in figures f-g.
- No matter how much force is applied the knot diameter around the tubing does not change and slipping of the suture does not happen as it is secured to the patients skin near the exit site.
- According to the article this technique has been proven to not damage the patients skin.

- Careful practice of securing the knots is necessary to avoid constricting the drain and causing an occlusion where liquid may no longer drain.
- This suture technique was used for plastic surgery.
- It is a braided suture technique using a Poly(ethylene terephthalate) suture coated with polybutylate.
- A braided suture allows for a tighter knot.
- No cases of infection, obstructivity, or knot laxity have been observed from the use of this knot tying technique.

Conclusions/action items:

This knot tying technique may be relevent for our project as we can practice it and determine if it is beneficial to continue to use sutures for securing drains or if we should develop a new way to secure them to the skin. I will conduct more research on the sutures used and research other methods such as glues and bandages.

Citation: S. Mura, G. F. Guarneri, and P. C. Parodi, “A modified technique for securing drains to the skin,” *JPRAS Open*, vol. 17, pp. 21–23, 2018.

2022/09/15 - A simple technique for securing surgical drains

Dana Stumpfoll - Sep 15, 2022, 6:21 PM CDT

Title: A simple technique for securing surgical drains

Date: 09/15/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Understand how surgical drains are secured

Content:

- Surgical drains are commonly used after elective abdominal, cardiothoracic, orthopaedic, and breast procedures.
- One of the most common methods is described as the Roman garter method.
    - This method uses silk for the suture material.
    - This material is not desired as it becomes loose when wet and looses its friction.
    - This can lead to the loss of the drain from its placement.
- When drains are removed sometimes they can accidentally slide back into the patient's body.
- A new suture also may need to be added and this can cause drain leakage and cause the drain to displace into the body as well.
- The technique in this article describes a Tie-Lok device that is used to secure the drain in place.
- This stops the drain from moving back into the body as a stopper is now present to prevent this.
    - Following this addtion a suture is used to keep the drain in place with the skin.
    - Another loop from the suture is then created to attach to the tie lock.

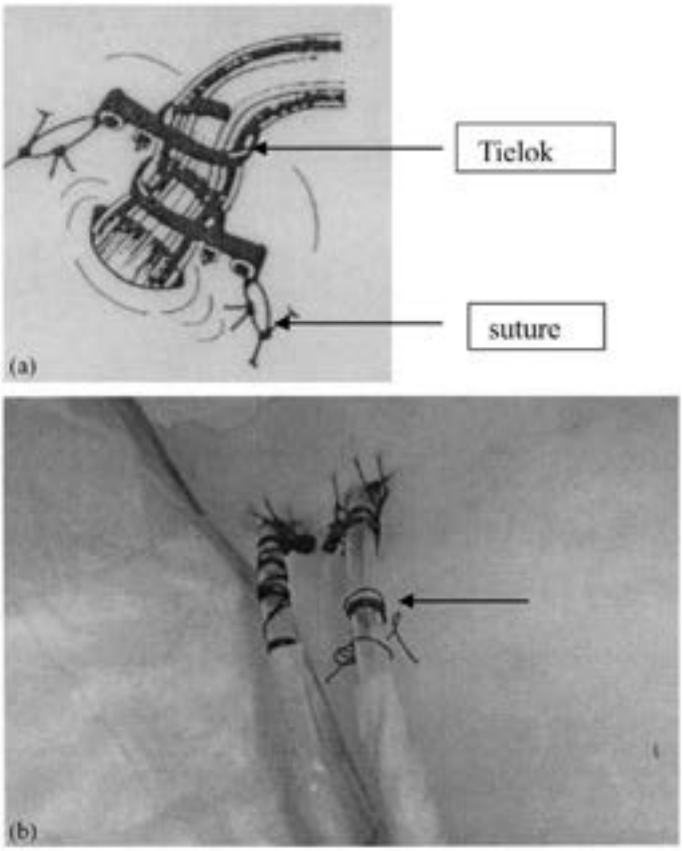


Figure 1: This image shows the tie lock in position on the drain and how the suture is attached to keep the drain in place on the skin of the patient.

- This mechanism is beneficial as it stops the drain from displacing and going back into the body, as well as moving from its original position.

Conclusions/action items:

This Tie-Lok device is a beneficial way to support the drain. It still uses a typical suture to keep the drain in place with the patients skin which causes discomfort, but is beneficial in that it will not allow the drain to go back into the patient any firther than it is. A stopped mechanism may be beneficial for our team to research as we are brainstorming. I will look more into the Tie-Lok design and the patents involved.

Citation: A. Tiwari, J. P. McFarlane, and J. L. Peters, “A simple technique for securing surgical drains,” Inj. extra, vol. 35, no. 11, pp. 91–93, 2004.

2022/09/15 - A new adaptation for a secure surgical drain placement

Dana Stumpfoll - Sep 15, 2022, 7:36 PM CDT

Title: A new adaptation for a secure surgical drain placement and a comparison with four common drain fixation methods

Date: 09/15/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Learn about four common drain fixation methods

Content:

- The methods that were studied are centurion sandal with plastic locking ties, centurion sandal or lattice method, centurion sandal with half-inch Steristrips®, double and multiple looped method.
- A tensiometer was used to apply force to the drains to determine when the securing methods would fail.
- The fixation method depends on the surgeon.
- They conducted a study at the Cork University Hospital and found that 90% of surgeons used the centurion sandal or lattice technique, 6.6% used the double loop technique, and 3.3% used a multiple loop technique.
- They tested these methods against the use of their technique which used the centurion sandal technique and two plastic ties.
    - They hypothesized the ties would increase the securing tension around the suture and also keep the lattic suture in place.
- Silk sutures have a tensile strength of 10N and energy to break point is 33.7N/mm
- To mimic patient movement and regular activites they applied a tension to one end of the drain in a cyclindrical pulsed loading fashion since a continuous applied force would not mimic the natural wear of the patient.
- Failure was determined by the exposure of a black dot on the drain which was placed below the skin surface into the drainage site hole.
- Each method was tested ten times and it showed that the most durable methods were the centurion sandal with plastic locking ties and centurion sandal with half-inch Steristrips®.

Conclusions/action items:

Different surgeons have different techniques for how they secure the drains to the patient. It seems that attaching the drain to the skin and securing a lattice structure around the drainage tube is the best method. I will consider this as I begin to design ideas for our project. I will come up with a method that secures the drain to the patients skin while also attaching to the end of the drain with out moving.

Citation: L. Heskin, V. Cahill, G. Filobbos, P. Regan, S. T. O'Sullivan, and K. Bryan, "A new adaptation for a secure surgical drain placement and a comparison with four common drain fixation methods," *Ann. R. Coll. Surg. Engl.*, vol. 101, no. 1, pp. 60–68, 2019.

2022/09/28- Fixing apparatus for surgical drainage tubes - Korean patent

Dana Stumpfoll - Sep 28, 2022, 12:27 PM CDT

Title: Fixing appartus for surgical drainage tubes

Date: 09/28/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: FInd patents for drain attachment devices

Content:

- This patent relates to a medical tube fixing device that is designed to be safe from accidents caused by infection or separation from the wound site.
- This device is patented as the "Medical drainage pipe fixing device" in the Korean Intellectual Property Office as patent registration No. 10-1948281.
- The patent part claims a fixing device comprised of an attachment fixing part and a clip part attched to the surgical site of the patient.
- The attachment fixing portion includes the attachment part to the patient's surgical site, a gauze receiving groove at a central position of a lower surface of the attachment portion, and a gauze receiving groove.
    - It also includes a tube insertion hole with a constant diameter in the center, and a slot cutout groove former to the be thinly extended into the tube insertion hole.
    - The clip portion is fixed to the upper surface of the attachment fixing portion with a fastener for the drainage tube.
    - The drainage tube is fastened with a strap which is clamped down by rotating the clamping cover attached to the body of the clip.
- This mechanism claims to cause less damage to the pateint's skin but seems to be more complicated for nurses to clean and access the wound site when necessary.
    - This lowered the price and competiveness of the device.
    - This design was created in South Korea.

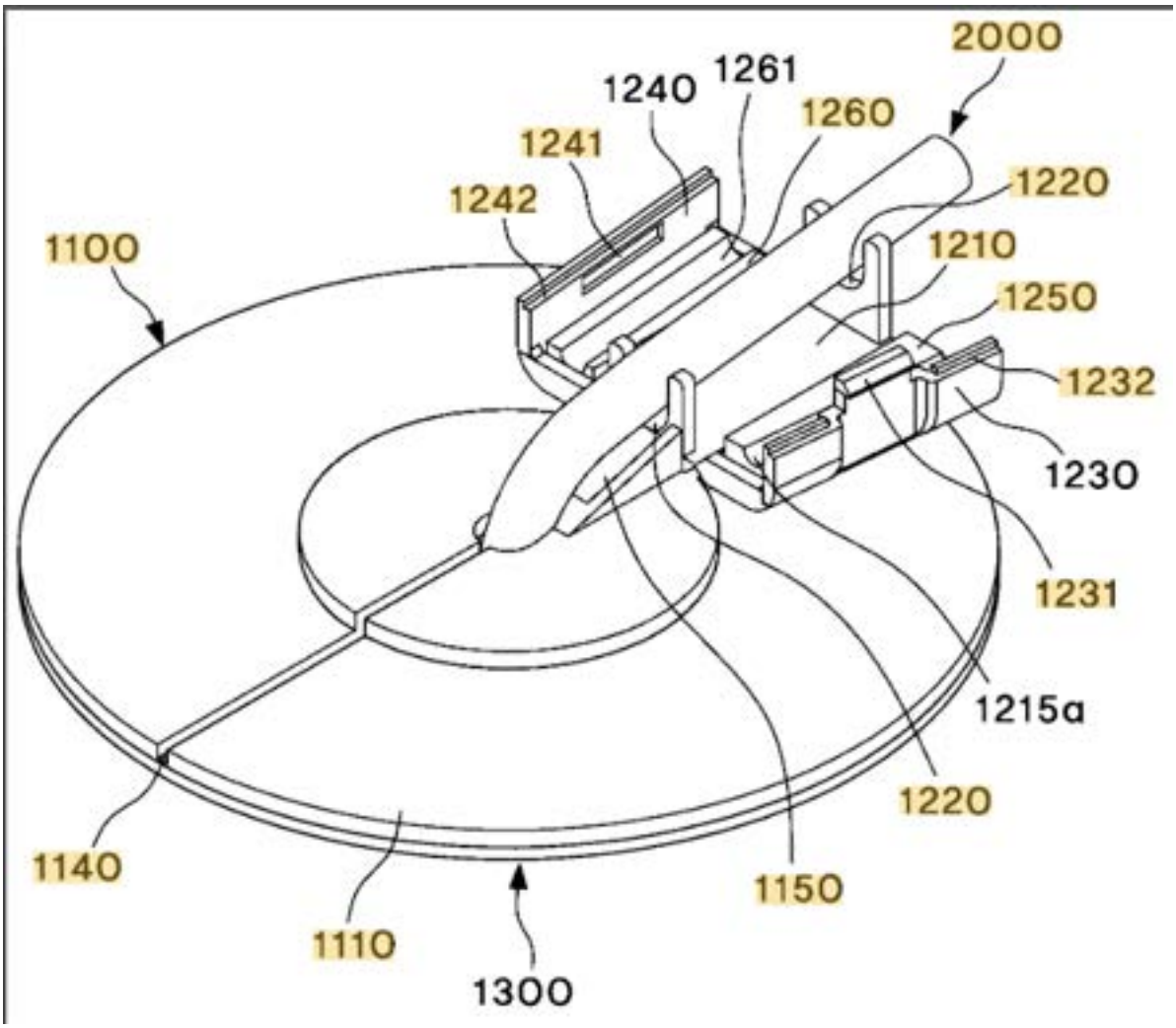


Figure 1: This patent covers the aspects of design shown in this figure.

Conclusions/action items:

This design is very similar to many other designs on the market and does not seem to allow for adjustment with different surgical drain types. I will continue to research other designs and try to come up with more creative ideas.

Citation: 김종태. (2021, May 10). Fixing apparatus for medical drainage tube.

2022/09/28- Drainage tube retention device

Dana Stumpfoll - Sep 28, 2022, 12:44 PM CDT

Title: Drainage tube rentention device patent

Date: 09/28/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: FInd patents for drain attachment devices

Content:

- The patent number for this design is US5073170.
- This patent is for a device that retains a drainage tube in place at the wound site of the patient.
- The design contains an adhesive pad with a flexible plastic retainer attached to the top of the design.
- The clip mechanism has teeth like ridges which line up with the face of the strap facing the surgical drain tube to the latch the surgical drain tube in place.

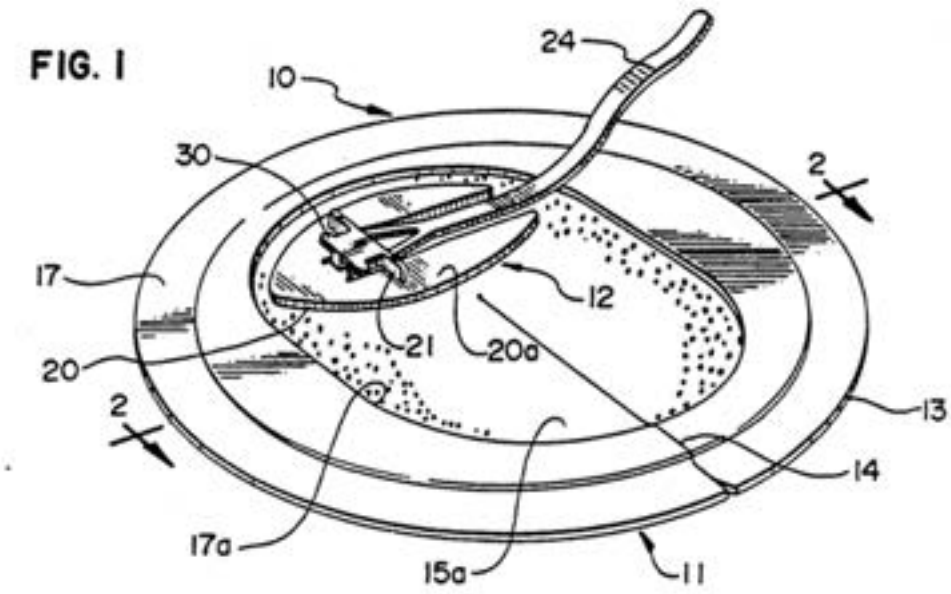


Figure 1: This figure shows the attachment device and the strap with teeth.

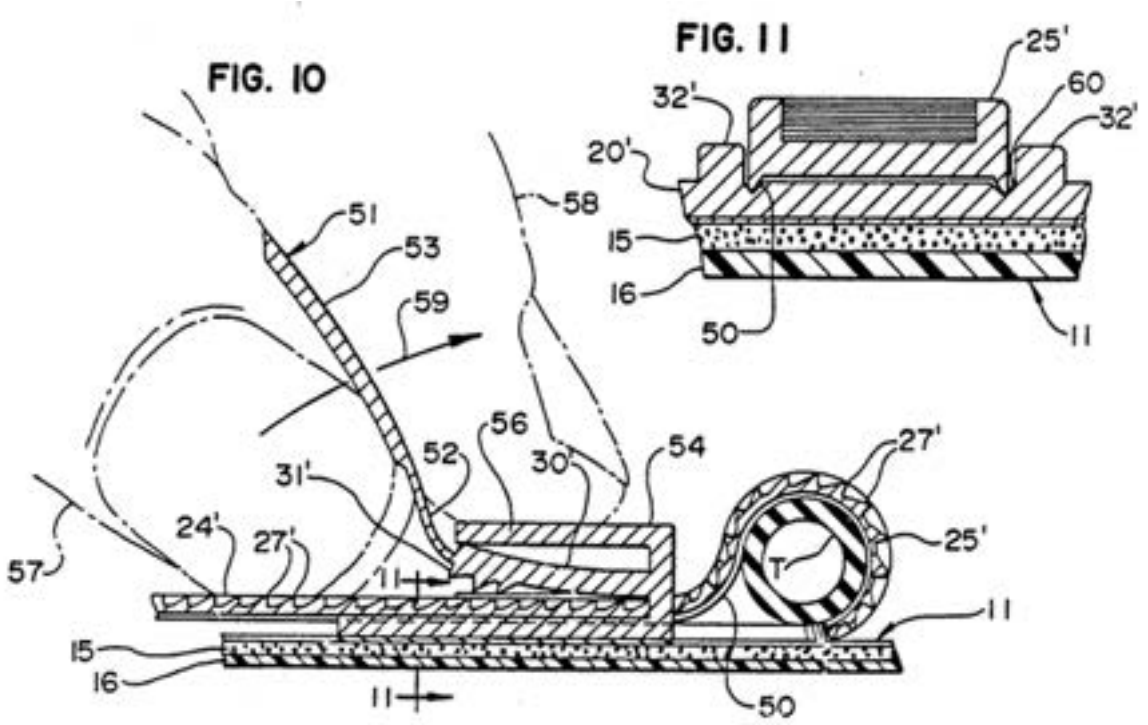


Figure 2: This image shows how the device would actually be wrapped around the drainage tube.

- This device is similar to many other devices on the market where it utilizes a zip-tie like design to secur the tube in place.
- The device also uses a similar mechanism where it attaches the device to the skin via an adhesive pad.

Conclusions/action items: It is apparent that a lot of patented designs are very similar to each other by the mechanism they use to secure the drain tube. This makes it difficult as coming up with a new design may be hard, but I will continue to be creative as I brainstorm more ideas.

Citation: Schneider, B. L. (1991, December 17). Drainage tube retention device .

2022/09/28- Interlocking low profile gripping device

Dana Stumpfoll - Sep 28, 2022, 1:11 PM CDT

Title: Interlocking low profile gripping device patent

Date: 09/28/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Find patents for drain attachment devices

Content:

- The patent number for this design is US11266813B2.
- This device is comprised of two straps with interlocking teeth that clip into the aperture of a buckle clip on a table platform.
- This device is specific for securing catheters and other flexible polymer tubing.
- The claims of this patent are for one or more locking mechanisms attached to a platform that attches to the patients skin.
    - The device has an open position and a locked in position.
    - The base of the strap is attached to the buckle where fins clip into place to lock it in.
    - The buckle has a root and distal end where the root end is where the strap enters and the distal end is where the strap can exit and be pulled on to tighten the strap.

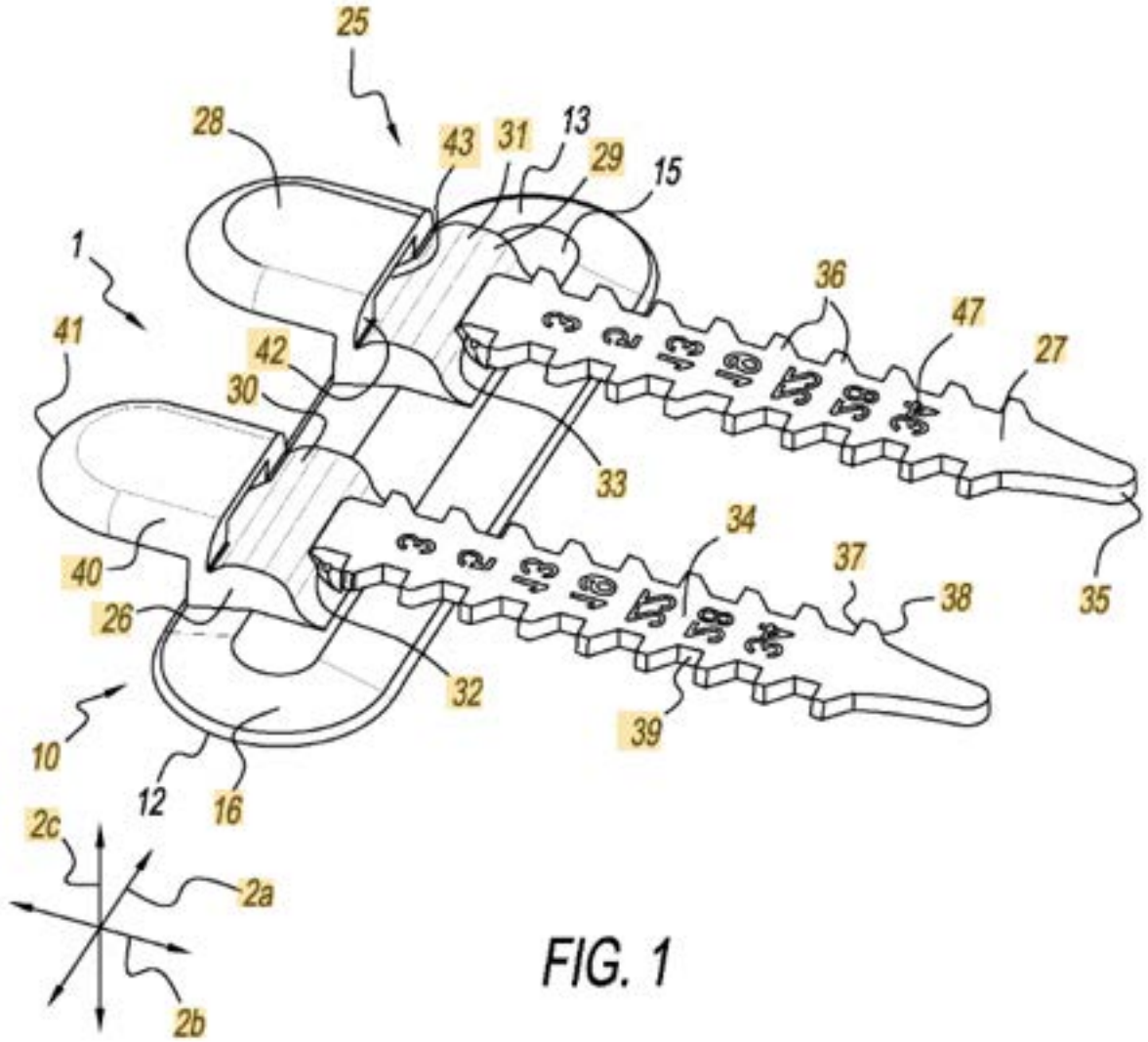


FIG. 1

Figure 1: This figure shows the detailed image of the claims made in this patent. The straps are ridge and lock into the buckled mechanism around the tube.

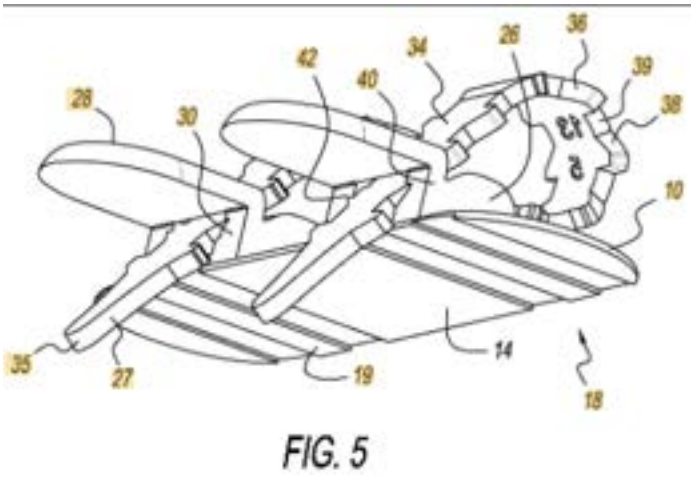


FIG. 5

Figure 2: This image shows how the wrap tucks into the buckle and how it would be wrapped around the tubing of the drain.

Conclusions/action items: This patent is very similar to the single ribbed strap mechanism I found. This patent does not expire until 2038 so it is currently being used for designs on the market. This is very common mechanism used on the market which involves a strap to wrap around the surgical tubing.

Citation: Harders, J., & Stone, S. (2022, March 8). Interlocking low profile gripping device.

2022/09/28- Post-surgical drainage bulb support sling

Dana Stumpfoll - Sep 30, 2022, 11:09 AM CDT

Title: Post-surgical drainage bulb support sling

Date: 09/28/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Find patents for surgical bulb support

Content:

- The patent number for this patent is US7927311B1.

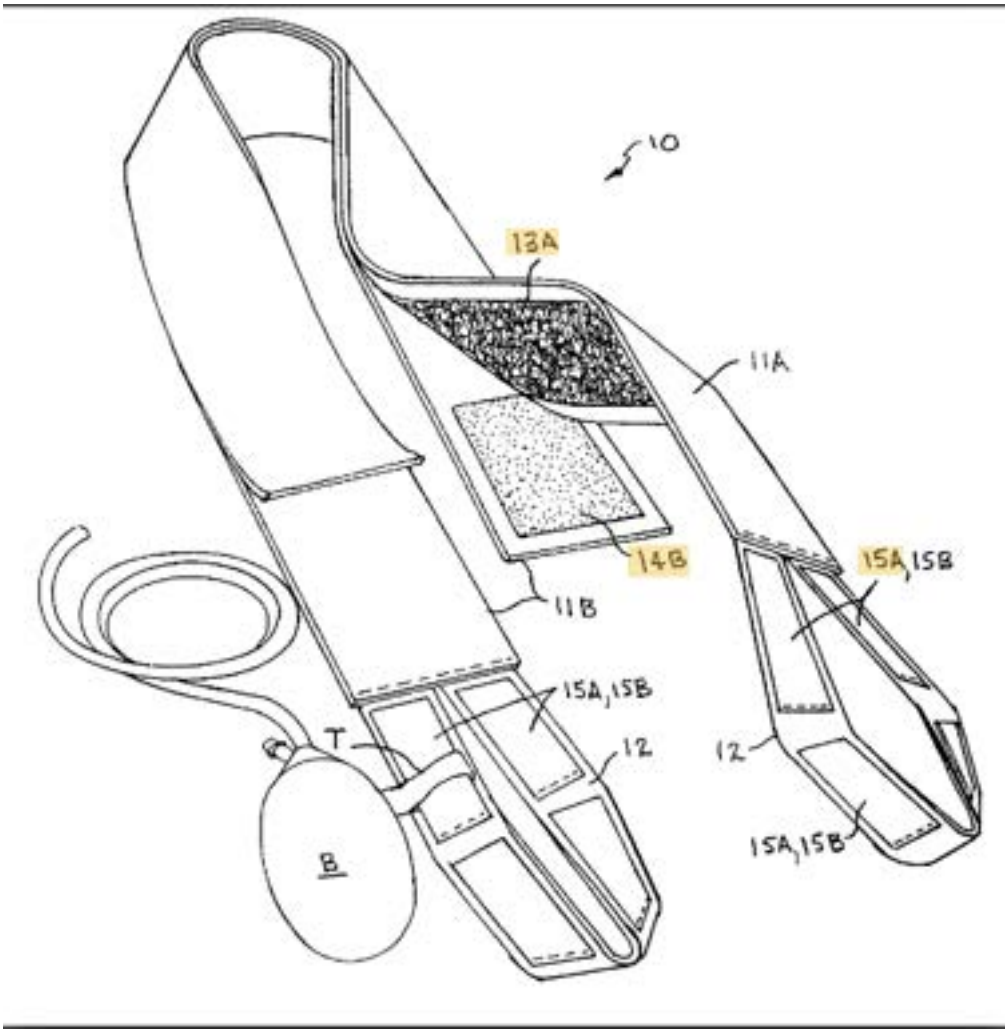


Figure 1: The design shown in this patent is an around the neck sling with velcro attachments for holding surgical bulbs.

- This patent claims the drains will be supported by the sling which wraps around the back of the patients neck.
- It also says it supports one or more drains held close to the body.
- It also claims the use of velcro hooks to support the bulbs.
- Lastly it claims the length of the sling is adjustable.

Conclusions/action items: The sling design has been commonly used for a bulb support device. I would find this to be uncomfortable over the surgery site especially if a masectomy was performed. I will continue to research different designs to see how they can be improved.

Citation: Bachelder, D. (2011, April 19). Post-surgical drainage bulb support sling.

2022/10/01 - Silicone-based adhesives for long term skin application

Dana Stumpfoll - Oct 09, 2022, 1:41 PM CDT

Title: Silicone-based adhesives for long term skin application

Date: 10/01/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Research adhesive materials

Content:

- An adhesive must have sufficient inital tack to secure the position of the device upon application and provide enough stickiness to secure the device throughout the duration of the wear time.
- The removal of the adhesive should not cause damage to the skin.
- Adhesives exhibit a viscoelastic form and develop adhesion to the skin and cohesion to resist removal from the skin.
- The three most common tests to test bandaids are tack, shear strength, and peel adhesion.
    - Tack is the instantaneous level of adhesion.
        - In order to hold something in place, a high level of tack is necessary.
    - Shear strength is also known as cohesion.
        - It describes the ability of the adhesive to resist shearing forces.
    - Peel adhesion describes the ability of the adhesive to resist peeling away from the skin.
        - This is tested after a period of adhesion.
- The silicone materials used were Silbione® RT 4717, Silbione® RT 4642, and Silpuran® 2130.
- The pads were tested on pig skin to determine their peel strength.
    - The difference between each material showed that the peel strengths were significantly different.
    - Silbione® RT 4717 showed a significantly higher peel strength than most medical grade adhesives such as BandAid and Dynarex clear surgical tape.
- A wash/wipe test showed that cleaning the silicone pad significantly reduces the peel strength of the material once it reused.
    - Since this material could be reused this would be beneficial for the time frame of our project.
- Silicone-based adhesives consist of two basic components, the polydimethylsiloxane and the silicate resin.
    - These materials may be beneficial for our adhesive material and I will continue to research on them.
- Pig skin resembles a similar texture to human skin and is a good model for testing adhesives.
- The bonding strength of the silicone material also increases with the thickness of the material.
- Due to envrionmental conditions and adhesive degradation, the material would only last for about a week long application.
- The Silbione® RT 4717 adhesive pad was shown to be the best material for adhesive applications.
    - I will do more research on this material and how resonable it would be for us to use it for our application.

Conclusions/action items: I will continue to research more adhesive silicone applications and how they could work with our design. I will also look into pig skin models we could use to test our design. This article is helpful for determining how cleaning the wound area would affect the adhesion of a silicone material if it were to be resusable to save money on the design.

Citation: L. Liu, K. Kuffel, D. K. Scott, G. Constantinescu, H.-J. Chung, and J. Rieger, “Silicone-based adhesives for long-term skin application: cleaning protocols and their effect on peel strength,” *Biomed. Phys. Eng. Express*, vol. 4, no. 1, p. 015004, 2017.

2022/10/05 - Kinesiology Tape Material

Dana Stumpfoll - Oct 05, 2022, 1:15 PM CDT

Title: Kinesiology Tape Material

Date: 10/05/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Research adhesive materials

Content:

- Kinesiology tape is an adhesive elastic material used in the treatment of musculoskeletal disorders.
- Manufacturers describe it as a cotton-based woven fabric with high elastic capability.
    - The adhesive is a thermostable resin.
    - Until the tape is used the adhesive resin is covered with some silicone type paper.
- KT tape is used because it is said to trigger mechanoreceptors in the skin and propioreceptors in muscles to accelerate repair processes under the site of the tape.
- The porosity of the tape greatly impacts its mechanical structure.
    - Specifically it helped with moisture absorbtion and bulk density of the material.
    - This also relates to air permeability or how breathable the tape is.
- The material is also water permeable to reduce the thermal degradation of the tape in relation to sweating.
- The adhesive material is described as 100% acrylic or more specifically as poly(butyl acrylate: sodium sulfoethyl methacrylate).

Conclusions/action items:

The KT tape is a great adhesive design as it is breathable and allows for wear during physical activities. The adhesive material may be beneficial as we figure out what we want to use for our design. I will continue to research adhesive materials and what they are made out of.

Citation: V. Tunakova, M. Tunak, J. Mullerova, M. Kolinova, and V. Bittner, “Material, structure, chosen mechanical andcomfort properties of kinesiology tape,” Journal of the Textile Institute, vol. 108, no. 12, pp. 2132–2146, 2017.

2022/10/10 - Hydrocolloid Bandage Material

Dana Stumpfoll - Oct 10, 2022, 9:50 PM CDT

Title: Hydrocolloid Bandages

Date: 10/10/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Research adhesive materials

Content:

- A hydrocolloid bandage has two layers.
- The first layer is the hydrocolloid adhesive that absorbs exudate to form a hydrated gel over the wound site.
    - This promotes a moist environment for healing and protects the new tissue that forms.
- The outer layer is used to form a seal to protect the wound from bacterial contamination and foreing debris.
    - It also works to maintain the moisture at the wound site.
- Hydrocolloid dressings are designed to be worn for up to 1 week.
- If drainage is not common for a wound another method for bandaging the site may be preferred.
- Since surgical drains sometimes leak at the wound site this bandage may be beneficial.
- Since hydrocolloid banages tend to have a water proof exterior layer and can be worn for up to a week this design may be beneficial for our adhesive.

Conclusions/action items:

A more waterproof bandage material may need to be found for our adhesive. A hydrocolloid material may be beneficial as it would absorb the excess fluid from the drain site that may leak out.

Citation: Barnes HR. Wound care: fact and fiction about hydrocolloid dressings. J Gerontol Nurs. 1993 Jun;19(6):23-6. doi: 10.3928/0098-9134-19930601-08. PMID: 8509607.

2022/10/10 - Plastic Materials Used in Medicine

Dana Stumpfoll - Oct 10, 2022, 9:49 PM CDT

Title: Plastic Materials

Date: 10/10/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Research plastic materials

Content:

- Typical plastics used in medical devices:
  - Polyvinyl chloride
    - It is tough but relatively cheap.
    - It is commonly used for articficial limbs.
    - The addition of plasticizers makes the material softer and more rubbbery.
    - It is commonly used for medical device gaskets, pipes, and seals and even medical gloves.
  - High density polyethylene
    - Typically used in medical applications.
    - White and rigid with a waxy layer.
    - Its toughness and nonporous structure make it ideal for the protective shell of medical deivces.
    - It absorbs little water and isn't affected by most acids making it ideal for medical implants.
  - Polycarbonate
    - A glass like material that is transparent but tougher than glass.
    - It is shatter resistant, chemical resistant, and can withstand higher temperatures.
    - This is typically used for hood covers and lab safety glasses or any other clear rigid items.
  - Polyetherimide
    - PEI is a rigid material typically used for protective covers for components that can get hot.
    - This material is more expensive compared to others.
    - It typically makes the circuit board of computerized medical devices.
    - It is heat resistant enough to be sanitized in an autoclave.
  - Acrylonitrile butadiene styrene
    - This material is cheap and is typically used for inhalers, tracheal tubes and non dissolvable sutures.
    - It can be used in a 3D printer which is beneficial for quick purposes.

Conclusions/action items:

High density polyethylene or acrylonitrile butadiene styrene would be good materials for the rigid plastic parts of our designs. I will look into the prices of these materials to decide which will be better and what is available through the makerspace.

Citation: J. Dewing, “Medical devices equipment: What plastic materials are used in them?,” Proto Plastics, 18-Feb-2022. [Online]. Available: https://protoplastics.com/plastic-materials-medical-devices-equipment/.

2022/10/17 - Silicone Bandaids

Dana Stumpfoll - Oct 23, 2022, 7:03 PM C

Title: Silicone Bandaids

Date: 10/17/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Research silicone bandaids and why they may be better

Content:

- Curad has devloped a silicone bandaid that may be better for the adhesive material for our project.
- The silicone bandaids are said to be ouchless and may be better for the purpose of our project if our product needs to be replaced once a week.
- The silicone adhesive layer is better for people with sensitive skin.
- The rubber based layer does not stick or pull on hair upon removal.
- The non stick pad of the bandaid has a foursided seal to prevent dirt and bacteria from getting stuck in the padding.

Conclusions/action items:

A silicone adhesive might be better for our purposes especially if our design needs to be replaced often as this will irritate the patients skin.

Citation: "Silicone bandages: Silicone Bandaids: AvaCare Medical," AvaCare Medical Supplies. [Online]. Available: https://www.avacaremedical.com/skin-wound-care/bandages/silicone-bandages.

Amazon link: https://www.amazon.com/Ouchless-Silicone-Adhesive-Bandages-Sensitive/dp/B07NQCJ4N8/ref=sr_1_5_mod_primary_sns?keywords=silicone+bandages&qid=1666568944&qu=eyJxc2MiOiI1LjQ3IiwicXNhIjoiNC45NiIsInFzcCI6IjQuNzcifQ%3D%3D&sbo=GLaw0Fx56FiNH%2FiZ%2B6XKiQ%3D%3D&s5

2022/10/10 - Code for Medical Adhesive Devices

Dana Stumpfoll - Oct 10, 2022, 9:50 PM CDT

Title: Code of Federal Regulation Title 21

Date: 10/10/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Research codes and standards

Content:

- This code from the FDA defines the classification of medical adhesive tape and adhesive bandages.
- It describes a medical adhesive tape or bandage as:
    - a device intended for medical purposes that consists of a strip of fabric or plastic coated with adhesive on one side and may include a pad of surgical dressing without the requirement of a disinfectant.
    - The device is used to cover and protect wounds
        - hold skin together at the edges of a wound
        - support an injured part of the body
        - or secure objects to the skin
- This classifies the device as Class I.
- This would classify our device as Class I since it would be used to secure a clip to the skin of the patient.

Conclusions/action items:

Our device would be classified as Class I. I will look into more standards and patents for our device.

Citation: “CFR - Code of Federal Regulations Title 21,” accessdata.fda.gov. [Online]. Available: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?FR=880.5240.

2022/10/10 - Standard Test Method for Strength Properties of Tissue Adhesives in Tension

Dana Stumpfoll - Oct 10, 2022, 10:25 PM CDT

Title: Standard Test Method for Strength Properties of Tissue Adhesives in Tension

Date: 10/10/22

Content by: Dana Stumpfoll

Present: Individual Work

Goals: Research codes and standards

Content:

- This standard is intended to provide a test method for comparing of the tissue adhesive strengths intended for surgical adhesives or sealants on soft tissue.
- It may also be used for quality control in the manufacturing of tissue adhesive materials.
- There are factors that must be considered for the success and efficacy of medical tissue adhesives including:
    - adequate tissue bonding strength
    - tissue compatability
    - acceptable biodegradable properties when used internally
    - availability
    - ease of application
    - cost
- A reproducible testing standard is necessary for evaluating the effectiveness of the device.
- The testing machine consists of
    - Fixed member
    - movable member
    - grips
        - fixed and self-aligning
    - drive mechanism
    - load indicator
    - temperature controlling equipment
- For testing the substrate, frozen or fresh porcine tissue may be used.
    - This is due to its wide availability and the fact that large samples can be obtained in one sample.
    - Tissue should typically be used within 24 hr of obtaining and be kept between 5 and 10 degrees celcius.
    - The tissue should be brought to the test temperature prior to applying the adhesive.
- Fixed tissue should not be used as fixatives can alter the mechanical properties of the skin.
- The thickness of the tissue should be minimized and should not exceed 5mm.
- Tissue substrates should be kept moist with PBS.
    - The tissue can be laid out on a soaked gauze with PBS and the other side can be patted dry for the adhesive to adhere to.
    - The tissue should be glued to the test fixture platform and the adhesive should be appied per the instructions given.
- The following should be recorded:
    - identification of the adhesive tested
    - identification of the tissue substrate used and how thick it is
    - estimation of how much adhesive is applied and how it was applied
    - ambient conditions of adhering
    - conditions of the specimen prior to adhesion

- number of specimens tested
- type of failure

Conclusions/action items:

This standard testing procedure may be beneficial after fabrication for testing if we are able to obtain porcine skin.

Citation: “Standard test method for strength properties of tissue adhesives in tension,” *Astm.org*. [Online]. Available: https://www.astm.org/f2258-05r15.html.

2022/09/22- Clipping bandaid mechanism

Dana Stumpfoll - Sep 22, 2022, 9:19 PM CDT

Title: Clipping Bandaid Mechanism

Date: 09/22/2021

Content by: Dana

Present: Individual work

Goals: Brainstorm for first brainstorming meeting with team

Content:

- My first idea was to design a adhesive mechanism that sticks to the skin around the drainage site that incorporates a clip to secure the drain in place.
- This adhesive mechanism would have a slit where it would be easy to place the design around the draintube and around the wound site.
- The clip would be apart of the adhesive design and would be controlled by two prongs, similar to how a hair clip functions.
- The clip would be adjustable to account for the different diameters of different surgical drains.

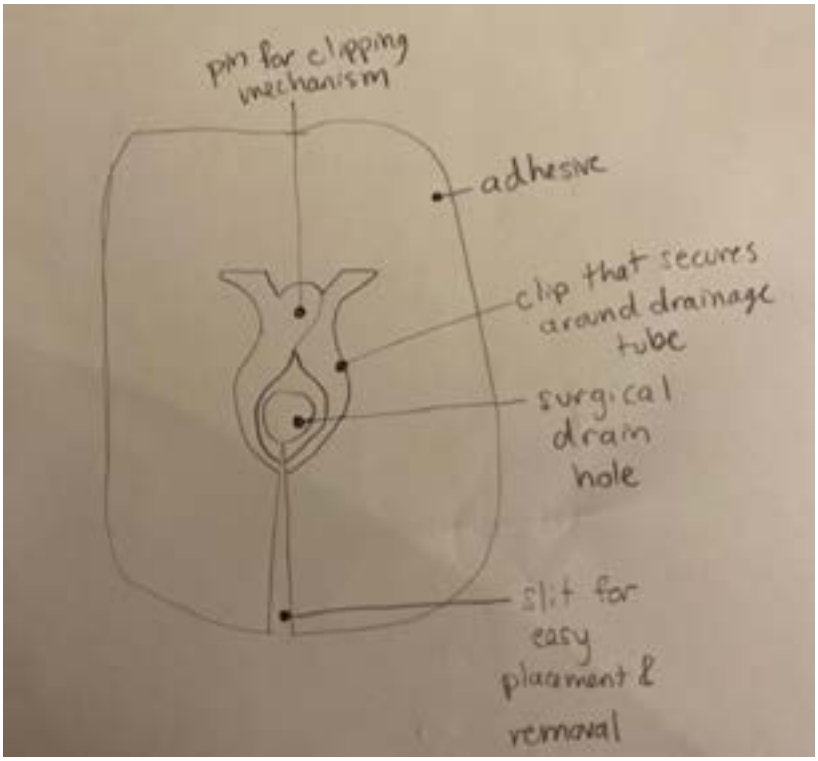


Figure 1: A labeled image of the design described above.

Conclusions/action items: I will continue to brainstorm more ideas involving sutures and other mechanisms to keep the drain in place. I will also show my designs to my team so we can design a decision matrix.

2022/09/28 - Attachment devices/ surgical tubing/bulb clothing

Dana Stumpfoll - Sep 28, 2022, 11:34 PM CDT

Title: Brainstorming 2

Date: 09/28/2021

Content by: Dana

Present: Individual work

Goals: Brainstorm more ideas

Content:

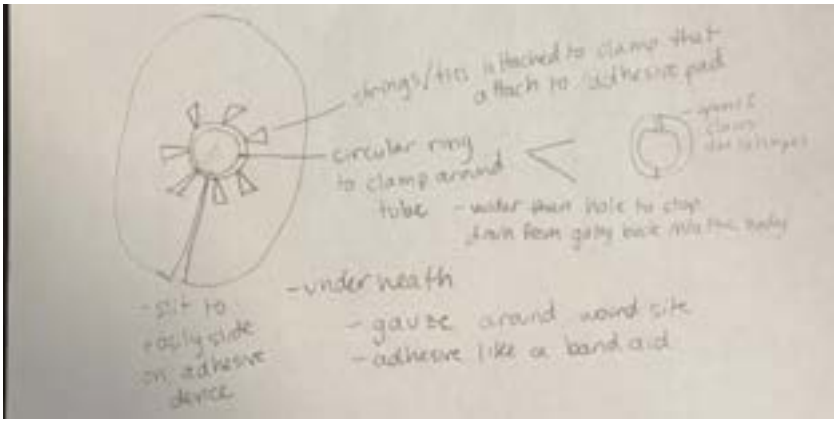


Figure 1: My first idea was to do a clamp device with strings that would attach to a an adhesive bandage.

- This first design uses a clamping mechanism to wrap around the tube of the surgical drain to hold it in place.
- The clamp is the attached to the skin of the patient by sewing strings or utilizing ties that attach it to an adhesive bandage.
- The clamp would also be a thicker material so that the outer circumference of the clamp is wider than the drain site hole and this will stop the drain from going back into the patient.
- There is a slit to easily slide the design on and off the patient.
- The adhesive side would have gauze around the site of the wound and would be adhesive bandage material for the rest.

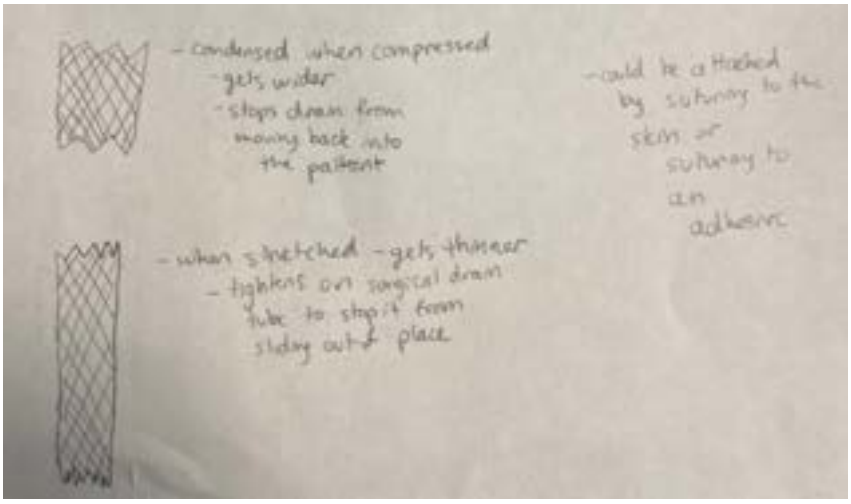


Figure 2: This design uses a braided structure that expands and contracts around the tubing of the drain.

- When the device is tugged on it would contract around the tube not allowing the tube to be moved from its position.

- When it is compressed the device expands and would not allow the tube to go back into the patient due to the diameter being bigger than the wound site.
- The device would be attached to the tube via strings that would wrap on the inside of the device around the tubing of the drain.
- These device would then be sutured to the skin of the patient or sewed onto an adhesive bandage.

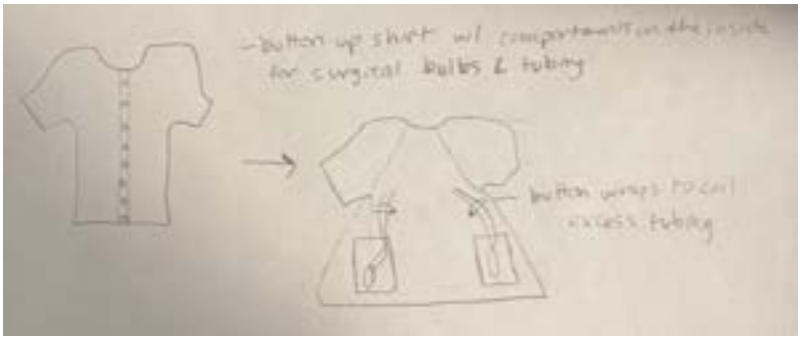


Figure 3: This design is similar to designs on the market where it is a shirt with pouches.

- A lot of the drain bag ideas are already on the market, but my idea is to invent a blouse that you could wear out that conceals the drains.
- The button up idea makes the shirt easier to put on since the patients range of motion may be limited.
- The design also incorporates a velcro strap to wrap the excess tubing around to ensure it does not dangle outside of the shirt.

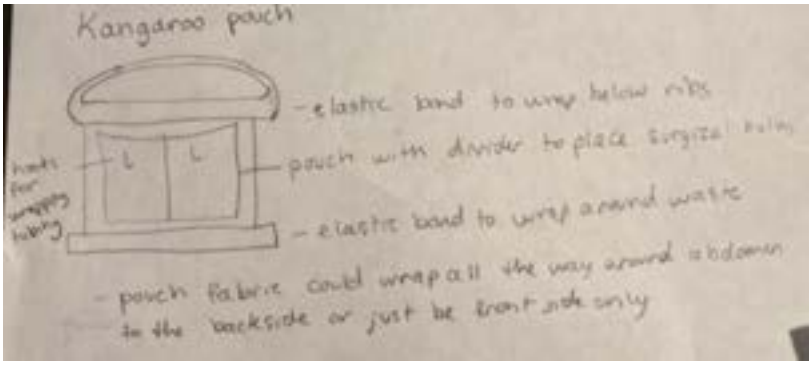


Figure 4: This design utilizes a similar mechanism to that of a kangaroo pouch.

- This design consists of two elastic bands used to keep the pouch from swining under the patients shirt.
- One band goes below the chest of the patient and the other wraps around their waist.
- The pouch in the middle holds the drain and would have hooks to coil the tubing from the drain.
- There is a divider between the two pouches to stop the drains from sliding into each other.
- The pouch material could wrap entirely around the back side of the patient or the backside could be left open.

Conclusions/action items: Overall it was difficult to come up with design ideas since there are so many devices already on the market.

2022/10/21 - SolidWorks Designs

Dana Stumpfoll - Oct 23, 2022, 6:48 PM CDT

Title: SolidWorks Designs

Date: 10/21/22

Content by: Dana

Present: Everyone

Goals: Model each design in Soliworks

Content:

I worked on modeling the designs we came up with in SolidWorks. I took the time during our meeting to try and figure out how to make a clip and the Oscar found a clip that we could buy that would better.

Conclusions/action items: I will work on adding dimensions to the model and make them look better. I will upload images to this page once I have added dimensions.

Dana Stumpfoll - Oct 23, 2022, 6:46 PM CDT

Download

Velcro_design.SLDPRT (126 kB)

Dana Stumpfoll - Oct 23, 2022, 6:46 PM CDT

Download

Adhesive_design.SLDPRT (113 kB)

Dana Stumpfoll - Oct 23, 2022, 6:46 PM CDT

Download

Clip_design.SLDPRT (159 kB)

9/13/22 Optimal Use of Surgical Drains: Evidence Based Strategies

LAUREN HELLER - Sep 14, 2022, 3:04 PM CDT

Title: Optimal Use of Surgical Drains: Evidence-Based Strategies

Date: 9/13/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Research the various uses of surgical drains, and what qualities the drain should have for each application.

Content:

An in vitro model was used to look at the effects of tubing length, tubing size, tubing type, fluid viscosity, fluid clotting, and evacuator type/squeeze method/fill/pressure on the performance of closed-suction drains.

When aiming to prevent seromas, high negative drain pressure proved to be more effective than low negative pressure. This means that our team's design must make sure not to inhibit the negative pressure in a closed-suction drain set-up. When assessing flow rate, use Poiseuille's Equation!

Materials and methods were carefully constructed. When testing, some of these methods will be good to look back on, and it may be helpful to recreate these tests during the testing phase to ensure our design does not inhibit proper drainage.

Due to a lack of existing studies, there are no set optimal parameters for drains, and the types of drains used tend to vary significantly from surgeon to surgeon, as well as based on the procedure site. Our design must be comprehensive and applicable to any size drain. It should not be a design with only one specific type of drain in mind.

Conclusions/action items:

Fluid flow rate through the drain increases with increasing intracavitary tubing length, decreasing extracavitary tubing length, increasing tubing diameter, increasing negative pressure, decreasing fluid viscosity, and the use of perforated rather than fluted drains. Bulbs generate more effective suction when squeezed “side-to-side” than when squeezed “bottom-up,” and evacuators were only able to generate half the maximal negative pressure when 25 percent full or greater. Stripping the drain tubing helped relieve obstruction caused by clotting.

This article will be specifically useful when looking to test the design against various different drain types and sizes. The sutured in method with our future design should have comparable drainage result values to those tested with the in vitro model in this study.

LAUREN HELLER - Sep 13, 2022, 9:07 PM CDT

Link: https://pubmed.ncbi.nlm.nih.gov/29608530/

IEEE Citation:

K. I. K. L. M. J. J. JE; “Optimal use of surgical drains: Evidence-based strategies,” *Plastic and reconstructive surgery*. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/29608530/. [Accessed: 13-Sep-2022].

LAUREN HELLER - Sep 13, 2022, 9:07 PM CDT


RECONSTRUCTIVE

Optimal Use of Surgical Drains: Evidence-Based Strategies

Download

Optimal_Use_of_Surgical_Drains__Evidence-Based_Strategies.pdf (331 kB)

9/20/22 Surgical Drain Use Duration Following Breast Surgery

LAUREN HELLER - Sep 20, 2022, 10:14 PM CDT

Title: Surgical Drain Use Duration Following Breast Surgery with Axillary Dissection

Date: 9/20/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Understand the varying time periods that surgical drains are used to better formulate preliminary designs.

Content:

- Suction drainage volumes were measured for 63 patients after two different variations of breast surgeries with axillary dissection.

-The median removal was after 4 days, with a range of 1-7 days. 51% of these patients later needed needle aspiration treatment for developed seromas.

- Seroma formation is common after breast and axillary surgery. Seromas are a term for a buildup of bodily fluids following tissue removal during surgery. Small seromas can go away on their own, but if they grow larger or appear to be infected, they need to be drained by a professional.

- Polyvinyl chloride tube drains (6mm external diameter and 3mm) were used.

- Patients had their drainage volumes measured every 24 hours, and the drains were removed when their respective clinicians decided it was time (standard practice).

- This study analyzed the relationship between drainage volumes, types of surgery, lymph node yield, and seroma formation.

Findings:

- Patients required a median of two aspirations, on separate occasions. There was no found increased risk for infection based on seroma formation.

- When the two surgeries were compared, there was no statistically significant difference in seroma rate between those in the mastectomy group over the wide incision group.

- The total volume of fluid drained into both bottles was significantly higher in those who later developed a seroma. The mean drainage of those who developed seromas was 480 mL, compared to a mean drainage quantity of 240mL in those who did not develop seromas.

- Those who developed seromas also had their drains left in longer on average (4 days compared to 3 days), however each drain had drained about 74% of its total volume after 48 hours on average.

- More seromas were seen when a larger number of lymph nodes were dissected from the axilla.

- Suction drainage has been shown to reduce the incidence of seroma formation, but it does not prevent it. This makes sense why closed system/negative pressure drains are much more common than open system drains.

- It is common to believe that leaving the drains in longer could help prevent seromas. However, it was found that keeping the drains in situ for an extra day on average did not show any additional protection against seroma formation.

- The discussion section does suggest that techniques other than prolonged suction drainage, such as sutures or tissue glues to assist in closing the space after drain removal may be more helpful at preventing seroma formation.

- Seroma aspiration can be a bit uncomfortable and an inconvenience, but it is not a serious complication overall. The discussion does suggest that patients may prefer to know that they are more likely to need an aspiration if it means that the drain can be removed earlier and they can return home quicker.

Conclusions/action items:

Initially I was expecting there to be more of a correlation between the duration that the drain stayed in and the success of healing properly. It appears that there isn't much of a correlation, and it really depends on each individual. While the range of drain use was only spread out over the course of a week, our design is not meant to be limited to breast surgeries specifically. Other applications of drains can be needed for several weeks. Our design should be durable enough to withstand long use times, but should also be versatile enough to assist in drain use for very short durations as well.

LAUREN HELLER - Sep 19, 2022, 9:27 PM CDT

Link: https://pubmed.ncbi.nlm.nih.gov/9422871/

IEEE Citation:

B. J. C. L. W. R. M. T. C; “How long should suction drains stay in after breast surgery with axillary dissection?,” *Annals of the Royal College of Surgeons of England*. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/9422871/. [Accessed: 19-Sep-2022].

LAUREN HELLER - Sep 19, 2022, 9:28 PM CDT

How long should suction drains stay in after breast surgery with axillary dissection?

Download

annrcse01610-0053.pdf (415 kB)

9/18/22 Surgical Seecrets "Seecret Apron" for Drain Storage

LAUREN HELLER - Sep 18, 2022, 5:52 PM CDT

Title: Surgical Seecrets "Seecret Apron" for Drain Storage

Date: 9/18/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Research current designs aiming to reduce drain pain.

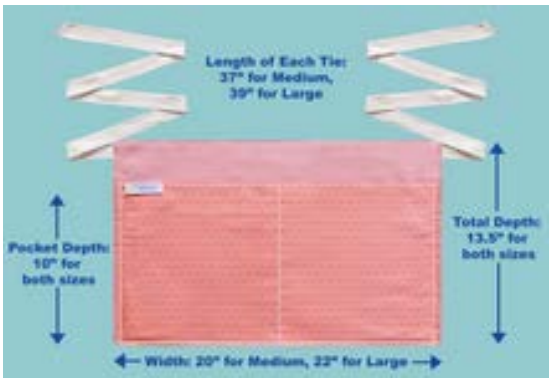
Content:

-The Seecret Apron is designed to be attached around the waist. There are two pockets on the apron, each of which can hold three standard drainage bulbs (can hold six total).

- The apron costs $25.00 per unit.

- The aprons are made out of poly-cotton, and are designed with extra long ties that can be trimmed to the person's preference.

- The design can be used by anyone with surgical drains, but is especially helpful for those who had breast, chest, abdominal, or hip region surgery.



Dimensions of the Apron Design.

One variation of the apron, available in a variety of designs.

A photo from the apron demo, showing the attachment around a mannequin's midsection and secured with the ties.

Conclusions/action items:

This design had very good reviews, and seemed to provide a lot of relief for those who used it. Even if our design focuses on the suture site specifically, we should also consider designing a way to hold the drains as well, to maximize drain pain relief.

LAUREN HELLER - Sep 18, 2022, 5:59 PM CDT

Link: https://surgicalseecrets.com/products/seecret-apron

IEEE Citation:

“Seecret Apron™ - post-surgical Drain Holder & Pouch,” *Surgical Seecrets*. [Online]. Available: https://surgicalseecrets.com/products/seecret-apron. [Accessed: 18-Sep-2022].

10/25/22 Use of Biopatch Devices at Drain Sites to Reduce Perioperative Complications

LAUREN HELLER - Oct 25, 2022, 3:27 PM CDT

Title: Does the Use of Biopatch Devices at Drain Sites Reduce Perioperative Infectious Complications in Patients?

Date: 10/25/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Research additional topics presented by Dr. Wilke in the past meeting.

Content:

- The Biopatch is currently used at drain exit sites by some surgeons to decrease the rate of infectious complications.

- Dr. Wilke noted that they do not commonly use them at the hospital, as they do not hold the drain securely enough to be advantageous over sutures.

- This review focuses on comparing controls with traditional adhesive dressings versus those with Biopatch disks at drain sites. The disks contain chlorhexidine gluconate, aimed to provide antimicrobial protection to the skin for seven days.

- Both groups needed to keep the drains in for similar amounts of time, averaging 9.6 days in the control, and 10.1 days in the antibiotic therapy group.

- There was no significant difference found in overall infection rates, mastectomy skin flap necrosis occurrence, or explantation rates. There was a higher rate of seroma formation in the Biopatch group (5.3%) versus the control group (2.8%).

- While the disks have been shown to be effective at protection for up to seven days, they likely need to be developed to last longer. This study also only focuses on one type of breast surgery, rather than all types. It does not appear that the Biopatch disks provide any advantage for infection prevention when placed at the drain site.

Conclusions/action items:

This study found similar results to those expressed by Dr. Wilke when we spoke with her. There is not enough of an advantage to use these over traditional sutures and dressings. This study does not mention if sutures were used in conjunction with the disks, or if the disks were used on their own. Sutures are especially helpful when drains are placed in the chest, as they are easier to disrupt than those placed in the abdomen.

LAUREN HELLER - Oct 25, 2022, 3:10 PM CDT

Link:
https://journals.lww.com/plasreconsurg/fulltext/2015/01000/Does_the_Use_of_Biopatch_Devices_at_Drain_Sites.4.aspx?casa_token=UNrotzyChb0AAAAA:auww7i3Fml-74TKN_xVkV20EcSGvgEgFvQ_xRGplJDxoeXSj3XQL4VwzQ98ENtqlYKae3-yZ8zerSRont9y_MzLqsA

IEEE Citation:

N. York, “Does the use of biopatch devices at drain sites reduce... : Plastic and reconstructive surgery,” *LWW*. [Online]. Available: https://journals.lww.com/plasreconsurg/fulltext/2015/01000/Does_the_Use_of_Biopatch_Devices_at_Drain_Sites.4.aspx?casa_token=UNrotzyChb0AAAAA%3Aauww7i3Fml-74TKN_xVkV20EcSGvgEgFvQ_xRGplJDxoeXSj3XQL4VwzQ98ENtqlYKae3-yZ8zerSRont9y_MzLqsA. [Accessed: 25-Oct-2022].

9/11/22 UW Health Care of Surgical Drain at Home

LAUREN HELLER - Sep 11, 2022, 11:18 AM CDT

Title: UW Health Care of Surgical Drain at Home

Date: 9/11/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Understand background information and project details prior to additional research.

Content:

Important Information to consider when brainstorming a design:

- The drain site must be cleaned daily, either in the shower or by using a wet compress.

- Dressing over the drain must be changed daily

- A drain should be stripped twice daily to keep the tube from backing up, but patient must be cautious not to pull the drain out

- The drainage is measured twice a day, so the design must not inhibit the ability to check drainage quantities

- A drain is an open wound, and must be treated carefully. Keep eye out for signs of infection, such as temperature, nausea, and pus.

- There are good diagrams in this as well, showing how to drain the fluid, and how to close it back while restoring suction.

Conclusions/action items:

There are many factors that must be considered when designing an alternative method to secure surgical drains. Continue reading suggested articles, and conduct additional research on the topic prior to next group meeting.

LAUREN HELLER - Sep 11, 2022, 11:20 AM CDT

Link: https://patient.uwhealth.org/healthfacts/4603

IEEE Citation:

“Patients & families: UW health,” *Health and Nutrition Facts for You | Patients & Families | UW Health*. [Online]. Available: https://patient.uwhealth.org/healthfacts/4603. [Accessed: 11-Sep-2022].

UWHealth Health Facts *for you*

Care of Your Surgical Drain at Home

Download

4603.pdf (529 kB)

9/11/22 "Surgical Secrets" Blog on Minimizing Drain Pain

LAUREN HELLER - Sep 11, 2022, 4:18 PM CDT

Title: Dr. Li's Guide to Getting Drains After Surgery

Date: 9/11/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Understand related information to project to prepare for client meeting and brainstorming.

Content:

Drains are used to prevent fluid build-up after a surgery. These drains need to be emptied, and the quantity of fluid needs to be measured. If pulled on or brushed over, they can become uncomfortable for the patient.

Drains are used after a surgery that creates a space, such as masectomies or axillary lymph node dissections. They are used to prevent an abscess that could form from fluid backup and infection. The attached bulbs work to create a negative pressure system, pulling the fluid out of the surgical site. These drains are typically attached using stitches to avoid unintentional removal.

Drain pain happens when the site is pulled on, leading to irritation and redness. It can also lead to infection if the site is not properly cared for. To minimize this pain, the doctor recommends either securing the drain by pinning it to your clothing, or buying their product called the "Seecret Apron" which holds all of the drains in one place. By leaving some slack in the tubing, this puts less pressure on the exit site, and can help reduce irritation and pain.

The major concerns with stitches is that they can loosen or fall out prematurely. If this happens, they suggest trying to keep it in place and to contact your surgeon. When the tube moves, there is risk of bringing additional infections or contaminants from the outside into the surgical site. They also say that you can use gauze and tape to support the drain, but that it may also lead to more irritation from the tape's adhesive.

Conclusions/action items:

There are many factors that can cause irritation at the drainage site. It is important to not only consider an alternative to the sutures, but to also consider treatment of the area needed with the new method.

LAUREN HELLER - Sep 11, 2022, 4:21 PM CDT

Link: https://surgicalseecrets.com/blogs/articles/guide-to-getting-drains-after-surgery

IEEE Citation:

D. W.-Y. Li, “Dr. Li's guide to getting drains after surgery,” *Surgical Seecrets*, 07-Oct-2020. [Online]. Available: https://surgicalseecrets.com/blogs/articles/guide-to-getting-drains-after-surgery. [Accessed: 11-Sep-2022].

9/11/22 A Simple Technique for Securing Surgical Drains

LAUREN HELLER - Sep 11, 2022, 6:12 PM CDT

Title: A Simple Technique for Securing Surgical Drains

Date: 9/11/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Begin early stages of the design project, including research and brainstorming, to prepare for the initial client meeting

Content:

Currently, the most common method for securing the drains is the Roman Garter Technique (silk for suturing). The silk creates friction around the drain to hold it in place, however it may become loose due to bad technique or too much wetness at the site.

Issues tend to most commonly arise with trauma patients, where there are so many issues that need to be treated, so there may have not been enough attention paid to securing the surgical drains. In abdominal surgery, there is also concern for the drain to possible be transected and slid back into the patient's body during the removal process.

This method uses the Tie-Lok to firmly secure the drainage compartment to the drain. The site is sutured in normal fashion, but then an additional loop of the stitch is passed through the eye of the Tie-Lok to better hold it in place. If the drain needs to be repositioned or shortened, the eye is cut, and a new Tie-Lok is used to secure the modified drain.

Conclusions/action items:

This method is mainly focused on securing the surgical drains as well as possible to avoid any chance of unwanted removal. It does not talk about any design features that are meant to reduce pain or irritation at the site, and still does require additional sutures.

LAUREN HELLER - Sep 11, 2022, 6:14 PM CDT

Link: https://www.sciencedirect.com/science/article/pii/S1572346104000327#bib1

IEEE Citation:

A. Tiwari, J. P. McFarlane, and J. L. Peters, “A simple technique for securing surgical drains,” *Injury Extra*, 11-Sep-2004. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1572346104000327#bib1. [Accessed: 11-Sep-2022].

LAUREN HELLER - Sep 11, 2022, 6:14 PM CDT

A simple technique for securing surgical drains

Download

1-s2.0-S1572346104000327-main.pdf (181 kB)

9/13/22 A New Adaptation For a Secure Surgical Drain Placement and a Comparison with Four Common Drain Fixation Methods

LAUREN HELLER - Sep 13, 2022, 8:57 PM CDT

Title: A New Adaptation for a Secure Surgical Drain Placement and a Comparison with Four Common Drain Fixation Methods

Date: 9/13/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Gather a basis of understanding on different surgical drain suture methods prior to designing an alternative solution.

Content:

See PDF attached for future image reference of each method.

Note: Each design was tested using a tensiometer to apply a measured force to the secured PVC drain. In order to mimic the real conditions that the drain would typically be under, the team made sure not to apply unnatural continuous force to the drains. The tension was instead applied in a cyclical pulsed loading fashion to mimic occasional stresses in the home or hospital settings.

Silk sutures have a tensile strength of 10 N. In this experiment, the cyclical force applied was increased gradually up to a force of 30 N, and then was repeated until each design failed. Each method was tested this way 10 times, and all fixations were performed by the same surgeon.

Centurion Sandal/Lattice Method with two plastic locking ties:

Among the highest failure rate, with an average of 7 cycles. However, had the least drain displacement with an average of 1mm.

Centurion Sandal (alone):

Among the lowest failure rates, completed an average of 8.5 cycles. High level of drain displacement, with an average value of 3.6mm.

Centurion Sandal with 1/2 inch Steristrips:

Among the highest failure rate, with an average of 7 cycles. Also had significant displacement, with an average of 2.4mm

Double Loop method:

In the middle for failure, average of 7.5 cycles. Average drain displacement of 2mm.

Multiple Loop method:

Second lowest failure rate, completed 8 cycles on average. However, there was a huge drain displacement average compared to the other designs, with an average displacement of 6.8mm.

Conclusions/action items:

The study results point to the centurion sandal with ties as a good modification overall. While there is a higher failure rate, the failure was always due to the sutures, and did not result in a large displacement of the drain. When securing a drain, it would be preferred that the failure point comes from the sutures, rather than due to the drain being dislodged and unable to properly remove fluids from the surgical site. The adhesive Steristrips worked decently well, however it was noted that the tests were done in a dry environment. Clinically, and in home care settings, the site will need to be cleaned, and cannot always remain dry. It is important to take careful considerations when choosing a method to proceed with during the preliminary design process.

LAUREN HELLER - Sep 12, 2022, 12:47 PM CDT

Link: https://publishing.rcseng.ac.uk/doi/epdf/10.1308/rcsann.2018.0177

IEEE Citation:

A new adaptation for a secure surgical drain placement and a comparison with four common drain fixation methods. [Online]. Available: https://publishing.rcseng.ac.uk/doi/epdf/10.1308/rcsann.2018.0177. [Accessed: 12-Sep-2022].

A new adaptation for a secure surgical drain placement and a comparison with four common drain fixation methods

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rcsann.2018.0177.pdf (1.05 MB)

9/18/22 FDA Suture Standards by Material and Absorbability

LAUREN HELLER - Sep 18, 2022, 4:22 PM CDT

Title: FDA Suture Standards by Material and Absorbability

Date: 9/18/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Research current FDA standards for suture types and materials to be informed on current best practices.

Content:

Suture types covered:

- Nonabsorbable synthetic polyethylene

- Nonabsorbable synthetic polypropylene

- Surgical nonabsorbable poly (vinylidene fluoride)

- Nonabsorbable nitinol

- Nonabsorbable steel monofilament and multifilament, sterile

- Nonabsorbable synthetic polyamide

- Nonabsorbable silk (one that we are currently interested in)

- Surgical nonabsorbable expanded polytetrafluoroethylene

- Absorbable synthetic polyglycolic acid

- Absorbable natural

- Surgical absorbable polydioxanone

All suture types have their attached regulations and regulation numbers. All sutures are classified as class 2 devices.

Class 2 Devices:

- Class II medical devices are more complicated than Class I devices, but are less complicated than Class III devices. They present a higher category of risk, because they are more likely to come into sustained contact with a patient.

- "devices for which general controls are insufficient to provide reasonable assurance of the safety and effectiveness of the device"

- Examples of Class II Devices include catheters, syringes, blood transfusion kits, contact lenses, surgical gloves, sutures

- Most class II devices need to go through the Premarket Notification (510k) process, where it must be demonstrated that the device is safe and effective by demonstrating that the device is equivalent to another device on the market.

Conclusions/action items:

It is important to be aware of FDA standards when working on any BME project. These standards may be helpful to reference in the future as we begin prototyping and testing. Continue research to assist in completion of the PDS. Begin brainstorming individually prior to group brainstorming and preliminary design evaluation.

Link: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfStandards/detail.cfm?standard__identification_no=43011

IEEE Citation:

“Recognized consensus standards,” *accessdata.fda.gov*. [Online]. Available: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfStandards/detail.cfm?standard__identification_no=43011. [Accessed: 18-Sep-2022].

9/18/22 Patent for Surgical Drainage Reservoir Support

LAUREN HELLER - Sep 18, 2022, 5:26 PM CDT

Title: Surgical Drainage Reservoir Support Patent

Date: 9/18/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Investigate current products and patents surrounding surgical drain reservoirs and methods to reduce drain pain.

Content:

The Prody Drainage Bulb Holder II is designed to help secure drainage bulbs without having to pin the drains to clothing. It was designed by a nurse, and aims to simultaneously maximize drain function and promote patient comfort.

Features:

-Can secure up to four drains without the need for pins.

- Can be positioned on chest, abdomen, waist or thigh, adjustable (can stretch up to 60 inches).

- Can be worn in the shower, but you will need two belts so that the shower one can dry between uses.

- Cost ranges between $25.85-$38.85 depending on what add-ons are purchased.

- Prevents pulling, drain dislodgement, and pain during daily activities/PT.

Patent Details:

The method of using a surgical drainage reservoir support system is comprised of several steps.

- Providing a surgical drainage reservoir support system for collecting a bodily fluid in a medical procedure. The design is comprised of an elastic band, one or more elongated mechanical fasteners, and a handle on each, with at least one drainage reservoir. Each drainage reservoir has an attachment band.

- An elastic band is placed around a body part of the patient at a selected tightness to affix the drainage reservoir securely but also comfortably.

- The handle of the one or more elongated mechanical fasteners are gripped, easily opening the mechanical fastener, and the drainage reservoir support to the patient.

- The handle or the fasteners are periodically gripped to remove the drainage reservoir for emptying. It is then reattached to continue collecting fluid.

Conclusions/action items:

This patent overlaps with competing designs. The "Seecret Apron" also has a similar purpose, but the designs are different. Both prices are similar in range, and we should aim to have a design similar in price or less in order to be competitive on the market. These prices will be reflected as a reference point in the PDS.

LAUREN HELLER - Sep 18, 2022, 4:39 PM CDT

Link: https://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=11090184.PN.&OS=PN/11090184&RS=PN/11090184

US Patent Number: 11090184

IEEE Citation:

“PATFT.” [Online]. Available: https://patft.uspto.gov/. [Accessed: 18-Sep-2022].

9/19/22 Surgical Drains Market by Product

LAUREN HELLER - Sep 19, 2022, 8:56 PM CDT

Title: Allied Market Research on Surgical Drains

Date: 9/19/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Understand the market demand for surgical drains, as well as how our design would need to be scaled up for market use.

Content:

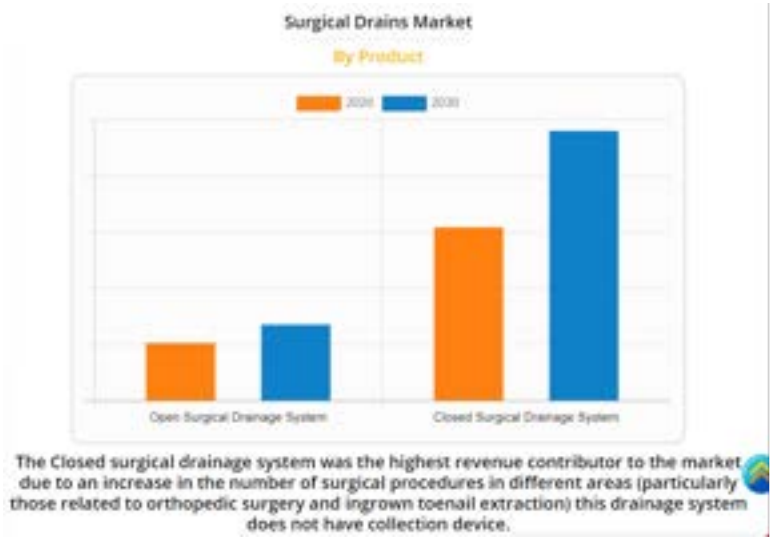
- The global surgical drain market was valued at $2.1 billion in 2020 and is projected to grow to $3.1 billion by 2030.

- By volume, the market was estimated at 75.5 million pieces in 2020, and is estimated to reach 95.5 million pieces by 2030.

- COVID-19 is believed to have had a negative effect on surgical drain usage, but this is due to a decrease overall in the number of surgeries that were performed.

- Growth in surgical drain market size has been mainly driven by a rise in chronic diseases and an increase in prevalence of these chronic diseases (cancer, cardiovascular diseases, strokes, diabetes)

- An increase in geriatric population, combined with technological advancements, have led to an increased use of surgical drains and more work is being done to innovate the tubing.



- Closed surgical drain systems are much more popular than open ones, so it makes sense to also see that active drains are more popular than passive ones. These two characteristics tend to go hand in hand.

Conclusions/action items:

This information will be helpful for portions of the PDS. Continue research, finish PDS for submission, and work on initial brainstorms to share in the upcoming team meeting.

Link: https://www.alliedmarketresearch.com/wound-drainage-surgical-drains-market-A07517

IEEE Citation:

“Surgical drains market statistics, Growth Drivers: Forecast- 2030,” *Allied Market Research*. [Online]. Available: https://www.alliedmarketresearch.com/wound-drainage-surgical-drains-market-A07517. [Accessed: 19-Sep-2022].

10/20/22 Butterfly Clip Patent

LAUREN HELLER - Oct 20, 2022, 1:13 PM CDT

Title: USD949476S1 Butterfly Hair Clip Patent

Date: 10/20/2022

Content by: Lauren Heller

Present: Lauren Heller

Goals: Research clip mechanisms to assist in modelling a clip in Solidworks.

Content:

-The patent is for a butterfly clip mechanism, all views of the design are provided in drawings. Drawings do not provide dimensions or any of the materials used.

- It appears that a torsion spring is used. Torsion springs aim to reduce or create a twisting force around a center point.

- The teeth of the clip interlock, and are meant to apply pressure around the hair, in our case we will be applying pressure around the tube to secure it, but do not want to inhibit tube drainage ability.

Conclusions/action items:

For our clip, we will likely want to use a torsion spring as well. Our Solidworks design will need to be constrained around the size of the spring. Need to research possible torsion springs with dimensions to assist in CAD work to be done on 10/21.

LAUREN HELLER - Oct 20, 2022, 1:10 PM CDT

Link: https://patents.google.com/patent/USD949476S1/en?q=butterfly+hair+clip&oq=butterfly+hair+clip

IEEE Citation:

“USD949476S1 - Butterfly hair clip,” *Google Patents*. [Online]. Available: https://patents.google.com/patent/USD949476S1/en?q=butterfly%2Bhair%2Bclip&oq=butterfly%2Bhair%2Bclip. [Accessed: 20-Oct-2022].

LAUREN HELLER - Oct 20, 2022, 12:20 PM CDT

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USD949476.pdf (209 kB)

10/26/22 Wound Closure Strength of Tissue Adhesives and Sealants Standard

LAUREN HELLER - Oct 26, 2022, 7:53 PM CDT

Title: ASTM F2458 Wound Closure Strength of Tissue Adhesives and Sealants

Date: 10/26/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Research standards for mechanical testing of bioadhesives.

Content:

- Standard cost: $54.00

- This standard specifically focuses on characterizing wound closure strength of tissue adhesives or sealants. Adhesive wound closure is sometimes preferrable to using staples or stitches, as it reduces patient discomfort and is easier to apply.

- Necessary to verify the strength of the adhesive is standardized and reliable, as failure could result in internal or external bleeding.

- This standard is mainly intended for comparative testing between different adhesive formulations.

- This test method may be used for comparing adhesives or bonding processes for susceptibility to fatigue, mode of failure, and environmental changes.

- The mechanical properties of a given adhesive composition can help us determine what parameters should be met for product consistency and quality control for the purpose of large-scale production.

Conclusions/action items:

This standard is applicable to our project, as we are aiming to test the adhesive properties on biological tissue for the purpose of wound closure in place of sutures. The standard would be helpful for conducting comparative testing of the different adhesive materials we have purchased. Following our initial prototyping, tweaking, and the creation of our first full-scale prototype, this testing may be very useful to revisit.

LAUREN HELLER - Oct 26, 2022, 7:56 PM CDT

Link: https://www.document-center.com/standards/show/ASTM-F2458

IEEE Citation:

“ASTM-F2458 | Standard Test Method for Wound Closure Strength of Tissue Adhesives and Sealants,” *Document Center, Inc.* [Online]. Available: https://www.document-center.com/standards/show/ASTM-F2458. [Accessed: 26-Oct-2022].

11/03/22 Standard Multi-directional Stress Testing

LAUREN HELLER - Nov 03, 2022, 4:53 PM CDT

Title: Standard Test Method for Stiffness of Fabric by the Circular Bend Procedure

Date: 11/03/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Research a method for comparing the stretch deformation of the materials in various directions to look at uniformity (or lack of) in a circular shape design.

Content:

Patent: ASTM D4032-08 (2016)

- Generally applicable to all types of fabrics of any fiber content.

- Summary of test method: A plunger forces a flat, folded swatch of fabric through an orifice in a platform. The maximum force required to push the fabric through the orifice is an indication of the fabric's resistance to bending.

- The circular bend procedure gives a force value related to fabric stiffness by averaging stiffness in all directions.

- Using the specimen marking template, cut 5 test specimens from staggered areas of each swatch in the sample. The short side of the specimen is placed parallel to the machine direction of the fabric.

- Tables included in the patent

Conclusions/action items:

LAUREN HELLER - Nov 03, 2022, 2:51 PM CDT

Link: https://compass.astm.org/document/?contentCode=ASTM%7CD4032-08R16%7Cen-US&proxycl=https%3A%2F%2Fsecure.astm.org&fromLogin=true

IEEE Citation:

“Standard Test Method for Stiffness of Fabric by the Circular Bend Procedure,” *ASTM compass*. [Online]. Available: https://compass.astm.org/document/?contentCode=ASTM%7CD4032-08R16%7Cen-US&proxycl=https%3A%2F%2Fsecure.astm.org&fromLogin=true. [Accessed: 03-Nov-2022].

9/28/22 How Tape Heals: The Secret Behind Kinesiology Tape

LAUREN HELLER - Sep 28, 2022, 5:14 PM CDT

Title: How Tape Heals: The Secret Behind Kinesiology Tape

Date: 9/28/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Understand more about K-Tape to understand if a similar material would be good for the at-site device.

Content:

- Kinesiology tape is used to aid muscle movement. It is meant to relieve pain, reduce swelling and inflammation, and provide support to joints and muscles.

- K-tape is believed to recruit blood vessels to the desired area, helping blood flow where the tape is applied. This leads to increased oxygen at the site, which in turn leads to decreased inflammation and swelling.

- It is also meant to help the body drain the lymphatic system of waste such as lactic acid. The material is very flexible, and still allows for a full range of motion.

- Research is already being conducted towards the use of K-tape for musculoskeletal injuries, breast cancer-related lymphedema, and balance ability in stroke patients. These results are varied, and more studies need to be done to get conclusive results.

Conclusions/action items:

Our application of the tape would be very different than the traditional muscular use. While this could potentially be useful for the flexibility aspect, there is still concern with using an adhesive material. Since the at-site design will be used on the skin surface, it will need to be removed quite frequently in order to clean the drain site. With an adhesive, there is concern that frequent removal and replacement will wear down the skin and create lots of discomfort for the patient.

LAUREN HELLER - Sep 28, 2022, 5:05 PM CDT

Link: https://www.premierhealth.com/your-health/articles/women-wisdom-wellness-/how-tape-heals-the-secret-behind-kinesiology-tape#:~:text=Kinesio%20tape%2C%20as%20it's%20often,way%20to%20enhance%20athletic%20performance.

IEEE Citation:

"How tape heals: The secret behind kinesiology tape," *Premier Health*. [Online]. Available: https://www.premierhealth.com/your-health/articles/women-wisdom-wellness-/how-tape-heals-the-secret-behind-kinesiology-tape#:~:text=Kinesio%20tape%2C%20as%20it's%20often,way%20to%20enhance%20athletic%20performance. [Accessed: 28-Sep-2022].

9/28/22 Comparing High Quality Suture Pads to Alternatives

LAUREN HELLER - Sep 30, 2022, 11:34 AM CDT

Title: Comparing High Quality Suture Pads to Alternatives

Date: 9/28/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Understand what characteristics are important for a high quality suture pad, and if it is a good model for initial testing.

Content:

- Suture pads are traditionally used to allow medical and nursing students additional practice of suture skills. It provides an intermediate practice step to bridge the gap between learning how to do it through observation, and physically suturing a patient.

-Before suture kits, supplemental items were used for suture practice such as pig feet or banana peels.

- Lower quality suture pads tend to be made of foam or low-quality silicone that can feel greasy. Higher quality silicone suture kits tend to have layering in the pad to mimic the different levels from epidermis to the tissue level.

- Many low quality suture pads have a thick top layer that is very hard to cut through, and does not reflect the toughness of skin. This leads to harsher pressure during practice that could be detrimental if reflected in patient care.

- High quality suture pads are much more durable and can be reused several times.

Conclusions/action items:

When purchasing a suture pad to use for our fabricated attachment apparatus, we need to make sure to obtain a high quality suture pad. This will allow for us to have the most life-like option, and can be reused as necessary over time. If a design does lead to drain displacement, we will be able to have it placed again in the same suture pad, rather than needing to purchase a new pad and delay progress until it arrives.

LAUREN HELLER - Sep 28, 2022, 11:15 PM CDT

Link: https://surgireal.com/blogs/news/comparing-high-quality-suture-pads-to-subpar-alternatives

IEEE Citation:

M. Group, “Comparing high quality suture pads to subpar alternatives,” *SurgiReal Products*, 16-Nov-2020. [Online]. Available: https://surgireal.com/blogs/news/comparing-high-quality-suture-pads-to-subpar-alternatives. [Accessed: 28-Sep-2022].

10/02/22 Ibuprofen-Loaded Biocompatible Latex Membrane

LAUREN HELLER - Oct 02, 2022, 3:21 PM CDT

Title: Ibuprofen-Loaded Biocompatible Latex Membrane for Drug Release

Date: 10/02/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Research different biocompatible materials to improve plans for preliminary design fabrication.

Content:

- Latex as an adhesive is commonly used with bandages (such as Band-aid).

- The inflammatory response occurs to promote protection of tissues and organs in the body, and occurs on injury. It is the first step of the wound healing process. Inflammatory diseases are not related to an acute injury, but rather a chronic condition that affects approximately 60 million people in the US alone. NSAIDs such as ibuprofen are used to treat inflammatory diseases.

- While NSAIDs help decrease inflammation, if administered over a long period of time or at high doses, they can have detrimental effects on the body. Several gastrointestinal issues have been observed, as well as nephritis (inflamed kidney leading to issues filtering waste from the blood). These issues are based on oral administration and observation of long-term oral use.

- Drug-delivery systems (DDSs) are gaining scientific interest due to the ability to deliver a compound more selectively to a specific site in the human body. By focusing the site of drug delivery, we aim to minimize the potential for adverse effects on the body.

- Latex used: NRL from BDF Rubber Latex Co. Ltd.

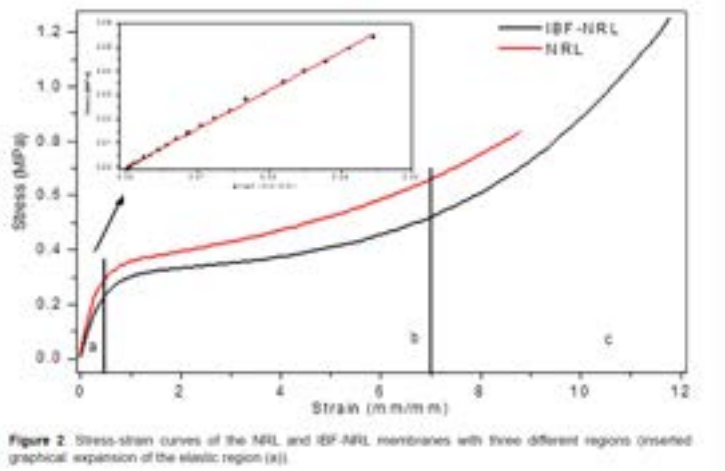

Figure 2: Stress-strain curves of the NRL and IBF-NRL membranes with three different regions (inserted graphical: expansion of the elastic region (a)).

- NRL membrane Stress/Strain results: Young's Modulus of 1.55 +/- 0.09 MPa, Rupture tension of 0.78 +/- 0.08 MPa, and Deformation of 786.07 +/- 95.01%.

- Ibuprofen-NRL membrane Stress/Strain results: Young's Modulus of 0.58 +/- 0.14 MPa, Rupture tension of 1.12 +/- 0.15 MPa, and Deformation of 1046.39 +/- 132.42%.

- Through statistical analysis (p-value of 0.05) it was concluded that the membranes were statistically similar in terms of strain, but that they were statistically different for rupture tension and Young's Modulus. The regular NRL membrane was more brittle, which makes sense why we also see a lower rupture tension value and lower deformation value.

- Literature values for biomedical applications of biomaterials for NRL application in human skin is 0.01-50 MPa for Young's modulus and 1-40 MPa for rupture tension.

- Through SEM imaging, it was determined that there is no chemical interaction between the drug and the polymer matrix.

Conclusions/action items:

For our application, we are more interested in the standard NRL matrix, as we do not need any drug delivery to the drain site. Latex is an incredibly common material for adhesives, and could potentially be used. More research should be done on Natural Rubber Latex to further understand the biomaterial. Literature values provided an important frame of reference, and should be referred to as necessary. In addition to this, many hospitals have moved away from latex gloves due to latex allergies, which may make latex a problematic material. Latex allergies are rare (less than 1% of the population) but should still be noted when looking for an appropriate material.

LAUREN HELLER - Oct 02, 2022, 2:28 PM CDT

Link: https://pubmed.ncbi.nlm.nih.gov/33781110/

IEEE Citation:

Lima AF;Pegorin GS;Miranda MCR;Cachaneski-Lopes JP;Silva WM;Borges FA;Guerra NB;Herculano RD;Batagin-Neto A; “Ibuprofen-loaded biocompatible latex membrane for drug release: Characterization and Molecular Modeling,” *Journal of applied biomaterials & functional materials*. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/33781110/. [Accessed: 02-Oct-2022].

LAUREN HELLER - Oct 02, 2022, 3:18 PM CDT

Ibuprofen-loaded biocompatible latex membrane for drug release: Characterization and molecular modeling

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22808000211005383.pdf (2.19 MB) PDF of Research Article

LAUREN HELLER - Oct 02, 2022, 3:19 PM CDT

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Vytex_Ind_Standard.pdf (116 kB) Vytex Natural Rubber Latex: Proposed Industry Standard for Commercial Natural Rubber Product Manufacturing

10/02/22 A Study of Reproducibility of Kinesiology Tape Applications

LAUREN HELLER - Oct 02, 2022, 8:44 PM CDT

Title: A Study of Reproducibility of Kinesiology Tape Applications: Review, Reliability, and Validity

Date: 10/02/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Research current biocompatible adhesives to learn of potential adhesives to use in design fabrication.

Content:

Rodriguez Study:

- 11 tapes from four brands, analyzed and compared on maximum percent stretch, maximum force to rupture, thickness, density, and grammage (mass per unit area).

- Concluded that there were differences between the mechanical properties depending on brands and colors, but did not complete a statistical analysis of their results (bad!)

Matheus Study:

- 10 samples from each of 5 different brands/manufacturers, tested maximum strain, deformation, load, and rigidity. They also found significant differences in adherence forces when removing the samples from the metal plate of an EMIC universal testing machine.

Study Conducted:

- MRI has been used to image tissue deformation, including the length of muscle fibers and the direction of this change after the application of kinesiology tape (KT).There is a lack of homogeneity, leading to mixed conclusions about if KT tape is useful for muscular injuries.

- There are currently no studies looking into maximum adherence force and work done when removing it from skin in dry vs wet vs sweaty states, which is something that would be important to research. Additionally, in order to repeatedly obtain a certain level of strain, there would need to be no variation in the properties of the tape.

- This study aims to determine different mechanical properties in terms of rupture and adherence in a dry state, wet state, and after being submerged in an artificial acid sweat solution. Tapes were grouped by color and brand to standardize the results. 380 samples were used from 19 different brands, each in four different colors (blue, black, beige, red)

-Each sample was 300mm long and 50mm in width. The specimens were stretched at a constant rate until rupture occurred. To evaluate adherence force, the tape was attached to untanned sheepskin at 0% elongation. The wet tests were submerged in water for 10 minutes prior to testing. The sweat tests were submerged in the artificial sweat solution for 10 minutes. (Maybe overkill, likely not sweating that much in real life, but could be representative of a long duration of sweating)

- Statistically significant differences were found in all tape parameters when grouped by brand (max force, tenacity, work, pre-elongation, and percentage elongation) as concluded from the Kolmogorov-Smirnov test, ANOVA test, and Tukey tests to control type I errors.

- Statistically significant differences were found based on the color of the KT in some cases. Black KT had the lowest maximum force capacity, tenacity, and pre-elongation, but also had the highest grammage. Blue KT had the highest work capacity and greatest pre-elongation. Differences between the other colors were not statistically significant.

- Adherence in dry state: Differences were found when grouped by brand in the maximum force category. No statistical difference was found when grouped by color with respect to maximum force or work

- Adherence in wet state: Statistical difference between brands were found, but none found between color groupings.

- Adherence with artificial sweat: Statistical differences between brands, no statistical difference between color variations.

- All hard mathematical values obtained in the study are available in the graph in the research study if we need to reference them in the future.

Conclusions/action items:

LAUREN HELLER - Oct 02, 2022, 3:27 PM CDT

Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6454724/

IEEE Citation:

F. Selva, A. Pardo, X. Aguado, I. Montava, L. Gil-Santos, and C. Barrios, “A study of reproducibility of kinesiology tape applications: Review, reliability and Validity,” *BMC musculoskeletal disorders*, 09-Apr-2019. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6454724/. [Accessed: 02-Oct-2022].

LAUREN HELLER - Oct 02, 2022, 3:27 PM CDT


A study of reproducibility of kinesiology tape applications: review, reliability and validity

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12891_2019_Article_2533.pdf (1.02 MB)

10/03/22 Factor XIII Cross-Linked Adhesive Chitosan Hydrogels

LAUREN HELLER - Oct 03, 2022, 12:04 PM CDT

Title: Factor XIII Cross-Linked Adhesive Chitosan Hydrogels

Date: 10/03/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Research adhesive materials and methods to create more concise preliminary designs.

Content:

- Most biomedical adhesives to date for the purpose of suture alternatives are based on synthetic and highly reactive chemicals. These methods are aiming to replace suturing (specifically in applications where suturing is not practical or seems less effective).

- Fibrin glue is a commercially available adhesive based on enzymatic cross-linking and is widely used clinically. It crosslinks when active with Factor XIII and thrombin, which replicates the last stage of the blood coagulation cascade when fibrinogen is present. (look into fibrin glue)

- Fibrin glue is relatively expensive, as the concentrated fibrinogen is pulled from donated human blood, also increasing the risk of transferring blood-borne diseases. Because of this, polysaccharides have become a good alternative due to their high abundance, safety, intrinsic bioactive effects, modifiable mechanical and chemical properties, and their ability to mimic the ECM (promotes tissue regeneration).

- Chitosan is a derivative of Chitin. Chitin is the most abundant natural biopolymer in the marine ecosystem, and is second on earth behind cellulose. It has many applications in drug and gene delivery, tissue engineering, and biomimetics (engineering of designs to mimic biological processes).

- Formation of the stable hydrogel in this application is due to enzymatic activity. In the absence of thrombin and Factor XIII, the Arg-Chi-TG (Arginine-Chitosan-Transglutaminase) does not form a gel. The difference in gel formation vs no gel formation can be seen below.

- The chitosan hydrogel offers antibacterial, antifungal, and antioxidant activity with hemostatic potential and in vivo mucoadhesivity (adhesive capability to a mucosal surface) due to its polycationic nature. This application is for use as an injectable adhesive.

- This study used cartilage as the tissue of choice for proof of concept, but want to be able to extend application to other tissues. There is also hope to expand applications past just a bioadhesive, but did not specify additional applications.

Conclusions/action items:

While the Chitosan Hydrogel proved to be an effective alternative to suturing, it is likely not an applicable form of adhesive for the purpose of our design. If we chose to focus on an alternative to the suturing rather than a device to cover the suture spot, this would be more useful research to help us. Continue researching medical-grade adhesives for future project advancements.

LAUREN HELLER - Oct 02, 2022, 8:54 PM CDT

Link: https://doi.org/10.1021/acsbiomaterials.1c00298

IEEE Citation:

“Sci-Hub | Factor XIII cross-linked adhesive chitosan hydrogels. ACS ...” [Online]. Available: https://sci-hub.se/10.1021/acsbiomaterials.1c00298. [Accessed: 03-Oct-2022].

LAUREN HELLER - Oct 02, 2022, 8:54 PM CDT

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19625514_40838843790002122_1_.pdf (3.86 MB)

10/10/22 Polyurethane Chemical and Mechanical Properties

LAUREN HELLER - Oct 10, 2022, 10:30 PM CDT

Title: Polyurethane Chemical and Mechanical Properties Research

Date: 10/10/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Research adhesive biomaterials to modify preliminary design specificity.

Content:

- Polyurethanes are used in a variety of medical devices, such as pacemakers, artificial hearts, and other blood-contacting applications. They are known for their great mechanical properties, stability, and biocompatibility.

- They are also known for their tough and elastomeric properties and good fatigue resistance, seen in adhesives, coatings, sealants, foams, and textile fibers.

-Most relevant polyurethanes are block polymers -> they have alternating segments of "A" and "B" repeating units, where one is a hard segment (glassy at use temperature) and one is a soft segment (rubbery at use temperature).

Thermosets:

- Produced by lightly cross-linking a low T polymer loosely. When strained, the segments between the cross-links deform and elongate, but will return to their original form (like a rubber band).

-Useful as injectable or moldable biomedical devices (tissue adhesives, scaffolds, bone grafts)

- Cannot be processed further once formed, heat and pressure do not have a notable effect.

Thermoplastic Elastomers:

- Similar to thermosets in the sense that the original form will be recovered after a load is removed. However, the application of heat can alter the cross-links between hard segments, This allows for the properties of elastomers to be combined with thermoplastics.

-These are abrasion and impact-resistant, so they are good for coatings and for blood-contacting.

Tuning Polyurethane Behavior:

- Cross-link density in thermosets controls material stiffness. The relative amounts of hard and soft segments in the PU can vary the modulus.

- Resorbable polyurethanes for tissue regeneration and repair -> degradation rate must be controlled, all byproducts must be non-toxic and excreted from the body. Ex: moisture-cure surgical adhesives as an alternative to surgical drains (look into this).

Conclusions/action items:

Polyurethane may be a good material to consider for an adhesive for its great biocompatibility characteristics. Polyurethane is a very versatile material, and can be fine tuned to exhibit desired traits. This could be advantageous for our team, or may make things more difficult, as we would need to be very specific with the type of polyurethane we choose.

Link: https://www.sciencedirect.com/science/article/pii/B9780128161371000106

IEEE Citation:

D. E. Heath, S. A. Guelcher, and S. L. Cooper, “Polyurethanes,” *Biomaterials Science (Fourth Edition)*, 29-May-2020. [Online]. Available: https://www.sciencedirect.com/science/article/pii/B9780128161371000106. [Accessed: 10-Oct-2022].

10/11/22 Polymers for Containers

LAUREN HELLER - Oct 11, 2022, 9:01 PM CDT

Title: Polymers for Containers

Date: 10/11/2022

Content by: Lauren Heller

Present: Lauren Heller

Goals: Research materials for the clip portion of final preliminary design.

Content:

High Density Polyethylene

- HDPE is very common for rigid containers. Most frequent use of HDPE is in packaging. Around 1.13e10 kg of HDPE was used for containers in the USA in 1997. (Old number, how has this changed?)

- Relatively inexpensive, especially when blow molding is used to form. 2000 price was $1.08 per kg of HDPE resin.

- Very flexible, resistant to impact damage at various temperatures. Exhibits good rigidity even when thin, allowing weight and cost to be reduced.

- Low permeability, used for milk and water bottles, liquid laundry detergent and fabric softener bottles. Used for pharmaceutical product containers.

General Conclusions: Good option, durable without needing to use lots of material, low in weight. These are all good characteristics for our clip.

Polyethylene Terephthalate

- PET is most common for soda bottles, as it has good CO2 retention capabilities. It is the fastest growing packaging plastic.

- Slightly more expensive than HDPE, but also has a higher glass transition temperature (78 deg C) and melting point (245 deg C). It is also very lightweight.

- PET is not as hydrophobic as HDPE, with an inferior water vapor barrier. It has a better oxygen barrier. It is stronger and stiffer than HDPE, allowing for lighter objects with similar mechanical properties. Commonly used in medical and health sectors for containers and storage.

General Conclusions: Lightweight and durable. Downside is that it is less water resistant, as carbon dioxide resistance is not relevant to our project.

Polypropylene

- Polypropylene (PP) has a higher glass transition temperature (-17 deg C) which is much higher than HDPA but lower than PET. This means that it is a stiffer material and less likely to experience deformation at moderate to high temperatures, but is more brittle at frozen temperatures.

- Due to PPs good mechanical properties at higher temperatures, it is commonly used for plastics meant to be placed in the microwave.

- PP is a bit cheaper than HDPE, but is less commonly used than both HDPE and PET. PP is usually best suited for applications where strength without deformations (at moderately elevated temperatures) are advantageous.

General Conclusions: This material may be a good choice for our clip. Since the design will lay flush against the skin, it will be at slightly elevated temperatures, especially during any physical exertion.

Table 1
Typical properties of common plastic packaging materials.

Material	Density ($g cm^{-3}$)	Tensile strength (MPa)	Tensile modulus (MPa)	Oxygen permeability ($10^{4} cm^{3} \mu m^{-2} d atm$)	Water vapor transmission rate ($g \mu m^{-2} d$ at 25°C, 90% RH)	Clarity	Impact strength	Mold shrinkage (cm/cm)
HDPE	0.94–0.965	17.3–44.8	620–1090	4.0–7.3	125	poor	good	0.015–0.040
EVOH	1.13–1.21	37.2–94.1	205–264	2.6 (0% RH)	550–15,000	good	poor	
Nylon	1.03–1.25	41.3–230	690–4110	60–12,500	630–4300	hazy/good		
PAN	1.11–1.15	65	3400	0.03+	2000–2900	good	good	
PC	1.2	63–72	2380	110,000	1900–2300	excellent	excellent	0.005–0.008
PEN	1.36	76[a]	2500[a]	0.17[a]	1/3 that of PET	excellent	excellent	small
PET	1.29–1.40	48.2–72.3 56[a]	2756–4135 2400[a]	0.12–0.24 0.49[a]	390–510	excellent	poor	0.020–0.025
PP	0.89–0.91	31–41.3	1140–1550	5.0–9.4	100–300	poor/good	fair	0.015–0.025
PS	1.04–1.05	35.8–51.7	2270–3270	9.8–15	1750–3900	excellent	poor	0.004–0.007
PVDC	1.60–1.75	19.3–34.5	344–551	7.9–2700	7.9–240	good		
PVC	1.35–1.41	10.3–55.3	to 4139	0.37–23.6	750–15,700	excellent	good	0.002–0.006

Processing Methods

- Most plastics are thermoplastics, made by softening with heat and pressure, shaping it, and then letting it cool.

- Extrusion Blow Molding: A plastic exits the extruder in a downward direction through an annular die. Sections are cut off as the tube is captured inside the blow mold. Compressed air stretches the plastic to come in contact with the mold and creates the shape. Extrusion blow molding is economical and fast, and can accommodate various designs without much change. It is not the most effective in producing uniform parts.

- Injection Molding uses a mold, where melted plastic travels through a series of channels and enters the mold cavities. The plastic is cooled in the cavities, and then the mold is ejected when cooled to maintain its shape. Excellent dimensional control possible, but more expensive than blow molding.

Design Considerations

- Environmental considerations (solid waste, pollution, energy use) should be considered.

- Look at life-cycle energy studies, as well as recyclability and minimizing waste.

Conclusions/action items:

The HDPE and PP plastic options could be great options for our clip on our design. The team needs to model the clip in SolidWorks and look into Makerspace printing materials/pricing.

LAUREN HELLER - Oct 10, 2022, 11:08 PM CDT

Link: https://www.sciencedirect.com/science/article/pii/B008043152601175X

IEEE:

S. E. Selke and R. J. Hernandez, “Packaging: Polymers for containers,” *Encyclopedia of Materials: Science and Technology (Second Edition)*, 01-Jan-2003. [Online]. Available: https://www.sciencedirect.com/science/article/pii/B008043152601175X. [Accessed: 10-Oct-2022].

10/20/22 Torsion Springs for Clip Mechanism

LAUREN HELLER - Oct 20, 2022, 3:13 PM CDT

Title: Torsion Springs for Clip Mechanism

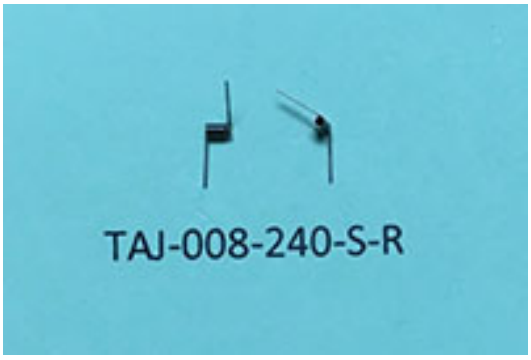
Date: 10/20/2022

Content by: Lauren Heller

Present: Lauren Heller

Goals: Research possible torsion springs with respective mechanical properties to assist in clip prototyping.

Content:



- List price: $2.25, discounts for large quantity orders. Left hand wind option also available.

Specifications:

Outside Diameter - in.	 - List price: $2.75, Left hand wind, right hand option listed. Very large max deflection angle, most likely too large, since we only need it to open like a clip. Over twice the diameter of the first torsion spring.

Outside Diameter - in.	.1
Inside Diameter - in.	.084
Wire Diameter - in.	.008
Rate - in-lbs./deg.	.00002
Free Angle - deg.	270
Total Coils	20.25
Body Length - in.	.170
Leg Length 1 - in.	.375
Leg Length 2 - in.	.375

Direction of Wind	Left Hand
End Type	Tangent
Material	Stainless Steel
Finish	None
Suggested Mandrel Size - in.	.063
Suggested Max. Deflection - deg.	755

- List Price: $2.25, Left hand wind also available, this spring seems to be a good size, however it has asymmetrical leg lengths. This could likely be trimmed down if needed. What is the purpose of different leg lengths?

Outside Diameter - in.	.044
Inside Diameter - in.	.026
Wire Diameter - in.	.009
Rate - in-lbs./deg.	.00008
Free Angle - deg.	180
Total Coils	8
Body Length - in.	.080
Leg Length 1 - in.	.22
Leg Length 2 - in.	.34
Direction of Wind	Right Hand
End Type	Tangent
Material	Phos. Bronze
Finish	None
Suggested Mandrel Size - in.	.016
Suggested Max. Deflection - deg.	105

Conclusions/action items:

These torsion springs are only a few of the options listed on the website, however they are among the smallest. If we need a bigger one, we should look into some alternatives on the website. Research into butterfly clips did not provide any information on the spring type used. It may be useful to purchase some butterfly clips, deconstruct them, and measure the dimensions of the spring inside.

Link: https://stocksprings.drtempleman.com/viewitems/all-categories-torsion-springs/all-categories-torsion-springs-torsion-springs?&forward=1

IEEE Citation:

"Torsion Springs on the D.R. Templeman Co..," *The D.R. Templeman Co.* [Online]. Available: https://stocksprings.drtempleman.com/viewitems/all-categories-torsion-springs/all-categories-torsion-springs-torsion-springs?&forward=1. [Accessed: 20-Oct-2022].

9/22/22 At Drain Site Idea

LAUREN HELLER - Sep 22, 2022, 4:03 PM CDT

Title: Brainstorm Idea for at Suture/Drain Site

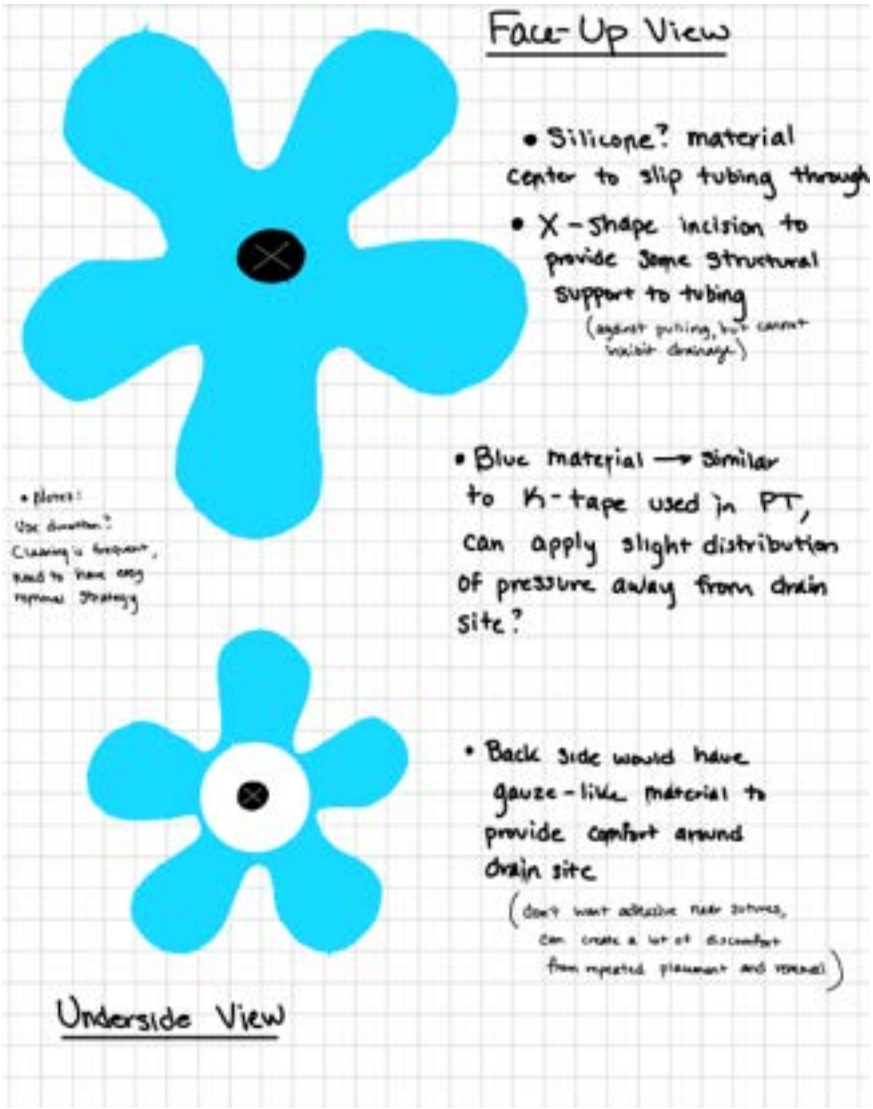
Date: 9/22/22

Content by: Lauren Heller

Present: Lauren Heller

Goals: Brainstorm designs prior to group brainstorming and preliminary design evaluation.

Content:



Conclusions/action items:

Share individual brainstorm ideas with teammates at upcoming meeting. Highlight pros and cons of each design, and begin deciding on design matrix criteria.

9/11/2022 Biosafety and Chemical Safety Training Documentation

LAUREN HELLER - Sep 11, 2022, 4:05 PM CDT

This certifies that Lauren Heller has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety Required Training	Biosafety Required Training Quiz	7/15/2021	
Chemical Safety: The OSHA Lab Standard	Final Quiz	5/19/2021	

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10/6/2022- Everything You Need to Know About Surgical Drains

Rebekah Makonnen - Oct 11, 2022, 3:58 PM CDT

Title: Everything you Need to Know about Surgical Drains

Date: 10/6/2022

Content by: Rebekah

Present: Rebekah

Goals: To understand the biology behind the need for surgical drains

Content:

- Main use of surgical drains is to prevent fluid accumulation, also called seromas
  - form underneath the skin and tissues
- Seroma- collection of fluid that occurs in a "pocket" underneath the skin
- the pocket occurs after tissue is removed from the body through surgery
- hematomas, which is a build up of blood beneath the skin, can also occur after surgery
- both seromas and hematomas require a surgical drain in order to ensure the fluid doesn't cause any adverse side effects
- The fluid that comes out of the site initially will be red as there is blood coming from the site but it should lighten up as the area heals
- once there is less blood in the fluid it should turn to a light red color, then pink, then once the blood is completely gone, it will be a yellow color
- this yellow fluid is called serous fluid, similar to fluid inside a blister
- any changes in color or smell of the fluid once it becomes a yellow color can be a sign of infection or additional bleeding

Conclusions/action items:

Complete more research on seromas and complete the preliminary report. Also meet with Dr. Russ Johnson to get his feedback on our current design.

IEEE Citation:

L. M. Np, “Everything you need to know about surgical drains,” *Plastic Surgery Of Chicago*, 09-Jun-2020.

10/6/2022- Seroma: What is it, Causes, Treatments, and More

Rebekah Makonnen - Oct 11, 2022, 4:17 PM CDT

Title: Seroma: What is it, Causes, Treatments, and More

Date: 10/6/2022

Content by: Rebekah

Present: Rebekah

Goals: To get a general understanding of what a seroma is

Content:

- Seroma is an extremely common potential complication after surgery
  - it refers to the build up of an uninfected and clear fluid under the skin
  - usually found near the surgical site and can form after the surgery or take weeks to form
- They usually develop in places where tissues have been removed through a surgery
  - a dead space, empty cavity, can form as a result of the wound not healing properly
- If neighboring lymphatic vessels are damages it can cause a leakage of serous fluid, leading to a seroma
- once a seroma forms, the way that it is treated completely depends on how much fluid builds up
  - most of the time the body will naturally reabsorb it without the need for any intervention
  - sometimes if there is a large amount of fluid build up, it may require medical intervention
    - methods for treatment include: aspiration, compression, and surgical intervention if its severe enough
- if a seroma is left untreated a fibrous capsule can from around the fluid, this makes it difficult to completely drain the seroma and allow for continuous fluid build up
  - if fluid continuously builds up, it is at risk of becoming infected and therefore becoming an abscess

Conclusions/action items:

Complete more research on the risks associated with seromas and work on the preliminary report. Continue preparing for the preliminary presentations.

IEEE Citation:

“Seroma: What Is It, Causes, Treatment, and More | Osmosis.” https://www.osmosis.org/answers/seroma (accessed Oct. 10, 2022).

10/9/2022- Seroma Formation after Breast Cancer Surgery: What We Have Learned in the Last Two Decades

Rebekah Makonnen - Oct 11, 2022, 3:53 PM CDT

Title: Seroma Formation after Breast Cancer Surgery: What We Have Learned in the Last Two Decades

Date: 10/9/2022

Content by: Rebekah

Present: Rebekah

Goals: To gain a greater understanding of seromas

Content:

- A seroma after breast surgery is defined as a collection of serous fluid that builds up under the skin flaps or dead space after a mastectomy
- the reason that these form is still uncertain but some risk factors include:
  - age
  - breast size
  - comorbid conditions
  - presence of malignant nodes in the axilla
  - previous surgical biopsies
  - use of heparin
- some hypothesize that seromas form as a result of an exudate from an inflammatory reaction
- there are different methods to eliminate dead space as a way to try and prevent seromas
  - mechanical- this method includes suturing flaps to subcutaneous tissue, avoiding the use of axillary drains, and eliminating axillary dead space by muscle approximation
  - chemical- this method could include the use of a fibrin glue or the use of a sclerosant

Conclusions/action items:

Complete more research on seromas and negative implications of them. Continue to work on the preliminary report

IEEE Citation:

V. Srivastava, S. Basu, and V. K. Shukla, “Seroma formation after breast cancer surgery: what we have learned in the last two decades,” *J. Breast Cancer*, vol. 15, no. 4, pp. 373–380, 2012

10/9/2022- Concepts of Seroma Formation and Prevention in Breast Cancer Surgery

Rebekah Makonnen - Oct 11, 2022, 4:47 PM CDT

Title: CONCEPTS OF SEROMA FORMATION AND PREVENTION IN BREAST CANCER SURGERY

Date: 10/9/2022

Content by: Rebekah

Present: Rebekah

Goals: To understand more about the risks that seromas cause

Content:

- seroma formation is the most common result after breast cancer surgery along with axillary (lymph nodes in the armpit) removal
- impact on the patient:
  - they can prolong recovery and increase the length of the patient's hospital stay
  - slow the healing of the wound
  - for a mastectomy, the fluid causes the flaps of the chest wall to elevate and interferes with the adherence to the tissue bed
  - it can cause:
    - delayed wound healing
    - wound infection
    - hematoma
    - flap necrosis
    - possible wound reopening
    - delayed recovery time
    - possible abscess formation
- the most common and most controversial method to prevent/reduce the prevalence of seromas is surgical drains
  - the goal of the surgical drains is to essentially get rid of the dead space with negative pressure
  - the idea is that the pressure will facilitate wound healing with the skin flap, reduce the frequency of infection, and flap necrosis
- it was found that when comparing suction vs passive drains, seroma formation is more frequent when using suction drains

Conclusions/action items:

Continue to research seromas and prepare for the meeting with Dr. Russ Johnson. Continue to work on the preliminary report.

IEEE Citation:

A. Agrawal, A. A. Ayantunde, and K. L. Cheung, “Concepts of seroma formation and prevention in breast cancer surgery,” *ANZ J. Surg.*, vol. 76, no. 12, pp. 1088–1095, 2006.

Rebekah Makonnen - Oct 11, 2022, 5:08 PM CDT

REVIEW ARTICLE

CONCEPTS OF SEROMA FORMATION AND PREVENTION IN BREAST CANCER SURGERY

Download

ANZ_Journal_of_Surgery_-_2006_-_Agrawal_-_CONCEPTS_OF_SEROMA_FORMATION_AND_PREVENTION_IN_BREAST_CANCER_SURGERY.pdf (99.2 kB)

9/22/2022- Seecret Apron

Rebekah Makonnen - Sep 23, 2022, 10:48 AM CDT

Title: Seecret Apron

Date: 9/22/2022

Content by: Rebekah

Present: Rebekah

Goals: To gain an understanding of competing designs that are currently on the market

Link: https://surgicalseecrets.com/products/seecret-apron

Content:

- This device is designed to hold and give easy access to surgical drains after a mastectomy or abdominal surgery
- this device has 2 large pockets that can hold up to 3 drains each, allowing it to carry up to 6 drains total
- the design of this allows for it to be customized in many ways such as:
  - tie length
  - where you tie the ties
  - pattern of the material (doesn't look medical/clinical)
- also machine washable and can be ironed

Conclusions/action items:

Complete more research on competing designs and patents and standards.

IEEE Citation:

Seecret apron," *Surgical Seecrets*. [Online]. Available: https://surgicalseecrets.com/products/seecret-apron. [Accessed: 23-Sep-2022].

9/22/2022- Drain Pouch Patents

Rebekah Makonnen - Sep 23, 2022, 11:27 AM CDT

Title: Drain Pouch Patents

Date: 9/22/2022

Content by: Rebekah

Present: Rebekah

Goals: To determine what types of drain pouches currently have patents

Content:

- Post-Surgical Drainage Container Carrier- US5643233A
  - Patent Application in 1995
  - this device includes a pouch and belt
  - the pouch loops around the belt, and the pouch mouth is easily accessible for easy access to the drainage bulb
- Abdominal Binder with Improved Drainage Bulb Holding System- US20090192432A1
  - Applied for Patent in 2008
  - abdominal binder includes at least one mechanism for holding a drainage bulb
    - one method uses at least one strip or hook to secure the bulb
    - another method looks at a way to secure multiple bulbs on the outside of the binder
- Post-Surgical Drain Facilitating Belt and Method of Use- US2011023086A1
  - Applied for Patent in 2011
  - a belt for securing and storing post-surgical drainage tubes and bulbs
  - the belt has at least one opening for receiving drainage tubing and at least one pocket that is partially fixed but also partially detachable to allow for easy access to the drainage bulb
  - the pockets act as a support as the drain bulb gets heavier, so it doesn't cause any tugging on the skin
- Drain Tube Holder System- US10207079B2
  - Applied for Patent in 2015
  - system for securely holding surgical drain tubing and bulbs without impacting how the wearer can move
  - it includes a strap that can be secured around different body parts (shoulder, waist, thigh, etc)
  - a retainer attachment is secured to the strap
    - includes at least one pouch to hold tubes and bulbs

Conclusions/action items:

Continue research on current patents for similar devices. Brainstorm design matrix criteria.

9/14/2022- A Novel Silicone Fixation Dressing: A Possibly Idea Method for Drainage Tube Fixation

Rebekah Makonnen - Sep 14, 2022, 4:33 PM CDT

Title: A Novel Silicone Fixation Dressing: A Possibly Idea Method for Drainage Tube Fixation

Date: 9/14/2022

Content by: Rebekah

Present: Rebekah

Goals: To gain an understanding of current methods used for securing surgical drains

Content:

- there are a lot of techniques that are currently used for drain fixation, however most of them can lead to scarring, poor drainage reliability, easy loosening of the fixation, tissue injury, and drain displacement
- The way that this dressing is applied is as follows:
  - the exit junction of the tube is sterilized with iodine solution then dried with gauze
  - the tube is then passed through the split end of the dressing and fixed at the center of it
  - the removable sheet is on the dressing is removed, allowing the dressing to be firmly secured to the skin around the tube
  - then medical adhesive tape is firmly wrapped around the tube to help fix it in place
- this method does not require sutures like the traditional methods which can lead to tissue injury and pain
- if there is a lot of fluid spill around the dressing within 10 days, it may require a change in dressing
- silicone was chosen due to its ideal properties such as its biocompatibility, ability to be bioinert, resistance to bacteria, ease of sterilization, non-irritability, anti-allergic properties, and extensive adhesive properties

Conclusions/action items:

Look into similar methods and their effectiveness in securing drains. Brainstorm questions for the client.

IEEE Citation:

P. David Papa Akuetteh, Y. Bridgette Akuetteh, X. Shen, Q. Zhang, and Q. Zeng, "A Novel Silicone Fixation Dressing: A Possibly Ideal Method for Drainage Tube Fixation," Surgical Innovation, vol. 27, no. 6, pp. 644-646, 2020.

Rebekah Makonnen - Sep 14, 2022, 4:07 PM CDT

Download

A_Novel_Silicone_Fixation_Dressing-_A_Possibly_Ideal_Method_for_Drainage_Tube_Fixations.pdf (731 kB)

10/25/2022- Biopatch Disk Drain Facts Sheet

Rebekah Makonnen - Oct 28, 2022, 11:40 AM CDT

Title: Biopatch Disc Drain Facts Sheet

Date: 10/25/2022

Content by: Rebekah

Present: Rebekah

Goals: To research the antibiotic disc that Dr. Wilke suggested after the meeting with her

Content:

- bacterial colonization of drain tracts that were initially sterile, increases the longer the drain is in place on the patient
- a simple antiseptic inventions such as a chlorohexidine disc (BIOPATCH) and a hypochlorite solution was created as a way to prevent this
- this device provides a constant release of CHG around the insertion site for up to 7 days

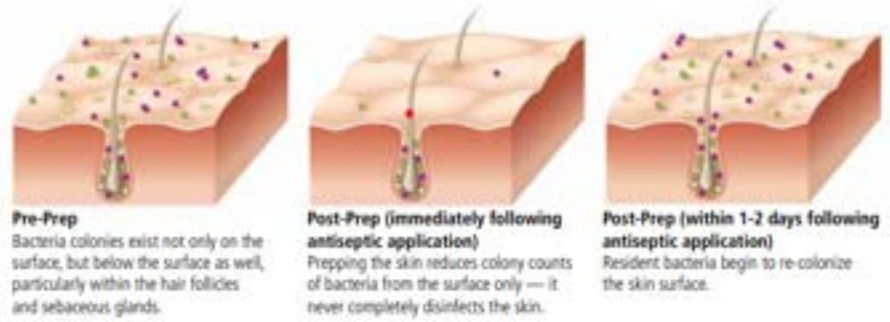


Image 1: Typical colonization of bacteria without the use of an antibiotic disc

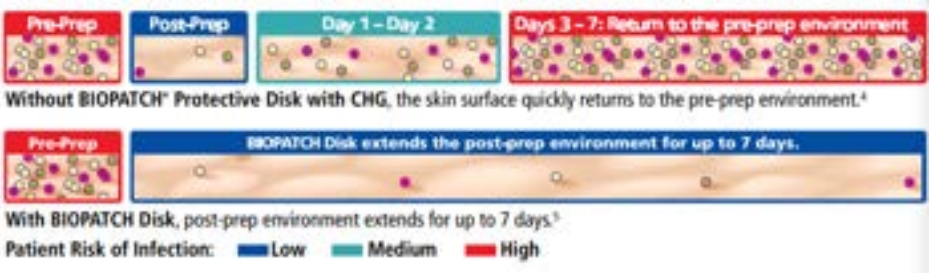


Image 2: Colonization of a Drain Site with and without the use of a antibacterial disc

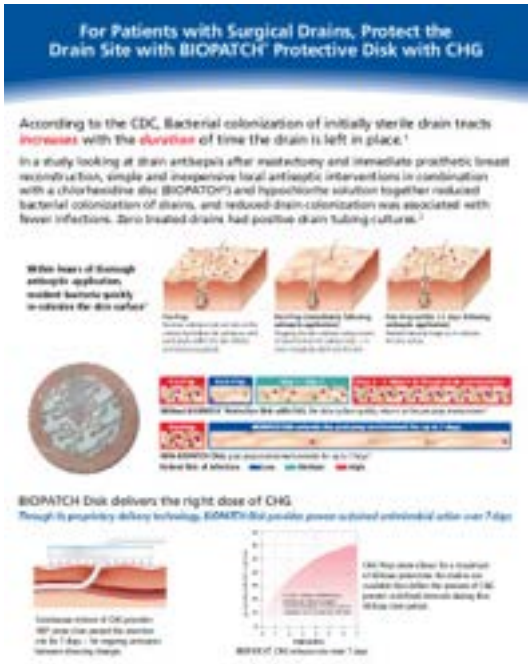
Conclusions/action items:

Complete more research on the efficacy of the use of these discs, as this was a fact sheet made by the manufacturer.

IEEE Citation:

Jnjmedtech.com. [Online]. Available: https://www.jnjmedtech.com/sites/default/files/user_uploaded_assets/pdf_assets/2020-09/BIOPATCH%20Disk%20Drain%20Fact%20Sheet%20021247-171012.pdf. [Accessed: 27-Oct-2022].

Rebekah Makonnen - Oct 27, 2022, 2:16 PM CDT



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BIOPATCH_Disk_Drain_Fact_Sheet_021247-171012.pdf (2.95 MB)

10/25/2022- The Effect of the Biopatch, a Chlorhexidine Impregnated Dressing, on Bacterial Colonization of Epidural Catheter Exit Sites

Rebekah Makonnen - Oct 28, 2022, 11:55 AM CDT

Title: The Effect of the Biopatch, a Chlorhexidine Impregnated Dressing, on Bacterial Colonization of Epidural Catheter Exit Sites

Date: 10/25/2022

Content by: Rebekah

Present: Rebekah

Goals: To understand the efficacy of the antimicrobial disc that Dr. Wilke suggest we look into

Content:

- a randomized study was done on women to compare the incidence of colonization of bacteria between a control group and a group using an antibacterial disc with chlorhexidine
- the results of the study showed that about 40% of the women in the control group had cultures that indicated the presence of bacteria
- only about 3% of women with the antibacterial disc has cultures that indicated a presence of bacteria

Conclusions/action items:

The use of an antibacterial disc such as this one could be a positive thing to incorporate into the design

IEEE Citation:

T. J. Mann, C. E. Orlikowski, L. C. Gurrin, and A. D. Keil, “The effect of the biopatch, a chlorhexidine impregnated dressing, on bacterial colonization of epidural catheter exit sites,” *Anaesth. Intensive Care*, vol. 29, no. 6, pp. 600–603, 2001.

The Effect of the Biopatch, a Chlorhexidine Impregnated Dressing, on Bacterial Colonization of Epidural Catheter Exit Sites

Download

0310057x0102900606.pdf (69.1 kB)

9/11/2022- Dr. Li's Guide to Getting Drains After Surgery

Rebekah Makonnen - Sep 13, 2022, 8:56 PM CDT

Title: Dr. Li's Guide to Getting Drains After Surgery

Date: 9/11/2022

Content by: Rebekah

Present: Rebekah

Goals: To understand the need for drains and the current procedure of caring for them

Link: https://surgicalseecrets.com/blogs/articles/guide-to-getting-drains-after-surgery

Content:

- A drain is needed after a surgery that creates a space, like a mastectomy.
- they prevent fluid build up and possibly causing an infection
- the fluid will travel through the clear plastic drain tube, outside of the body, and into a bulb
- a drain works as a vacuum
    - the bulb is squeezed to create negative pressure
    - pressure will slowly and gently pull fluid from the surgical area
    - drain is usually stitched to skin so it will not accidentally pulled out
- drains can cause stress and discomfort, one major reason is that they can get tugged on
    - this irritates the skin around the drain and it can sometimes become infected
- ways to minimize "drain pain"
    - secure the drain- either pin it to clothes or wear something that secures the drain

Conclusions/action items:

Complete more research on methods for securing surgical drains and brainstorm questions to ask the client

IEEE Citation:

W.-Y. Li, “Dr. Li’s guide to getting drains after surgery,” Surgical Seecrets, 07-Oct-2020. [Online]. Available: https://surgicalseecrets.com/blogs/articles/guide-to-getting-drains-after-surgery. [Accessed: 11-Sep-2022].

9/11/2022- UW Health Guide to Drain Care at Home

Rebekah Makonnen - Sep 13, 2022, 8:57 PM CDT

Title: UW Health Guide to Drain Care at Home

Date: 9/11/2022

Content by: Rebekah

Present: Rebekah

Goals: Understand what entails having a surgical drain

Link: https://assets.ctfassets.net/4yx69hifndy8/4603.pdf/59ab6897088ff03c5198c5444f74b4c7/4603.pdf

Content:

- surgical drains are placed to help treat or prevent a buildup of fluid in the body
- site needs to be cleaned daily
  - have clean hands, remove old dressing, wash hands again, use soap and water, clean around drain where it enters the skin with a wash cloth, pat the site dry (do not rub), and apply a new dressing
- cannot soak in a tub, pool, hot tub, etc. while the drain is in place
- "stripping" the drain may be necessary to keep the tube open and working
  - strip 2x a day, hold tube between thumb and index finger where the drain comes out of your skin, squeeze fingers to pinch tubing, place fingers of other hand on tubing below where it is pinched off, while holding the two fingers in place, slide the bottom two fingers down the tube while squeezing it gently
    - this helps pull clots into collection bulb, repeat multiple times to ensure tubing is clot free
- emptying the drain
  - empty and measure amount of drainage in the drain twice a day, keep a record and bring it to your clinic visit to help the doctor determine when the drain can be removed
  - fluid should be anywhere from a dark red to a straw-like color (if it starts smelling or gets thick it may be a sign of infection)
  - always keep suction in the drain, there are 2 types:
    - bulb-type drain: open the drain and compress it in one hand, recap the opening with the other hand
    - reliavac drain: open the drain and squeeze several times on the top of the container until the balloon inside completely fills up the inside container, recap the opening

Conclusions/action items:

Complete more background research on different methods for securing surgical drains and come up with questions to ask the client during our first meeting.

IEEE Citation:

“Care of your surgical drain at home,” Ctfassets.net. [Online]. Available: https://assets.ctfassets.net/4yx69hifndy8/4603.pdf/59ab6897088ff03c5198c5444f74b4c7/4603.pdf. [Accessed: 14-Sep-2022].

9/11/2022- A Simple Technique for Securing Surgical Drains

Rebekah Makonnen - Sep 13, 2022, 9:20 PM CDT

Title: A Simple Technique for Securing Surgical Drains

Date: 9/11/2022

Content by: Rebekah

Present: Rebekah

Goals: To understand the technique used to secure surgical drains

Link: https://www.sciencedirect.com/science/article/pii/S1572346104000327#bib1

Content:

- there are many different methods and materials used to secure surgical drains
- one of the most common methods is the Roman garter technique using silk as the suture material
  - relies on silk creating friction around the drain to secure it
- issue with this is that the silk can become loose for various reasons (incorrect technique or it becomes wet)
- can lead to loss of the drain into the draining cavity or the misplacement of the drain
- current techniques for removing the drain can lead to the drain sliding back into the patients body (abdominal surgery especially)
- even when drains have to be reduced, it involves cutting the original suture material and inserting another suture
  - comes with the risk of damaging the drain, along with the risk of displacement into the cavity
- the technique described prevents accidental dislocation or loss of the drain, along with the need for scissors or other sharp instruments to cut sutures

Technique

- once the drain is places two Tie-Lok are used to secure the component to the body of the drain
- the tail of the Tie-Lok can be snipped with scissors
  - prevents the drain from going back into the body because of the flange in place
- suture is stitched to skin using a classical technique
- a different loop of the stitch is passed through the hollow eye of the tie-lok and another surgical knot is completed
- in order to shorten or reposition the drain, the hollow eye is cut from the tie-lok, the drain is revised, and another tie-lok is applied to the drain and is secured to the cut hollow of the tie-lok

Conclusions/action items:

Research more methods for securing surgical drains and brainstorm questions to ask the client

IEEE Citation:

A. Tiwari, J. P. McFarlane, and J. L. Peters, “A simple technique for securing surgical drains,” Inj. extra, vol. 35, no. 11, pp. 91–93, 2004.

9/14/2022- A New Adaptation For a Secure Surgical Drain Placement and a Comparison with Four Common Drain Fixation Methods

Rebekah Makonnen - Sep 14, 2022, 3:54 PM CDT

Title: A New Adaptation For a Secure Surgical Drain Placement and a Comparison with Four Common Drain Fixation Methods

Date: 9/14/2022

Content by: Rebekah

Present: Rebekah

Goals: To understand how a novel method for securing drains compares to other common methods

Link: https://publishing.rcseng.ac.uk/doi/10.1308/rcsann.2018.0177

Content:

Introduction

- drains are placed extremely selectively
- if a drain gets dislodged or is retracted into the wound, it can have very adverse effects on the patient
- factors that impact drain security-
    - how snug the wound around the drain is
    - how the drain is fixated
    - external pull on the drain
        - weight of collection bag
        - lack of adhesives
        - postoperative mobility levels of the patient
- fixation method is dependent on the surgeon
- this study evaluates the surgeon's choice of method, type of fixation in literature, and the reliability and security of commonly used methods
- also a new method described that combines two of the methods that are examined in this study, the centurion sandal method and the plastic locking tie method
    - this hybrid method is also compared against four other fixation methods

Materials and Methods

- 90% of surgeons surveyed used the centurion sandal or lattice technique, 6.6% used the double loop technique, 3.3% used a multiple loop technique
- these three methods were selected to compare against the author's proposed hybrid methods
    - two hybrid methods:
        - centurion sandal with two additional plastic locking strips
        - centurion sandal with half-inch steristrips
- In total there are five methods being tested against each other (images of each method are attached below):
    - centurion sandal
    - double loop
    - multiple loop
    - centurion sandal with plastic locking strips
    - centurion sandal with SteriStrips

Results

- centurion sandal and multiple loop methods showed the lowest failure rates
- centurion sandal w/ plastic ties showed the least displacement
- multiple loop had the highest displacement

Discussion

- centurion sandal method indicated good hold under some tension but if the suture retracts toward to body, it loses its security
    - can happen with patient movement
- hybrid method using the two plastic locking ties is the best method because it offers extra security to the fixation method (applies circumferential tension) and it keeps the centurion suture in place, preventing it from losing security

Conclusions/action items:

Look into other methods for securing surgical drains and brainstorm questions to ask the client. Also begin brainstorming design ideas.

IEEE Citation:

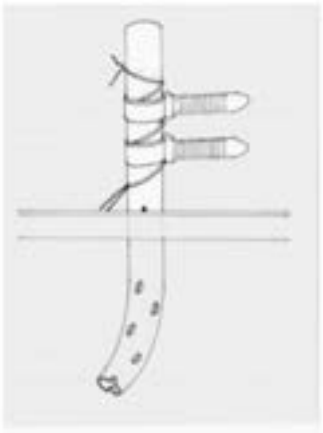
L. Heskin, V. Cahill, G. Filobbos, P. Regan, S. T. O'Sullivan, and K. Bryan, "A new adaptation for a secure surgical drain placement and a comparison with four common drain fixation methods," Ann. R. Coll. Surg. Engl., vol. 101, no. 1, pp. 60–68, 2019

Rebekah Makonnen - Sep 14, 2022, 3:06 PM CDT

Download

rcsann.2018.0177.pdf (1.05 MB)

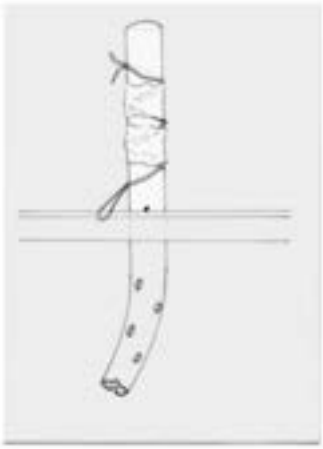
Rebekah Makonnen - Sep 14, 2022, 3:39 PM CDT



Download

Centurion_Sandal_with_Plastic_Ties.png (85.4 kB) Centurion Sandal with Plastic Ties Method

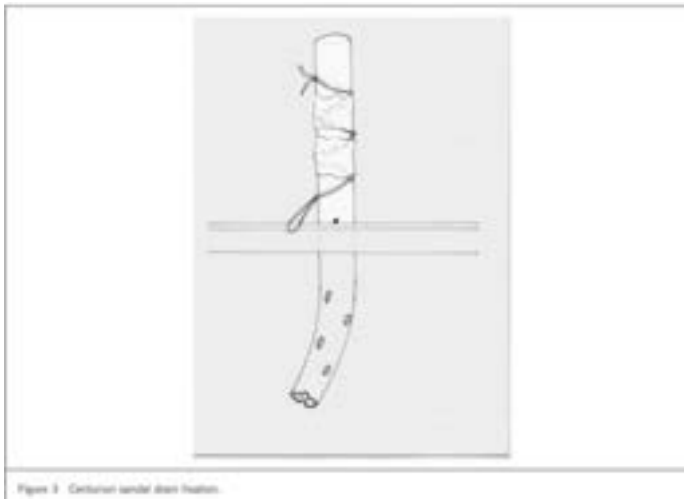
Rebekah Makonnen - Sep 14, 2022, 3:39 PM CDT



Download

Centurion_Sandal_with_SteriStrips.png (81.7 kB) Centurion Sandal with SteriStrip Hybrid Method

Rebekah Makonnen - Sep 14, 2022, 3:39 PM CDT



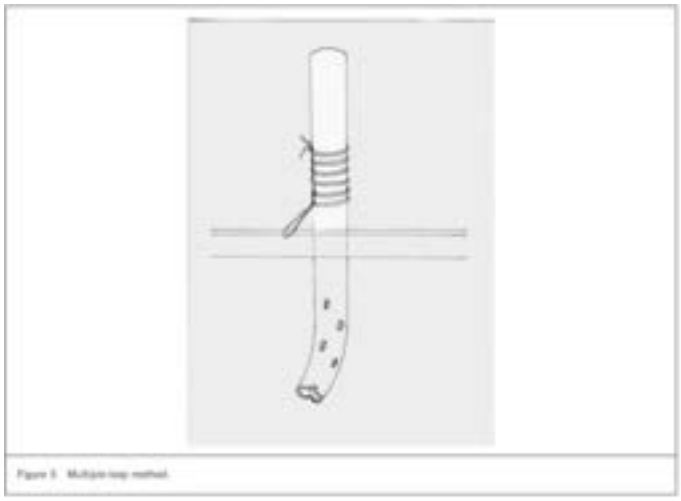
Download

Centurion_Sandal.png (80 kB) Centurion Sandal Method

Rebekah Makonnen - Sep 14, 2022, 3:40 PM CDT

Download

Double-loop.png (79.8 kB) Double Loop Method



Download

Multiple-loop.png (68.9 kB) Multiple Loop Method

10/4/2022- A Study of Reproducibility of Kinesiology Tape Applications

Rebekah Makonnen - Oct 11, 2022, 6:10 PM CDT

Title: A Study of Reproducibility of Kinesiology Tape Applications

Date: 10/4/2022

Content by: Rebekah

Present: Rebekah

Goals: Research kinesiology tape and determine its validity for possible use in a design

Content:

- kinesiology tape (KT) has a plane weave structure that allows for longitudinal stretch thanks to its elastane content
- this study looks to determine the mechanical characteristics of KT, more specifically its mechanical properties and its adherence properties were tested according to the ISO international standards

Methods

- Specimen
  - 380 specimens were tested from 19 different brands of KT
  - tape of different colors were tested as well, including blue, black, beige, and red
- Study Design
  - characteristics tested were: elongation while still attached to the tape- to test adherence force, maximum force (N or kg), tenacity (kg/mm^2), work (kg/mm), and elongation without paper (%)
  - how each characteristic was evaluated:
    - adherence force and work- pieces of untanned sheepskin, 50mm by 80mm, were also tested. 50mm of one end of KT was attached to the piece of skin with 0% elongation, which leaves 30mm of skin at the other end of the uncovered piece
      - the dry adherence test was performed by securing the uncovered skin in the lower clamp of the dynamometer, the backing paper was removed and the unattached end of KT was secured to the top clamp, the KT was preloaded with 2N of strain, once the setup was complete the the dynamometer began to separate the clamps stretching the specimen until it disconnected from the skin
      - for a wet state adherence test, the sample was submerged in water for 10 minutes and the procedure above was followed
      - the same procedure was tested with an artificial sweat formula, it test procedure follows the one above

Results

- Rupture
  - Grouped by Brand
    - all parameters were found to have statistically significant differences when grouped by brand
  - Grouped by KT Color

        - some parameters were found to have statistically significant differences when grouped by color
            - blue had the highest capacity for work and largest pre-elongation
            - black had the highest grammage but it had the lowest maximum force capacity, pre-elongation, and tenacity
- Dry State Adherence
    - Grouped by Brand
        - statistically significant differences were found between tape brands in the characteristics of maximum force and work
    - Grouped by Color
        - no statistically significant differences were found between the characteristics maximum force and work
            - blue tape had the greatest maximum force
            - black tape showed the greatest work
            - red tape showed the least work
- Wet Adherence Test- Water
    - Brand
        - statistically significant differences were found in characteristics of maximum force and work
    - Color
        - no statistically significant difference in terms of maximum force or work
            - red showed greatest max force and work
            - beige showed least max force and work
- Wet Adherence Test- Artificial Sweat
    - Brand
        - statistically significant differences were found with max force and work
    - Color
        - no statistically significant differences were found with mac force and work

Discussion

- showed significant variation between different brands and colors of KT in terms of max force, tenacity, work, pre-elongation, and grammage
- max adherence force and work done in removing the tape from the skin was extremely high in the dry state, lower when submerged in water, and the lowest when submerged in the artificial sweat solution

Conclusions/action items:

Continue research on possible materials for to be used for fabrication. Prepare for preliminary presentation and begin working on the preliminary report

A study of reproducibility of kinesiology tape applications: review, reliability and validity

Download

s12891-019-2533-0.pdf (1.02 MB)

10/4/2022- Comparison of the Morphological and Physical Properties of Different Absorbent Wound Dressings

Rebekah Makonnen - Oct 11, 2022, 7:24 PM CDT

Title: Comparison of the Morphological and Physical Properties of Different Absorbent Wound Dressings

Date: 10/4/2022

Content by: Rebekah

Present: Rebekah

Goals: Research different types of wound dressing materials that could be used for the adhesive bandage

Content:

- the type of dressing that is used on a wound is dependent on the characteristics of the wound
  - a wound that has a lot of exudate will need to be more absorbent
- absorbent wound dressings are categorized into 3 types:
  - hydrocolloid
  - alginate
  - foams
- this study looks at 2 hydrocolloids, 2 alginates, and 2 foams and are evaluated and compared in vitro

Materials and Methods

- the types of dressing used in this study include a hydrocolloid dressing (Nexcare), a hydrocolloid with a foam layer dressing (DuoDERM CGF), a calcium alginate dressing (Algisite), a calcium sodium alginate dressing (Kaltostat), a foam with polyurethean film layer dressing (Allevyn), and a foam with hydrogel and polyurethane film layer dressing (Askina)
- the properties analyzed were:
  - morphological properties, absorption properties, and dehydration properties along with water vapor transmission rate and dispersion characteristics

Results and Discussion

- Morphological Properties
  - foam with a polyurethane dressing showed the best wound healing characteristics (cell attachment, migration, and proliferation)
  - it was shown that having multiple materials in a dressing impacted its morphology in terms of their ability to effectively heal wounds
- Absorption Properties
  - number of pores impact the absorption capacity
  - shown that both hydrocolloid dressings had low absorption capacities
  - multilayer dressings did not have an impact on absorption properties
  - the figure below shows the absorption properties of the wound dressings

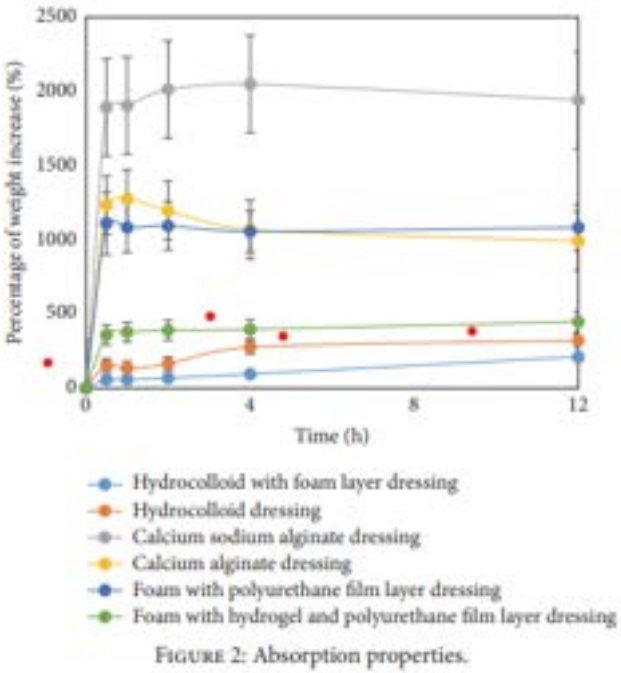


FIGURE 2: Absorption properties.

Figure 1: Absorption Properties of Wound Dressings

- Dehydration Properties
  - the alginate dressings showed the highest dehydration rate
  - the hydrocolloid dressing showed the lowest dehydration rate
- Water Vapor Transmission Rate
  - hydrocolloid dressing did not allow for permeable water vapor
  - alginate dressings showed best water vapor permeability
- Dispersion Characteristics
  - alginate dressings showed highest dispersion, causing a difficulty with dressing removal
- although the calcium sodium alginate dressing had the best absorption, it did not hold its shape when tested for dispersion

Conclusions/action items:

Bring up these findings with the team as we were planning on using a hydrocolloid bandage for our design, however the absorption and water vapor transmission rate results indicate that it may not be the best material. Continue materials research and prepare for the preliminary presentation. Begin working on the preliminary report.

IEEE Citation:

S. Hasatsri, A. Pitiratanaworanat, S. Swangwit, C. Boochakul, and C. Tragoonsupachai, “Comparison of the morphological and physical properties of different absorbent wound dressings,” *Dermatol. Res. Pract.*, vol. 2018, pp. 1–6, 2018.

Research Article

Comparison of the Morphological and Physical Properties of Different Absorbent Wound Dressings

Download

9367034.pdf (4.78 MB)

10/17/2022- A critical review of modern and emerging absorbent dressings used to treat exuding wounds

Rebekah Makonnen - Oct 27, 2022, 1:56 PM CDT

Title: A critical review of modern and emerging absorbent dressings used to treat exuding wounds

Date: 10/17/2022

Content by: Rebekah

Present: Rebekah

Goals: To better understand current trends of absorbent wound dressings

Content:

- the correct type of wound dressing is dependent on many things such as how big the wound is, if there is an infection, and how much exudate there is
- if the correct wound dressing is not chosen it can have negative consequences on the patient in terms of their health and well being
- although exudate is not always a bad thing, as it is produced to to help facilitate wound healing, it can become an issue when there is a large volume of exudate and it gets to be unmanageable
- popular wound dressings that are used to currently treat exudate wounds include:
    - alginate dressings
        - these dressings can wick away exudate from the wound site while also maintaining a moist environment that facilitates wound healing
        - with enough exudate present, these dressings do not adhere to the wound as they form a homogenous gel, meaning that these dressings are relatively pain free for the patient
        - dressing donates calcium ions in exchange with sodium ions in the exudate which aids in blood coagulation as well
        - under pressure, the dressing can struggle to hold all of the exudate which can lead to maceration and infection
        - in comparison to a standard gauze dressing, there was not evidence to support that the alginate dressing had an impact on the healing rate
    - hydro-fiber dressings
        - these dressings have high absorbency and retention which allows the patient to wear these for a long amount of time
        - the gel promotes a moist environment while also wicking away excess exudate to give the wound an ideal environment to heal
            - also believed that the dressing is able to draw out and bind bacteria within the structure which helps reduce the chance of infection
        - one drawback is that these dressings can be bioinert and does not necessarily aid in the healing process
    - foam dressings
        - these dressings have an open cell structure which allows for a high moisture vapor transmission rate, good thermal insulation, and can be left in place for up to 7 days
        - some disadvantages are that these dressings can cause inflammation as an allergic reaction to polyurethane or as a result of increased blood flow
        - there was no significant difference between the speed of wound healing between a regular gauze dressing and a foam dressing

    - hydrocolloid dressings
        - hydrocolloid dressing are waterproof, impermeable to bacteria, have thermal insulation, and are occlusive- meaning they provide a moist wound environment that promotes wound healing
        - they also swell when they come into contact with exudate which then swells to fill the wound cavity
        - some disadvantages are that they can lead to a reduction in mitotic activity, cause maceration of the surrounding tissues and can leak excessive exudate to the surrounding areas
            - they are also more suited for wounds with a low to moderate amount of exudate
        - if these dressings are applied to the appropriate wounds, they can greatly encourage wound healing
- finding an effective management/treatment for large volumes of exudate is an ongoing challenge for researchers

Conclusions/action items:

Discuss the findings of this article with the team, put together a finalized list for another funding proposal, and order materials for testing. Also prepare for the meetings with Dr. Russ Johnson and Dr. Wilke.

IEEE Citation:

I. R. Sweeney, M. Miraftab, and G. Collyer, “A critical review of modern and emerging absorbent dressings used to treat exuding wounds,” *Int. Wound J.*, vol. 9, no. 6, pp. 601–612, 2012.

Rebekah Makonnen - Oct 17, 2022, 10:25 AM CDT


A critical review of modern and emerging absorbent dressings used to treat exuding wounds

Download

International_Wound_Journal_-_2012_-_Sweeney_-_A_critical_review_of_modern_and_emerging_absorbent_dressings_used_to_treat.pdf (551 kB)

11/4/2022- Standard Test Method for Stiffness of Fabric by the Circular Bend Procedure

Rebekah Makonnen - Nov 04, 2022, 3:06 PM CDT

Title: Standard Test Method for Stiffness of Fabric by the Circular Bend Procedure

Date: 11/4/2022

Content by: Rebekah

Present: Rebekah

Goals: To learn about standard testing methods in multiple directions

Content:

- a general overview of the testing method:
  - plunger forces a flat swatch of fabric through an opening on a platform
  - the maximum force recorded will give an indication of the forces required to cause the fabric to rip and determine if there are common weak points within the fabric
- this procedure, the circular bend procedure, is able to give a force value related to the stiffness of the fabric
  - can be done using many different types of fabric including: knitted, woven, and nonwoven fabrics (could also possible use it to test the hydrocolloid bandage ?)
- Number and preparation of test specimen
  - using the 4in by 8in template marker, mark and cut 5 specimens from the laboratory sample
  - short side must be parallel to the machine direction of the fabric
    - important to keep handling of fabric to a minimum to avoid impacting the stiffness properties
- Conditioning
  - it is important to bring them to moisture equilibrium according to Practice D1776/D1776M
- Procedure
  1. test conditioned specimens at standard room temperature (21 +/- 1°C) and relative humidity (65 +/- 2%)
  2. set tester on a flat surface and ensure that the dial is at eye level
  3. select gage where the capacity of results will fall within 15 to 100% of dial gage force
  4. check plunger for speed and full stroke length
  5. center the specimen on the platform, below the plunger
  6. check gage and adjust if necessary
  7. actuate (deploy) the plunger to full stroke length and avoid touching the specimen if necessary
  8. record the maximum force reading to the closest gage graduation
  9. repeat steps 5-9 until all specimens have been tested
- calculation
  - average individual specimen readings and round to the closest gage increment
- report
  - state that specimens were tested as directed in Test Method D4032 and describe the material/product sampled and the method of sampling
  - make sure to report to following information:
    - average gage force in units
    - number of specimens tested
    - gage type and capacity
    - if/how the fabric was folded

- plunger clearance if not standard

Conclusions/action items:

I think that this standard could be helpful for determining if the k-tape or hydrocolloid bandage is more ideal for the teams design. I plan to share this with the team at the next team meeting (11/7). The next steps in the project are to continue creating samples to use for testing, finalize testing methods/protocols that are most helpful for this project, and begin preliminary mechanical testing using an MTS machine.

IEEE Citation:

Standard Test Method for Stiffness of Fabric by the Circular Bend Procedure, ATSM D4032-08, ATSM International, Pennsylvania, USA, 2016.

Rebekah Makonnen - Nov 04, 2022, 11:17 AM CDT

Standard Test Method for
Stiffness of Fabric by the Circular Bend Procedure

Download

Standard_Test_Method_for_Stiffness_of_Fabric_by_the_Circular_Bend_Procedure.pdf (595 kB)

9/20/2022- Individual Brainstorming

Rebekah Makonnen - Sep 20, 2022, 4:16 PM CDT

Title: Initial Individual Brainstorming

Date: 9/20/2022

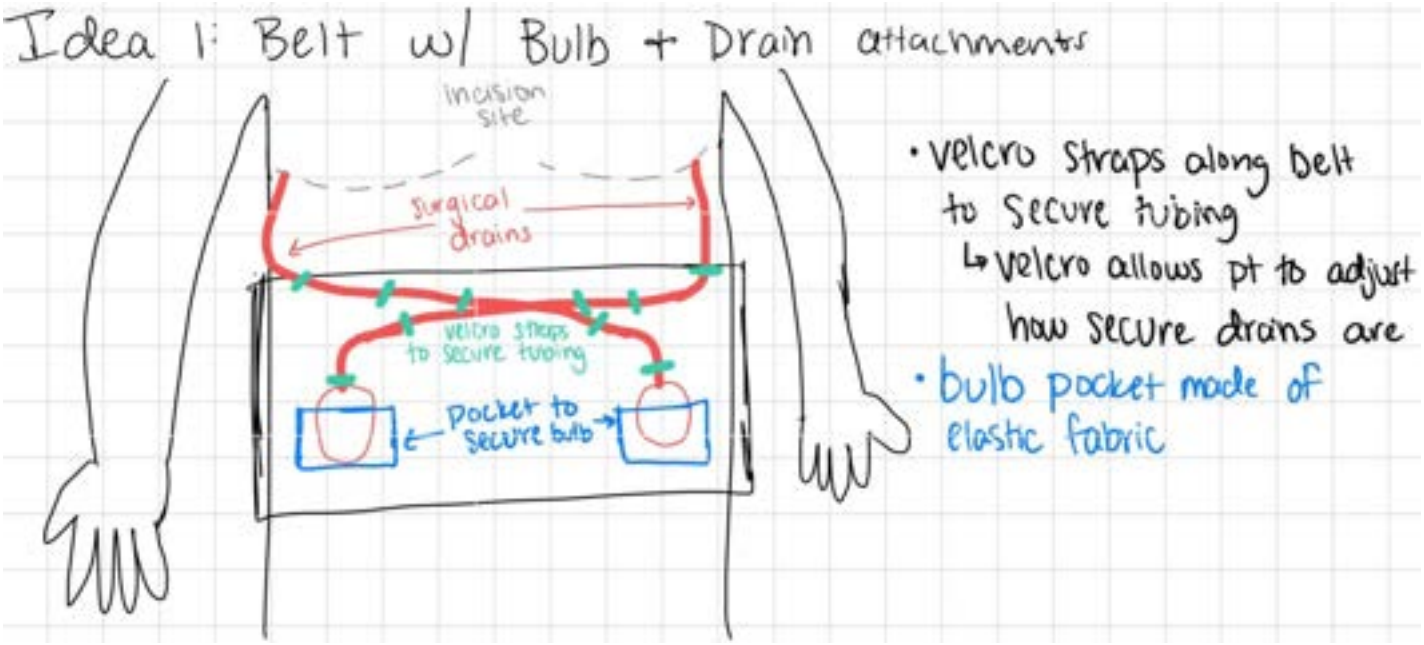
Content by: Rebekah

Present: Rebekah

Goals: To brainstorm design ideas

Content:

During this individual brainstorming session, I came up with one idea that is an external belt to secure the surgical drain and pump. The device I brainstormed considered drains from a double mastectomy, as that is the same type of drains that the client had.



Above I have attached a rough sketch of my initial idea. The belt material will be made out of a soft, stretchy material to ensure it is comfortable for the patient. I imagined the bulb pocked to be composed of some type of elastic material so the bulb will stay securely in place. The velcro straps are to ensure the drain is held in place but also allows for some customization on how secure the patient wants the drains to be.

Conclusions/action items:

Brainstorm 1-2 more ideas before meeting with the team. Finish the product design specifications and meet with the team to share brainstorming ideas. Continue research on how surgical drains are secured.

9/22/2022- Individual Brainstorming

Rebekah Makonnen - Sep 23, 2022, 10:36 AM CDT

Title: Individual Brainstorming Session

Date: 9/22/2022

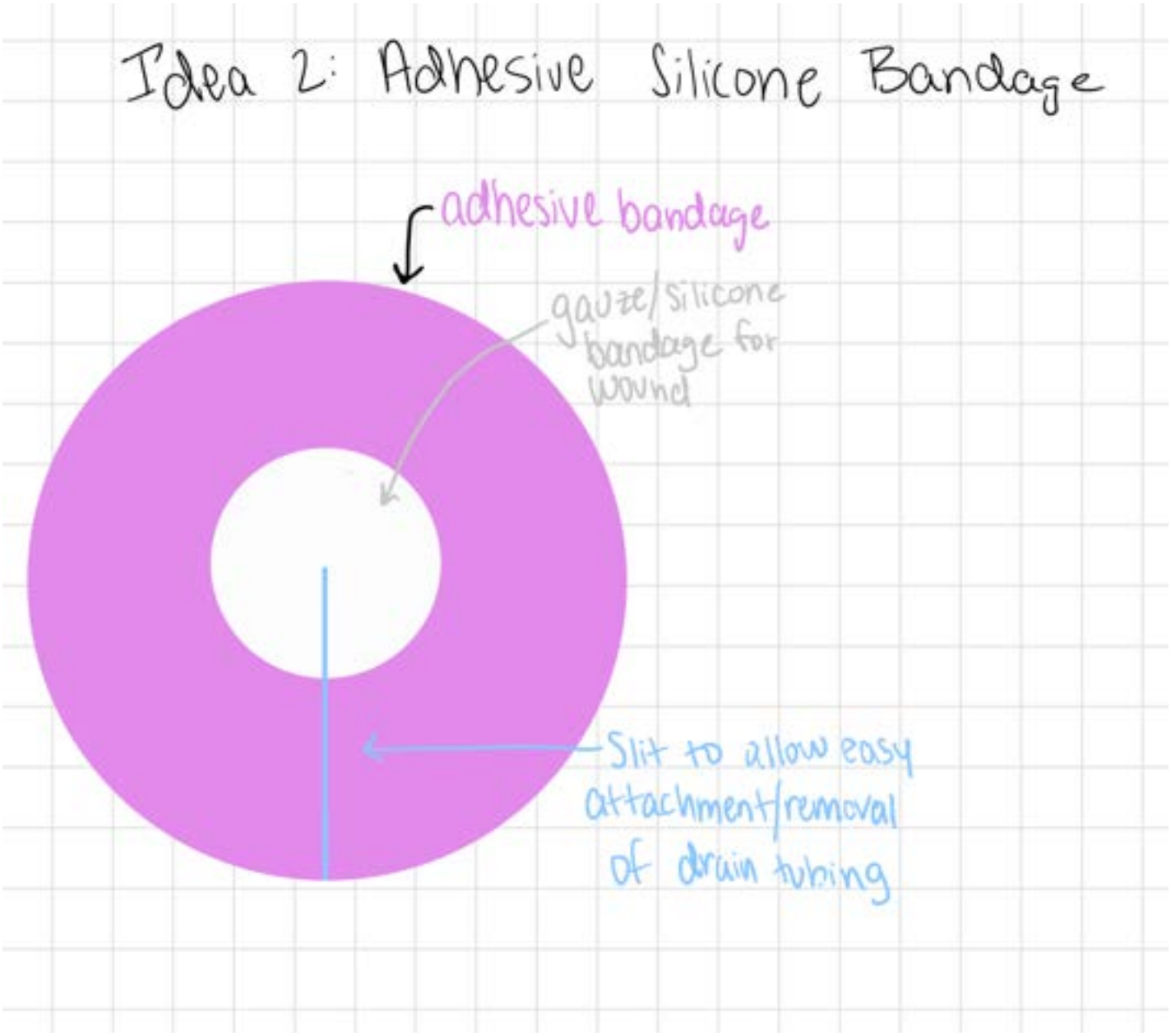
Content by: Rebekah

Present: Rebekah

Goals: To brainstorm another idea on my own before the team brainstorming meeting

Content:

This brainstorm approach is different than my previous idea. In this design I propose an adhesive silicone bandage that will secure the drain tubing at the sight and could possibly help to prevent possible irritation or tugging on the skin.



In this image, the pink outer circle represents the adhesive of the bandage that would stick to the skin. The inner white circle is the gauze that would be directly on top of the incision site, the purpose of this is that the gauze is there to act as a barrier between the adhesive and the incision site in order to prevent any irritation or cause any pain. It will also be able to absorb any excess fluid that comes out at the incision site. The blue line represents a slit in the bandage, this allows the drain tubing to be placed in the center of the adhesive bandage and it could possibly provide a way to adjust how tightly the seal is around the tubing.

Conclusions/action items:

Continue research on standards and patents for similar devices. Meet with the team to share brainstorming ideas. Begin brainstorming design matrix criteria.

09/22/2022 - Patents for Drain Pouches

Oscar Zarneke - Sep 22, 2022, 12:45 PM CDT

Title: Patents for Drain Pouches

Date: 09/22/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To record a non-exhaustive list of patents for drain pouches

Content:

- Medical drainage pouch - US8292860B1 - Medical drainage pouch - Google Patents
- Post-surgical drainage bulb support sling - US7927311B1 - Post-surgical drainage bulb support sling - Google Patents
- Post-surgical drainage container carrier - US5643233A - Post-surgical drainage container carrier - Google Patents
- Drain tube belt and shower pack kit - US6152915A - Drain tube belt and shower pack kit - Google Patents
- Surgical recovery brassiere - US6390885B1 - Surgical recovery brassiere - Google Patents
- Drainage reservoir support assembly - US6524288B1 - Drainage reservoir support assembly - Google Patents
- Surgical drainage device - US6610032B1 - Surgical drainage device - Google Patents
- Abdominal binder with improved drainage bulb holding system - US20090192432A1 - Abdominal binder with improved drainage bulb holding system - Google Patents
- Apparatus and method for carrying and storing medical drains - US20120091181A1 - Apparatus and Method for Carrying and Storing Medical Drains - Google Patents
- Drain pouch caddy - US20150157490A1 - Drain pouch caddy - Google Patents
- Post-operative compression bra and drain apron - WO2015195170A1 - Post-operative compression bra and drain apron - Google Patents
- Surgical drain management apparatus - WO2018004846A1 - Surgical drain management apparatus - Google Patents
- Drain tube holder system - US10207079B2 - Drain tube holder system - Google Patents
- Ostomy pouch holding system - US11033420B2 - Ostomy pouch holding system - Google Patents
- Surgical drainage reservoir support - US11090184B1 - Surgical drainage reservoir support - Google Patents
- Medical drain carrier - USD938580S1 - Medical drain carrier - Google Patents

Conclusions/action items:

This is a non-exhaustive list of existing patents for drain pouches. Make sure to check these patents (and their citations for other patents) if/when designing new drain pouches.

09/22/2022 - Techniques to Secure Surgical Drains

Oscar Zarneke - Sep 22, 2022, 4:18 PM CDT

Title: Techniques to Secure Surgical Drains

Date: 09/22/2022

Content by: Oscar Zarneke

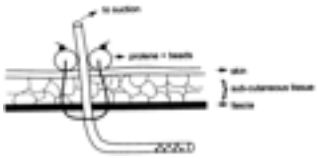
Present: Oscar Zarneke

Goals: To record a non-exhaustive list of different techniques of securing surgical drains.

Content:

- Tie-Lok - a device to be used with sutures to create a flange, preventing the drain falling into the body cavity
    - A. Tiwari, J. P. McFarlane, and J. L. Peters, “A simple technique for securing surgical drains,” Injury Extra, vol. 35, no. 11, pp. 91–93, Nov. 2004, doi: 10.1016/j.injury.2004.07.025.
- Adhesive pad - a pad with a sterile flexible support fixed to an adhesive synthetic skin barrier; a small slit accommodates the insertion site

    - A. Yousefpour, A. J. Gibbons, and N. M. Whear, “A simple way of securing suction drains: Technical note,” British Journal of Oral and Maxillofacial Surgery, vol. 44, no. 2, pp. 161–162, Apr. 2006, doi: 10.1016/j.bjoms.2004.10.019.
- Prolene suture w/ beads - a suture running through the submerged drain with beads on either end to prevent the suture from pulling into the skin



    - P. O'flynn and S. Akhtar, “Effective securing of a drain,” Ann R Coll Surg Engl, vol. 81, no. 6, pp. 418–419, Nov. 1999, doi: PMID: 10655897; PMCID: PMC2503306.
- Source analyzing the Centurian sandal, Centurian sandal with two locking plastic ties, Centurian sandal with Steristrips, double loop, and multiple loop suture techniques - recommends using Centurian sandal, particularly with plastic ties or Steristrips
    - 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.
- A site demonstrating various suture techniques including a classical loop and knot, Roman gaiter, and Locking-Turns
    - Epomedicine, “Techniques of Securing Surgical Drain to Skin (Drain Fixation),” Epomedicine, Jun. 10, 2021. https://epomedicine.com/surgical-skills/techniques-securing-surgical-drain-fixation/

Conclusions/action items:

This is a non-exhaustive list of surgical drain attachment methods. Make sure to consult if/when designing new drain attachment methods.

10/05/2022 - Techniques of Drain Fixation

Oscar Zarneke - Oct 05, 2022, 5:32 PM CDT

Title: Techniques of Drain Fixation

Date: 10/05/2022

Content by: Oscar Zarneke

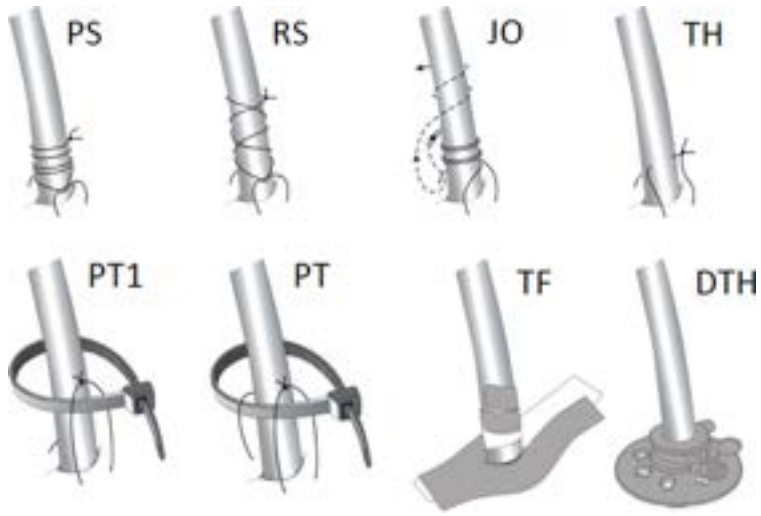
Present: Oscar Zarneke

Goals: To identify common drain fixation techniques

Content:

Y. Ringel, O. Haberfeld, R. Kremer, E. Kroll, R. Steinberg, and A. Lehavi, “Intercostal chest drain fixation strength: comparison of techniques and sutures,” BMJ Military Health, vol. 167, no. 4, p. bmjmilitary-2020-001555, Oct. 2020, doi: 10.1136/bmjmilitary-2020-001555.

- The article examined different fixation methods to determine the mechanically strongest fixation
- Most of the time, the method is chosen based on personal preference and material availability
- The methods:
    - Purse string (PS)
    - Roman Sandal (RS)
    - Jo'burg (JO)
    - Through the tube (TH)
    - One pass locking tie (PT1)
    - Two pass locking tie (PT2)
    - Tape fixation (TF) - Leukoplast tape - RESEARCH THIS
    - Disposable drainage tube holder (DTH) - Drainage Tube Holder Fixation Device - China Catheter Fixation and Fixation Device (made-in-china.com)



Conclusions/action items:

The results of this study are not vital. This is simply to identify current methods. Sutures are really common, with different tying techniques used. However, they will all feel similar to the patient. Look into and research the Leukoplast tape as well as the drain tube holder.

10/06/2022 - Techniques of Drain Fixation

Oscar Zarneke - Oct 11, 2022, 11:39 AM CDT

Title: Techniques of Drain Fixation

Date: 10/06/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

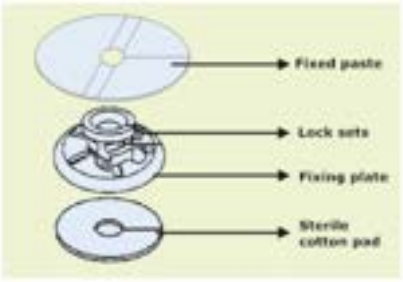
Goals: To identify common drain fixation techniques

Content:

“Disposable Drainage Tube Holder - Changzhou Haiers Medical Devices Co., Ltd.,” Hasmedicalstapler.com, 2018. https://www.hasmedicalstapler.com/Disposable_Drainage_Tube_Holder (accessed Oct. 10, 2022).

“Tube Attachment Devices | Critical Care Products | Hollister US,” www.hollister.com, 2022. https://www.hollister.com/en/products/Critical-Care-Products/Tube-Securement/Tube-Attachment-Devices# (accessed Oct. 10, 2022).

- More drain fixation techniques were found
- One is a device from a company in China
- It is a "Disposable Drain Tube Attachment Device"



- There are more options from Hollister Incorporated

Conclusions/action items:

More drain fixation methods were found. These ones were short-term (<1 week) drain tube holders using adhesive bandages and locking mechanisms.

10/27/2022 - NPWT Fixation

Oscar Zarneke - Oct 27, 2022, 12:11 PM CDT

Title: NPWT Fixation

Date: 10/27/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To identify how negative pressure wound therapy devices are fixed.

Content:

Invia NPWT Dressings and Kits | Medela US (medelahealthcare.com)

- Invia negative pressure wound therapy (NPWT) device
- Foam dressing kit w/ "FitPad suction interface"
    - Black foam using reticulated polyether and polyurethane hydrophobic material
    - Transparent film - WHAT IS THIS?
    - Packed/sterilised w/ ethylene oxide
- Gauze dressing kit
    - Gauze pad/roll
    - Transparent film
    - Saline
- Abdominal dressing kit
    - Organ contact layer
    - Charcoal foam
    - Transparent film
- White foam
    - Open-cell polyvinyl alcohol foam
    - Hydrophilic properties
- Silverlon antimicrobial wound contact dressing
    - Barrier for bacterial prevention
    - Uses silver ions activated by moisture
- Can also look at videos for dressing applications

Conclusions/action items:

Try to find what the suction interface is made of and its exact design. It appears to be one entire item, continuous with the tube. Could we change the drain tubes to include an attachment method?

Some of these materials (dressings) could be useful for our design.

09/13/2022 - Surgical Drain Info (for residents)

Oscar Zarneke - Sep 13, 2022, 11:57 AM CDT

Title: Surgical Drain Info (for residents)

Date: 09/13/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To learn basic background info about surgical drains.

Content:

- Intro
  - Management for surgical patients
  - Deliberate channel(s) for pus/blood/body fluid egress
    - Prevent build-up in body
  - Date back to Hippocrates (fun fact)
  - Sometimes, drain needed to prevent catastrophes - what catastrophes?
    - However, can cause more problems
- Mechanisms of Drains
  - Removes...
    - Contents of body organs (e.g. urinary bladder)
    - Excess secretions of body cavities (e.g. peritoneal/pleural cavities)
    - Tissue fluids (e.g. blood, serum, lymph)
    - Other body fluids that accumulate in wound bed
  - Works via...
    - Gravitational force
    - Negative pressure
    - Positive pressure
  - Necessary b/c...
    - Pressure on surgical site/adjacent organs/nerves/blood vessels
    - Causes pain, decreases perfusion delays, impairs wound healing
    - Excess fluid good for bacterial growth (can cause infections)
  - Drain efficiency dependent on...
    - Diameter
    - Length
    - Fluid viscosity
    - Fluid consistency
    - Force (positive/negative pressure)
- Classifications
  - Mechanism
    - Passive/active
  - Nature
    - Tube/Sheet (flat)
  - Disposition
    - Open/closed
  - Location

        - Internal/external
    - Property
        - Inert/irritant
- Passive drains
    - Act via capillary action, gravity, or intra-cavity pressure
    - Examples: corrugated rubber drain, Penrose drain, sump drain
    - Used with viscous fluids
- Active drains
    - Aided by active suction
        - Low continuous, low intermittent, high suction
    - Examples: Jackson-Pratt drains, Surgivac drain, Redivac drain
    - Effluent measurement reliable
    - Wound infection risk smaller
    - Tissue trauma small
    - No skin excoriation
    - Regular reservoir activation required

Table II: The major differences between active and passive drains

	Active	Passive
Function	Works by active suction	Depends on pressure differentials
Pressure gradient	Negative pressure(low, moderate, high)	Positive pressure
Drain exit site	Dependent position not necessary	Dependent position necessary for best function
Drain site dressing	Minimal or not required	Bulky to absorb fluid output
Measurement of effluent	Reliable and accurate	Difficult to quantify
Fluid re-collection	Unlikely because negative pressure improves tissue apposition	Likely because of limited effect on the dead space
Retrograde infection	Lower incidence especially with close suction system	High incidence especially with open system
Obstruction of drain	More common due to smaller caliber	Less common
Radiographic studies	Easy to perform	Difficult except in special circumstances like T-tube and Nasogastric tube
Pressure necrosis	High incidence	Low incidence

** More info on specific drain types is included (with pictures). Reference as needed. **

- Ideal drain
    - Firm, not too rigid, not too soft (no kinks)
    - Remain in place
    - Smooth (no fibrin adhesion)
    - No decomp or disintegration
    - Large enough to prevent easy blockage
    - Non-electrolytic/carcinogenic/thrombogenic
- Drain purposes
    - Therapeutic
        - Exit of gases/liquid

        - Treat conditions
    - Palliation
        - Bypass luminal obstruction - what does this mean?
    - Diagnostic
        - Post-cholecystectomy diagnoses (for stones in the common bile duct)
    - Prophylactic
        - Prevent postoperative complication
    - Monitoring
        - Urinary output, upper GI bleeding, etc.
    - Access route
        - Percutaneous therapy
- Care for drains
    - Safest/shortest route
    - Reach deepest, most dependent part
    - External drains through stab wound, not main wound
        - Minimize incidence of infection
    - No kinks, debris, and clots
        - Free drainage
    - Secure drain well
        - No falling, migration, or erosion of surrounding tissue
    - Lower than incision at all times
    - Prevent dislodgement, infection, irritaion
        - Roman Garter, nylon suture, safety pin, drain clip, adhesives, Tie-lok - LOOK INTO ALL OF THESE
    - Keep area clean/dry
    - Gauze protects, absorbs drainage, and helps stabilize
    - Record drainage outputs
- Complications
    - Tissue reaction
    - Source of contamination
    - Delayed return of function
    - Retained foreign body
    - Tissue necrosis
    - Bowel herniation
    - Hemorrhage
    - Prolonged healing time
    - Drain entrapment and loss
    - Fluid, electrolytes, and protein loss
    - Migration of drain
    - Erosion of viscera

Conclusions/action items:

This source is a good starting point. It includes plenty of background info on surgical drains, how they are used/work, drain types, and problems with them. Reference often as needed. The references may be a good guide for more in-depth knowledge of specifics.

REVIEW ARTICLE

Surgical Drains: What the Resident Needs To Know

Download

SurgicalDrains_WhatResidentNeedKnow-ReviewArticle.pdf (1.43 MB)

09/14/2022 - Surgical Drains Nursing Guidelines

Oscar Zarneke - Sep 14, 2022, 9:21 PM CDT

Title: Surgical Drains Nursing Guidelines

Date: 09/14/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To understand some surgical drain guidelines for nurses.

Content:

Clinical Guidelines (Nursing) : Surgical drains (non cardiac) (rch.org.au)

- Terms
  - Jackson-Pratt
    - Soft, pliable tube
    - Multiple perforations and bulb
    - Low negative pressure vacuum
  - Redivac
    - High negative pressure drain
  - Pigtail
    - Small lumen
    - Pigtail coil
    - Drains single cavity
    - Passive
    - Easily blocked
    - Self retaining
  - Penrose
    - Flat, ribbon-like
    - Gauze needed for drainage
- Assessments
  - Initial
    - Air leakage, redness, irritation?
    - Is it secured with sutures or tape?
    - Below insertion site?
    - Kinks or knots?
    - Check drain patency
  - Ongoing
    - Febrile, redness, tenderness, increased ooze?
    - Check patency and insertion site
    - Proper suction?
    - Drains removed ASAP - decrease infection risk
    - For patient: drain below insertion w/out pulling; dislodgement risk and pain w/ motion; mobilize while supervised if possible

** The rest of the article regards care and removal. Reference if needed. **

Conclusions/action items:

This source describes four different drain types used in a clinical setting. It also tells us what a nurse should be able to check and monitor; something to keep in mind while coming up with designs.

10/20/2022 - Surgical Drain Diameters

Oscar Zarneke - Oct 20, 2022, 11:09 AM CDT

Title: Surgical Drain Diameters

Date: 10/20/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To record the range of surgical drain diameters so we know how to size the clip

Content:

- We are using Jackson-Pratt drains, so all of the diameters of the Jackson-Pratt drains from Cardinal Health were recorded
  - Cardinal Health™ Jackson-Pratt® The name you trust for wound drainage products.
- Some were recorded in fr, which has a conversion of 1fr = 0.33mm
- The range was from 2.31mm - 10mm with a median of 6.27 mm

Conclusions/action items:

The diameters of Jackson-Pratt drain tubes from Cardinal Health were recorded. The diameters of more tubes can be located to see if the range of diameters needs to be expanded.

Oscar Zarneke - Oct 20, 2022, 11:40 AM CDT

Download

SurgicalDrains-TubeDiameters.xlsx (9.74 kB) THIS IS AN OLD DOCUMENT

Oscar Zarneke - Oct 20, 2022, 11:39 AM CDT

Title: Surgical Drain Diameters - UPDATE

Date: 10/20/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To record the range of surgical drain diameters so we know how to size the clip

Content:

- We are using Jackson-Pratt drains, so all of the diameters of the Jackson-Pratt drains from Cardinal Health were recorded
  - Cardinal Health™ Jackson-Pratt® The name you trust for wound drainage products.
- Some were recorded in fr, which has a conversion of 1fr = 0.33mm
- The range was from 2.31mm - 10mm with a median of 6.27 mm

- More surgical drains from Cardinal Health were found (cardinal-health-wound-drains-catalog.pdf (cardinalhealth.com))
- The new range is 2.31mm - 13.3mm with a median of 6.27mm
- The size of 89 drains/drain kits was recorded
  - Some may be the same drain, but in a kit rather than just the drain

Conclusions/action items:

The diameters of drain tubes from Cardinal Health were recorded. The diameters of more tubes can be located to see if the range of diameters needs to be expanded.

Oscar Zarneke - Oct 20, 2022, 11:40 AM CDT

Download

SurgicalDrains-TubeDiameters.xlsx (11.8 kB) MOST UPDATED DOCUMENT

10/05/2022 - Band-Aid Materials

Oscar Zarneke - Oct 05, 2022, 4:52 PM CDT

Title: Band-Aid Materials

Date: 10/05/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To research what Band-Aids are made of to identify what bandage materials to use.

Content:

- Hydro Seal Band-Aids are hydrocolloid gel bandages - HYDRO SEAL™ All Purpose Hydrocolloid Gel All Purpose Bandages | BAND-AID® Brand
- Hydrocolloid bandages - Wound care: fact and fiction about hydrocolloid dressings - PubMed (nih.gov)
    - Two layers
    - Inner layer is hydrocolloid adhesive
        - Particles absorb exudate
        - Form hydrated gel over wound
        - Creates moist environment - good for healing and protection
    - Outer layer is film, foam, or both
        - Forms seal to protect wound from external debris and contamination
        - Maintains moist environment
        - Prevents shearing
    - Designed to be worn up to a week
    - Not good for limited drainage or copious drainage
- Amazon shows the cost of large bandages (4"x4") to be about $1.60 per bandage - Amazon.com: Hydrocolloid Adhesive Bandage, Hydrocolloid Wound Dressing Thin Type 4" x 4", Individually Sterile Packed Hydrocolloid Patches, Box of 10 Dressings : Health & Household
    - This could be cheaper in bulk from the manufacturer
    - How would we package it with a clip?

Conclusions/action items:

A hydrocolloid bandage may be a good option at the incision site. It can stay on for a while and will help protect the site. However, it could be costly, especially if large modifications are added.

10/05/2022 - KT Tape

Oscar Zarneke - Oct 05, 2022, 5:06 PM CDT

Title: KT Tape

Date: 10/05/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To research what KT tape is made of to identify what bandage materials to use.

Content:

What is KT Tape®?

- Elastic sports and fitness tape
- For muscle/ligament/tendon pain relief and support
- 100% cotton fibers OR "highly engineered, ultra-durable synthetic fabric"
- Specialized elastic cores
- Unidirectional elasticity
- The synthetic fibers allow for moisture release
- Latex-free and hypo-allergenic
- Designed for humidity, sweat, showers, and multiple days wear
- It works by reducing pressure to tissues
    - Reduces pain and discomfort
    - Supports muscles by preventing over-extension and over-contraction
    - HOWEVER, there is no proof to the claims, could be placebo
- 20 precut strips is $21 - KT Tape Pro®

Conclusions/action items:

KT tape is definitely comfortable to wear, especially during activity. However, I am concerned about shaping it out of the standard strip; would it still work? Also, it could get very expensive with modifications, especially if it needs to be shaped differently.

10/20/2022 - Clip Materials

Oscar Zarneke - Oct 20, 2022, 9:18 AM CDT

Title: Clip Materials

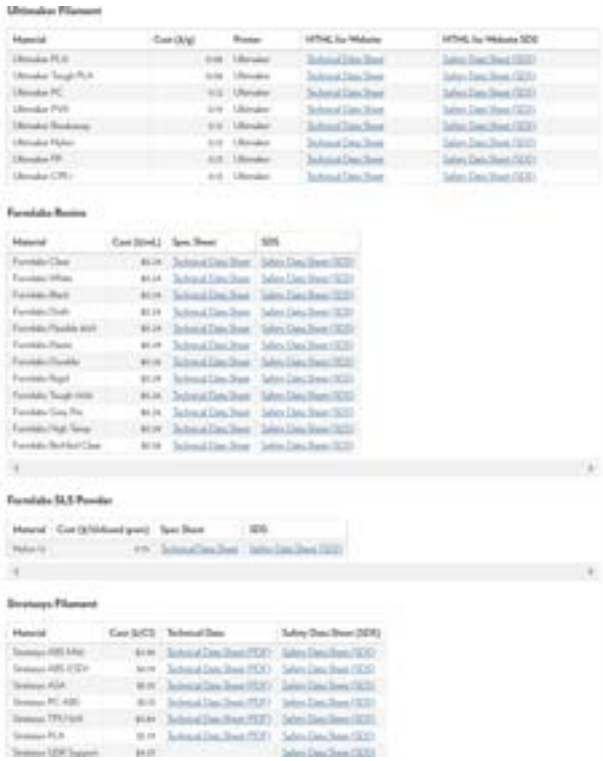
Date: 10/20/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To record some of my thoughts and research on clip materials

Content:

- We desired to use high-density polyethylene (HDPE)
    - Good, strong material properties
    - Already used in medical equipment, so we know it is safe
- On the UW Madison Makerspace website (3D Printers – UW Makerspace – UW–Madison (wisc.edu)) - NO HDPE
    - 
    - So we must prototype using something else, or find a new material
- Because we are not inserting this plastic into the body, does it need to be HDPE?
    - Could we use some other plastic for the clip?
    - Or should we just prototype using PLA?
    - Or can we purchase a commercial clip?

Conclusions/action items:

Looking at the UW Makerspace website, we cannot prototype with HDPE because we cannot 3D print HDPE. We can either prototype with a different material, choose a different material to use, or purchase a commercial clip.

09/22/2022 - FDA Standards to Consider

Title: FDA Standards to Consider

Date: 09/22/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To record some FDA standards that may be relevant to our project

Content:

- Surgical sutures are considered FDA medical devices class II with special controls: https://www.fda.gov/medical-devices/guidance-documents-medical-devices-and-radiation-emitting-products/surgical-sutures-class-ii-sp
- Surgical topical adhesive is considered FDA medical devices class II with special controls: https://www.fda.gov/medical-devices/guidance-documents-medical-devices-and-radiation-emitting-products/tissue-adhesive-top staff#:~:text=FDA%20believes%20that%20special%20controls%2C%20when,for%20the%20topical%20approximation%20of%20skin.&text=FDA%20believes%20that%20special,topical%20approximation%20of%20s
- All products should follow FDA medical devices sterilization techniques: https://www.fda.gov/medical-devices/general-hospital-devices-and-supplies/sterilization-medical-devices

Conclusions/action items:

These are a few standards that should be followed when designing our new method. Reference frequently.

09/26/2022 - Single Suture w/ Beads

Oscar Zarneke - Sep 26, 2022, 6:20 PM CDT

Title: Single Suture w/ Beads

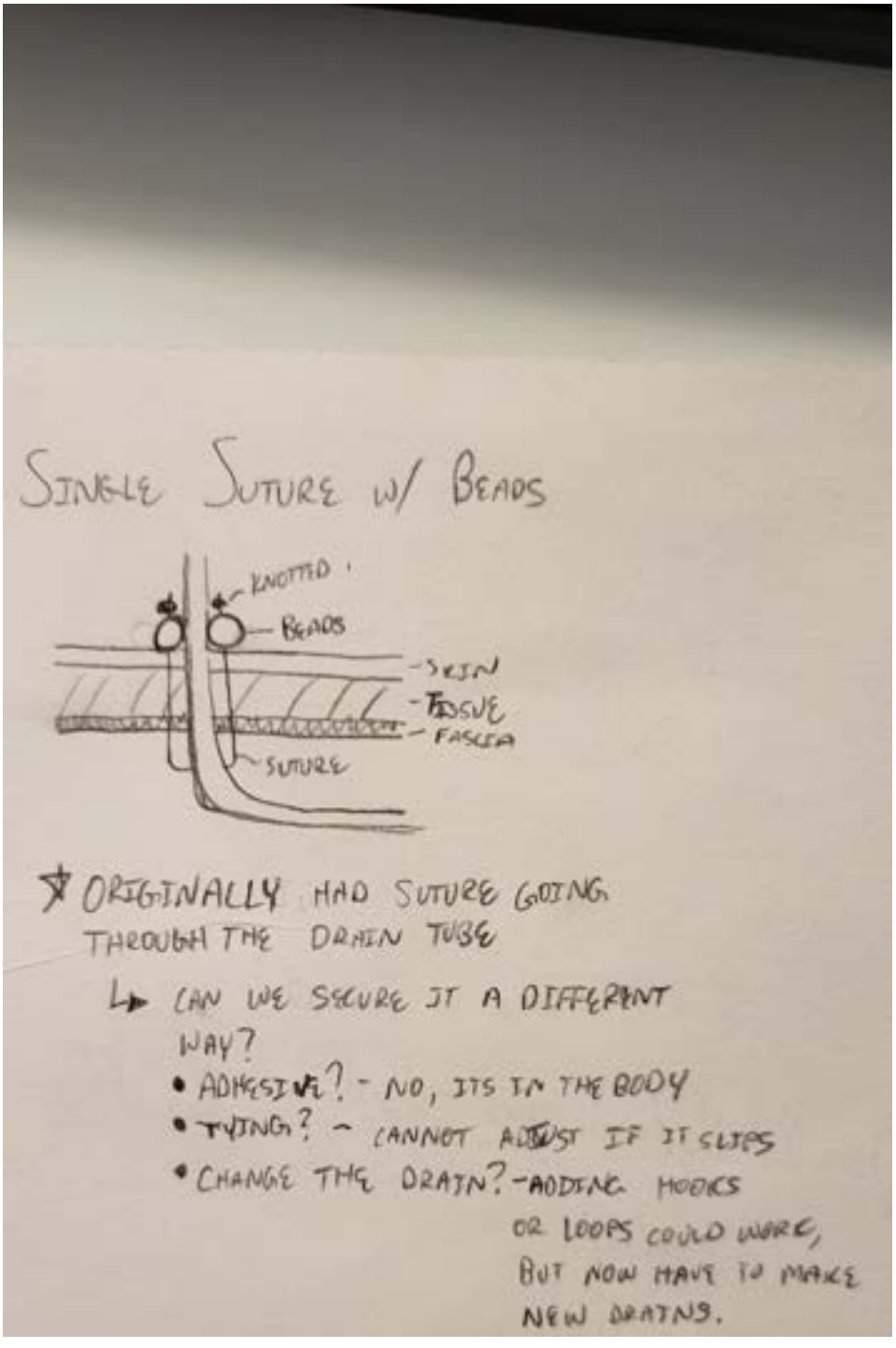
Date: 09/26/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To record one of my design ideas.

Content:



Conclusions/action items:

Address the questions and cons of this design. Improve and iterate if possible.

Oscar Zarneke - Sep 29, 2022, 11:06 AM CDT

Title: Single Suture w/ Beads - Revisited

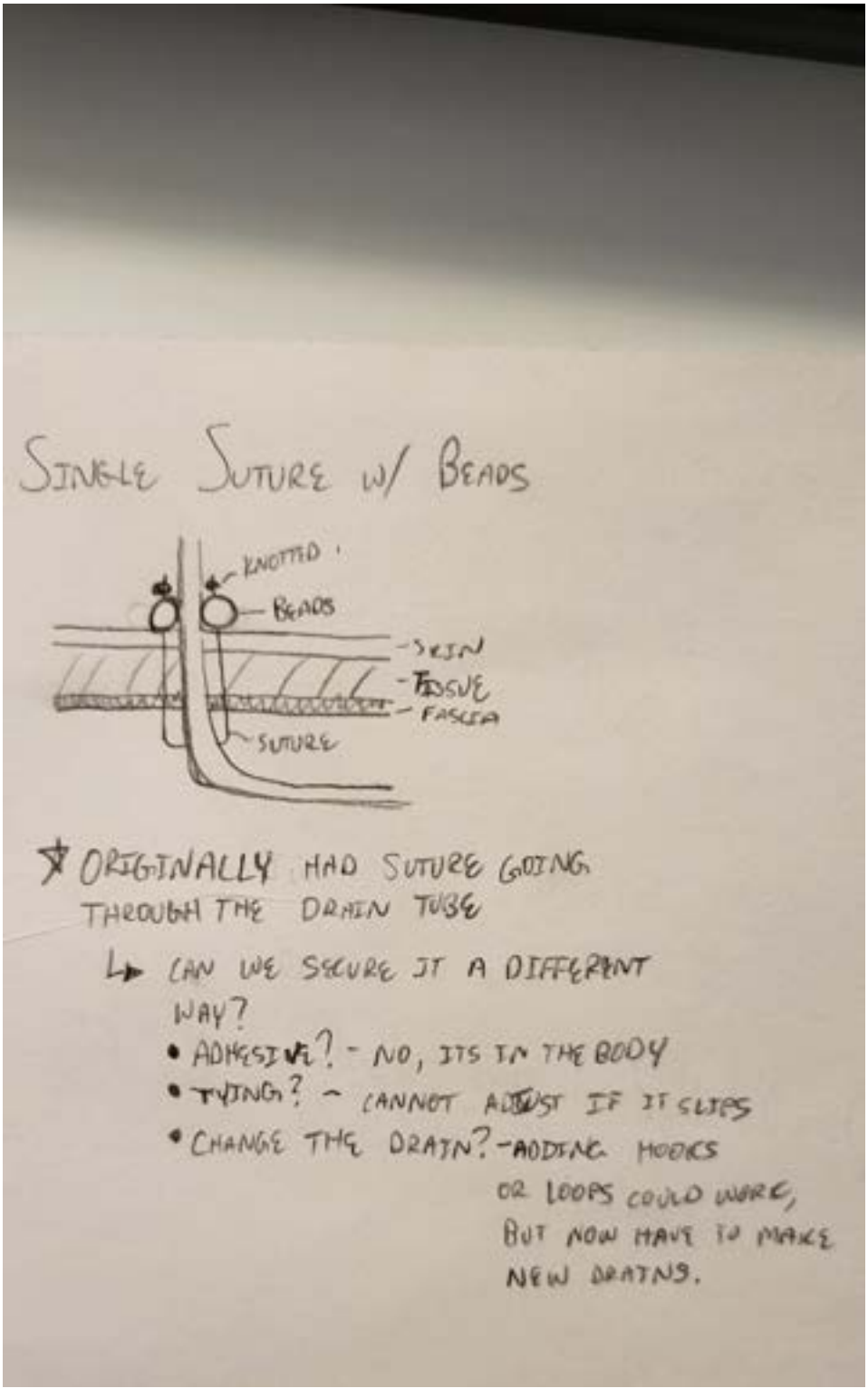
Date: 09/29/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To revisit one of my design ideas

Content:



Putting a hole through the drain is the design as reported in the literature and it presents the problem of having a hole in the drain tube that could cause leakage. An adhesive could work in the short term, but it could erode over time if left in for a month; being in the body requires surgery to re-adhere it. Changing the drain would work, but that creates a new (substantial) cost of changing the entire surgical drain industry; possible, but not ideal. Maybe talking with the contact from Cardinal Health R&D could clarify that design possibility. Additionally, the loops or hooks would not have to go into the body. One could simply use it to help tie the standard suture knots.

Conclusions/action items:

Present the design idea to the Cardinal Health contact to get their opinion on the design's viability.

09/26/2022 - Waterproof Band-Aid w/ Clip

Oscar Zarneke - Sep 26, 2022, 6:21 PM CDT

Title: Waterproof Band-Aid w/ Clip

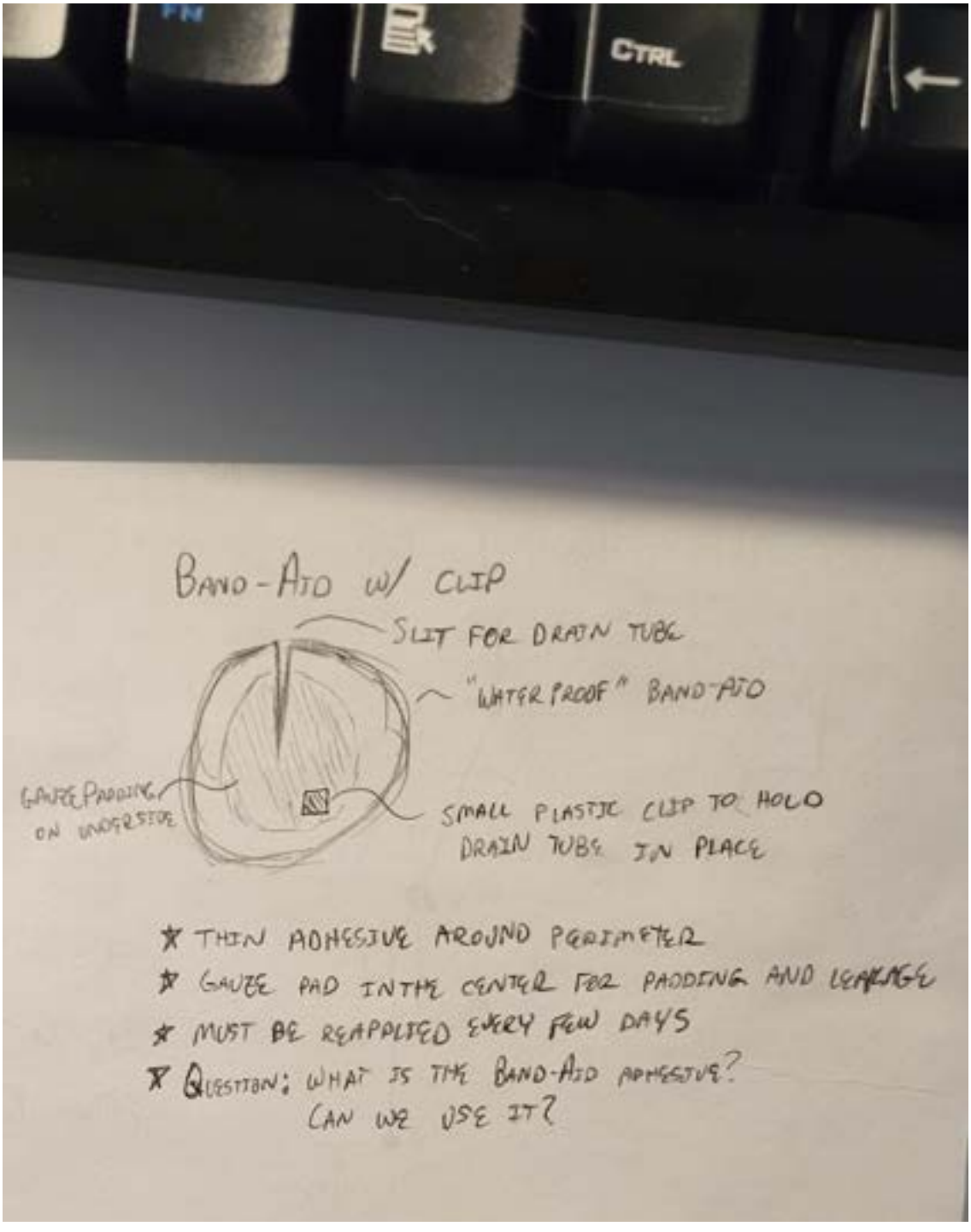
Date: 09/26/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To record one of my design ideas.

Content:



Conclusions/action items:

Address the questions and cons of this design. Improve and iterate if possible.

Oscar Zarneke - Sep 29, 2022, 11:39 AM CDT

Title: Waterproof Band-Aid w/ Clip Revisited

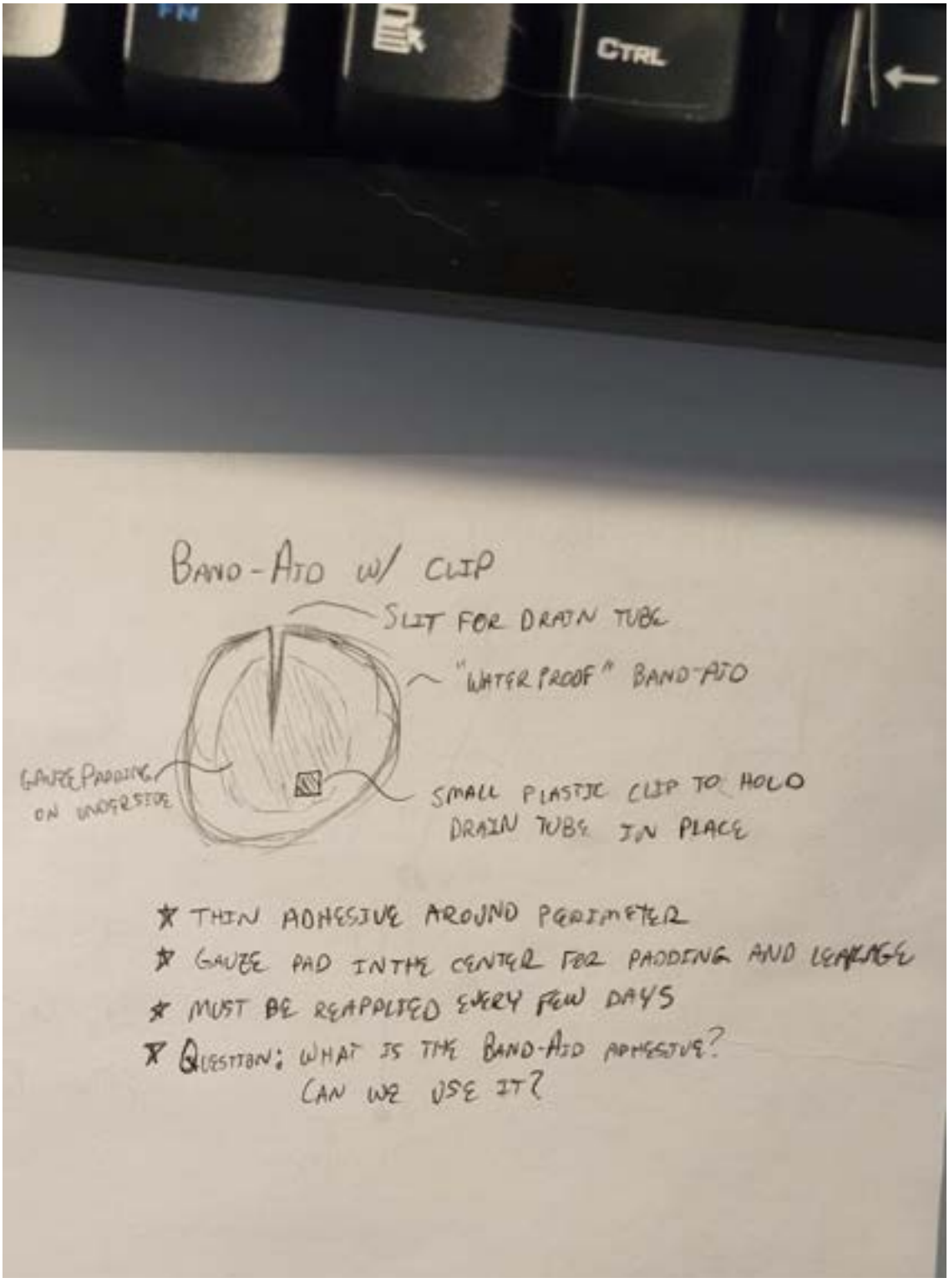
Date: 09/29/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To revisit one of my design ideas.

Content:



Large waterproof Band-Aids are on the market for less than $1 per bandage, so the design seems like it could be cost-effective depending on the cost of the clip. Other possible clip ideas are Velcro straps of some sort to prevent pinching of the tube, clothespin, or plastic chip bag clips. There are many, many types of adhesive bandages (fabric, plastic, foam, latex, etc.) with pads made of cotton and hydrogels. The adhesive is usually an acrylate (i.e., methacrylates and epoxy diacrylates known as vinyl resins). The major question is in regard to patent concerns (not that we are looking to patent). Can we simply use an existing bandage and fix a clip to it? Or do we need to create our own bandage? If we create our own bandage, what limitations are there, if any?

Once we get the tubing, we can test clips on it to find an ideal clip strength and material, so I do not think it is important to identify one right now. However, the group needs to discuss types of adhesive bandages and use the information to refine design ideas.

Note, most of the material info came from Wikipedia. Most sources do not talk about adhesive bandage materials, just the types. Use this info as a starting point, but continue trying to find information from more reliable sources. Adhesive bandage - Wikipedia

Use this source to identify possible adhesive types that could be used with this (or similar) designs: Master Bond Biocompatible Epoxy Systems | MasterBond.com

Conclusions/action items:

Discuss this design idea with the group, going over the unknowns and legal concerns. Maybe they will have ideas on how to refine this design or incorporate parts of this design into another.

10/20/2022 - Clip Design Ideas

Oscar Zarneke - Oct 20, 2022, 11:53 AM CDT

Title: Clip Design Ideas

Date: 10/20/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To record my thoughts on the clip design

Content:

- As stated in *Oscar Zarneke -- Research Notes -- Clip Materials -- 10/20/2022 - Clip Materials*, we cannot prototype in HDPE as originally planned
- Can we simply purchase a clip rather than design one?
    - Do not remake the wheel
- The clip must support a range of tube diameters
    - *Oscar Zarneke -- Research Notes -- Surgical Drains -- 10/20/2022 - Surgical Drain Diameters* shows a range from **2.31 - 13.3mm**
- One option could be cable clips (used for electronic cord organization)
    - I am partial to these clips from SOULWIT on Amazon (AmazonSmile: SOULWIT 50Pcs Adjustable Cable Management Clips, Adhesive Cable Organizers Sticky Wire Clips Cord Holder for TV PC Ethernet Cable Under Desk Wall Home Office : Electronics)
    - 
    - They have a diameter range of 2.7 - 9mm - we could prototype with these, then see if we can make a similar version with a larger diameter range
    - The material is PA66 - a form of nylon
    - The adhesive is a double-faced adhesive tape - we could scratch it off and apply our own adhesive (something stronger)

Conclusions/action items:

Discuss the clip design with the group; see if they are ok with purchasing clips like these.

10/27/2022 - Testing Brainstorm

Oscar Zarneke - Oct 27, 2022, 11:22 AM CDT

Title: Testing Brainstorm

Date: 10/27/2022

Content by: Oscar Zarneke

Present: Oscar Zarneke

Goals: To brainstorm questions and key points that testing must answer/address

Content:

- How comfortable is the design?
  - Just to wear
  - How do the materials feel?
- How long will the design last?
  - Once applied, will the device last 1 week?
  - What causes it to fail?
- Does the design reduce suture tension?
  - Will it direct tension away from the sutures?
- Will the design last in the shower? While sweating? etc.
  - How does it last in different environments?
- Does the device allow for normal drain flow?
  - Any pinching?
  - Any kinking?
- Can the device stay in place while the drain is stripped?
- Does the device accommodate the range of drain diameters?
- Can the device be sterilized prior to packaging?

Conclusions/action items:

Research and generate tests that can answer/address these questions.

2022/09/26 - Surgical drain securing device Patent #1

ABDOULAHI BAH (anbah@wisc.edu) - Sep 26, 2022, 6:54 PM CDT

Title: Surgical drain securing device Patent #1

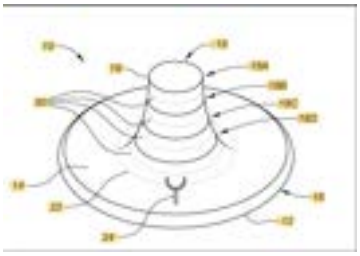
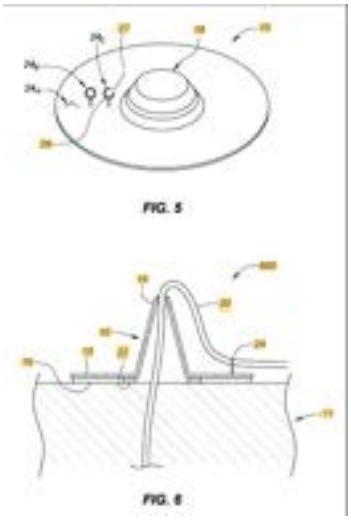
Date: 9/26/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Research on design to improve surgical drains

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** T. J. Frew, “Surgical drain securing device,” 20180353735:A1, 13-Dec-2018.
- 
- 

- This was a patent I found on google patents. Some Pros from this device is:
    - Uses a strong adhesive to stick tube holder on to the skin
    - It does not require a suture
    - Can apply antibiotics on it, so patient those not have to constantly reapply
    - Has a latch on the outer surface to secure the tube
- Some cons:
    - I don’t think this would be a good idea when it comes to taking a shower or if the patient starts perspiring because the adhesive might not hold

    - Could be a pinching of the tube when pulling the tube over the top cone, this could cause blood clots and other things to easily get stuck
    - Seems very big and just out there, could experience poking if accidentally bump into something
    - Tube might slip in, even though there is a latch, there can still be slipping of the tube at the insertion site.

- Some questions I had from the reading:
    - N/A

Conclusions/action items: This has helped me identify some parts the team can implement into a design and also look at certain consequences that could occur if we add certain parts. My action items will be to continue looking at more patents and competing designs to brainstorm another design.

2022/09/26 - Surgical drain securing device Patent #2

ABDOULAHI BAH (anbah@wisc.edu) - Sep 26, 2022, 6:55 PM CDT

Title: Surgical drain securing device Patent #2

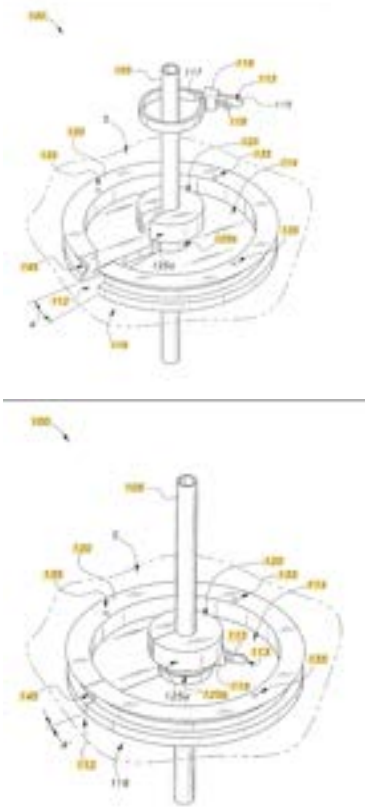
Date: 9/26/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Research on design to improve surgical drains

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation: A. E. A. Al-Terki, “Surgical drain anchoring device,” 9919133, 20-Mar-2018.**
- 
-
  FIG. 3

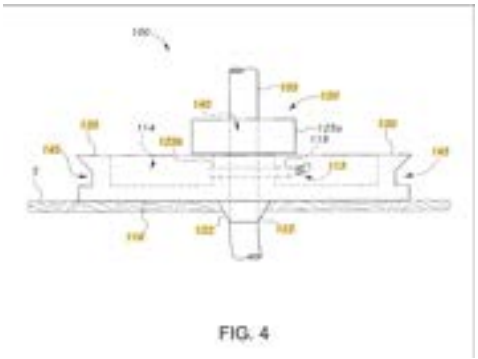


FIG. 4

- This is another patent for securing the surgical drain in the patient. It is very similar to the design I came up with but there are some differences. Some pros:
    - Used a washer type of design so there is a lot of support in terms of holding tube up and not letting it fall in
    - Does not need sutures but can be used if added securement is needed
    - The tension is dispersed throughout a larger surface area
    - Slits #145 in the diagram provide a way for a surgical device to be attached
- Some cons:
    - If the tube is not strong enough zip tie might decrease its diameter causing obstruction of flow
    - Seems like getting the pieces in the skin would require a big incision area.

- Some questions I had from the reading:
    - Why is the Zip tie placed under piece 125a in the diagram above?
    - How would the procedure work?

Conclusions/action items: This patented design was pretty similar to my design, however there were some things that were different about it. I could possibly take components that I like and improve my design. My action item will be to continue looking at more designs to create another design.

2022/09/26 - RecoverEase Mastectomy Pouch

ABDOULAHI BAH (anbah@wisc.edu) - Sep 29, 2022, 12:46 PM CDT

Title: RecoverEase Mastectomy Pouch

Date: 9/28/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Identify pros and cons of current devices for surgical drains

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** https://www.amazon.com/RecoverEase-Mastectomy-Treatment-Recovery-Regular/dp/B09FW651ZP?th=1
- “RecoverEase,” RecoverEase. [Online]. Available: https://www.myrecoverease.com/. [Accessed: 28-Sep-2022].
- This is a current product on the market that is sold on Amazon for $50 by a company called RecoverEase. I really like the design because it is almost like an undershirt but holds really tight to the patient's body, so it is very discrete and you can wear other clothes over it.

Pictures of Product:

- Some Pros of the product:
    - Holds the surgical drains very close to the body and are very secure
    - Does not use as many materials, it's like a sock with little flaps in which the drains can go in
    - Very discrete, and close to skin so patient can wear other clothes over it and nobody would notice
- Some Cons:
    - Only one color
    - Very overpriced - two reviews in which people stated this
    - The product is said to be made up of 86% nylon and 14% spandex material. This can be questionable since a material like nylon doesn't do as well with absorbing sweat. In addition, the spandex material may lose its elasticity after a couple of uses
    - Can most likely not be used in the shower

- Some questions I had from the reading:
    - What are some alternatives for a nylon material?
    - What materials can be worn on the skin for long periods of time?
    - How can spandex materials be preserved and keep their mechanical properties longer?

Conclusions/action items: I like this design a lot, because of the pros listed above. However, more research will need to be done to find better materials that can be used to better this idea. My action items will be to do some research on other materials that can be worn on the skin for long periods of time and spandex materials.

2022/09/13 - General Information About Surgical Drains

ABDOULAHI BAH (anbah@wisc.edu) - Sep 16, 2022, 4:52 PM CDT

Title: General Information About Surgical Drains

Date: 9/13/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Understand surgical drains

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** R. Durai and P. C. H. Ng, “Surgical vacuum drains: types, uses, and complications,” AORN J., vol. 91, no. 2, pp. 266–71; quiz 272–4, 2010.
- Surgical drains are used to prevent the accumulation of fluid in an area that has been recently operated. The article highlighted that there are two categories of surgical drains, active and passive. Active drains use negative pressure to pull out the fluid from the site, while with passive the fluid just flows out by gravity. Some problems with surgical drains is that they can fall into the wound or out. Surgical drains can also get caught in clothes or just things in general. In addition, it can be uncomfortable for the patient since they have less freedom of movement due to the surgical drains
- Some questions I had from the reading:
    - Ask Client: For our project are we focusing on active or passive drains or does it not matter?
        - client thinks it is cool if the design is able to work for both active and passive drains
    - How does the bulb active surgical drain specifically work?

Conclusions/action items: This was a good article that provided me with some general knowledge on surgical drains. My action items after reading this article is to find answers to my questions above through more research, and do research on some of the specific surgical drains that were provided in the article (Redi-vac, Penrose, Jackson-Pratt).

Surgical Vacuum Drains: Types, Uses, and Complications

1.2

ABSTRACT

Download

Surgical_Vacuum_Drains_Types_Uses_and_Complications.pdf (476 kB)

2022/09/13 - A Simple Technique for Securing Surgical Drains

ABDOULAHI BAH (anbah@wisc.edu) - Sep 18, 2022, 10:05 PM CDT

Title: A Simple Technique for Securing Surgical Drains

Date: 9/13/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Understand surgical drains

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** J. P. Mcfarlane and L. Joseph, “A simple technique for securing surgical drains Alok Tiwari,” Princess Alexandra Hospital.
- This article showed a proposed technique to secure surgical drains. The technique still used a suture (string attaching), but it also included zip ties, to hold the drain tube in place and not allow it to displace into the wound. My understanding is that the zip ties worked like a washer/anchor. For the washer analogy, the drain is the bolt, and the washer is the zip ties, and they provided reinforcement to the skin so that the drain (bolt) did not fall into the wound (hole). For the anchor analogy, the drain is the thing we want to hold up and the zip ties were the supports we used to hold the drain up.
- Some questions I had from the reading:
    - Why is silk used when performing a suture? Why is it a good and safe material to use for this application?
        - Silk has good mechanical strength, toughness, ductility and is biocompatible with the skin. This is why it is popular in the application of sutures. However, medicine has now been using more synthetics for sutures
    - Ask Client: Did your surgical drains ever displace due to it getting caught in clothes/cleaning? Was the displacement of the drains the cause of pain?
        - sutures held the tube in place pretty well, however there was a lot of tugging on the suture which caused the pain
    - Ask Client: Do you want this new method to rely on sutures to secure the surgical drains on to the patient?
        - We can create a device that doesn't focus on attachment but to hold up the drain and tube

Conclusions/action items: This article gave an idea to secure surgical drains however it still required sutures. Some action items will be to do some research on why silk is a popular choice when performing sutures, and do some extra research on the references provided.

A simple technique for securing surgical drains

Alok Tiwari*, John P. McFarlane, Joseph E. Peters

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A_simple_technique_for_securing_surgical_drains.pdf (189 kB)

2022/09/13 - Surgical Drain @ Home

ABDOULAHI BAH (anbah@wisc.edu) - Sep 16, 2022, 4:51 PM CDT

Title: Surgical Drain @ Home

Date: 9/13/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Understand surgical drains

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** “Care of your surgical drain at home,” Uwhealth.org. [Online]. Available: https://patient.uwhealth.org/healthfacts/4603. [Accessed: 14-Sep-2022]
- When surgical drains are taken home they are to be maintained. These instructions have provided me with the instructions on how to maintain them and will help when trying to design our improved securement.
- Some things to highlight:
    - The surgical drains can be showered with. This would require that our device can endure moist and varied amounts of water. A shower can be cold or hot so the device's material will need to keep structural integrity in different temperatures/climates.
    - Will also be cleaned daily with soap and other cleaning solutions, so the devices material will need to successfully undergo this sanitization
    - The device will also need a material that is biocompatible with the skin and will not cause irritation when in contact
- Some questions I had from the reading:
    - Ask Client: Were there any problems you faced with securement of surgical drains when cleaning or emptying drains? And was there a specific kind of soap or cleaning solution you needed to use when cleaning the area?
        - showering was difficult, had to use a lanyard to hold up the drains and tubes. Only used alcohol wipes and Neosporin for the wound site

Conclusions/action items: This document provided the instructions to take care of surgical drains. I found it helpful as I was able to pull out some expectations for our device. The action items will be to ask the client the questions above to make sure our preliminary design meets certain expectations.

UWHealth Health Facts *for you*

Care of Your Surgical Drain at Home

Download

Care_of_Your_Surgical_Drain_at_Home.pdf (536 kB)

2022/09/18 - Silk for Sutures

ABDOULAHI BAH (anbah@wisc.edu) - Sep 18, 2022, 10:40 PM CDT

Title: Silk for Sutures

Date: 9/18/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Understand surgical drains specifically why the use of silk

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** G. V. Vishaka, “Studies on Silk as a suture in medical science,” The Pharma Innovation Journal, vol. 8, pp. 97–100, 2019.
- This article was a study on silk sutures in medicine. The study found that 90% of medical professionals used silk when suturing. Some reasons for the high favorability of sutures is that silk sutures are biocompatible with the skin, thermally stable, promote healing, easy to sterilize, have controlled degradation and promote healing. In addition, it is a slow absorbable, so once it is installed it will eventually absorb into the skin and will not need to be taken out
- Some questions I had from the reading:
    - N/A

Conclusions/action items: This article helped me with my general understanding of surgical drains, specifically the material that is used to attach them. Now that I have cleared up my curiosity about the use of silk in sutures I will continue to do more research on sutures.

2022/09/21 - Guide to Drains after Surgery

ABDOULAHI BAH (anbah@wisc.edu) - Sep 22, 2022, 2:46 AM CDT

Title: Guide to Drains after Surgery

Date: 9/21/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Understand surgical drains

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** W.-Y. Li, “Dr. Li’s guide to getting drains after surgery,” Surgical Seecrets, 07-Oct-2020. [Online].Available:https://surgicalseecrets.com/blogs/articles/guide-to-getting-drains-after-surgery. [Accessed: 21-Sep-2022].
- This article was a general guide created by a physician to help people with surgical drains post surgery.
- Surgical drains are needed for surgeries in which there is a space created, and in order to prevent fluid build up and infection of the surgery site.
- “Drain Pain” is what the physician calls it. To sum it up it describes the discomfort of surgical drains specifically with the tugging on the attachment site
- The fluid and amount of fluid being drained by day will change
- The bulb that holds the fluid will need to be changed 2-3 times a day
- The drain will be removed once the fluid drained is less than 30 cm^3
- Some questions I had from the reading:
    - N/A

Conclusions/action items: This article helped me understand surgical drains from a doctor's perspective and provides me with important information in terms of the discomfort and when it is to be removed.

2022/09/21 - Draining After breast reduction: a randomised controlled inter-patient study

ABDOULAHI BAH (anbah@wisc.edu) - Sep 22, 2022, 2:48 AM CDT

Title: Draining After breast reduction: a randomised controlled inter-patient study

Date: 9/21/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Understand surgical drains

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** L. U. M. Corion, M. J. C. Smeulders, P. P. M. van Zuijlen, and C. M. A. M. van der Horst, “Draining after breast reduction: a randomised controlled inter-patient study,” J. Plast. Reconstr. Aesthet. Surg., vol. 62, no. 7, pp. 865–868, 2009.
- This reading was a study on whether surgical drains were necessary after breast reduction surgery. This was done by looking at complications of random patients after surgery (with or without surgical drains) and if they experienced pain using the visual analogue scale. Something that was worth highlighting from this reading was that there was a mean pain score of 5.62. Relative to the visual analogue scale that is higher than severe.
- Some questions I had from the reading:
    - N/A

Conclusions/action items: Something that I could take from this reading was that pain and discomfort were discussed. There is not much literature review on the pain and discomfort that comes with surgical drains. My action items would be to find more research discussing the pain that comes with surgical drains.

Draining after breast reduction: a randomised controlled inter-patient study

Leonard U.M. Corion*, Mark J.C. Smeulders, Paul P.M. van Zuijlen, Chantal M.A.M. van der Horst

Download

Draining_after_breast_reduction_a_randomised_controlled_inter_patient_study.pdf (99.1 kB)

2022/09/21 - Role of subcutaneous drains in obese patients undergoing elective cholecystectomy: A cohort study

ABDOULAHI BAH (anbah@wisc.edu) - Sep 22, 2022, 2:49 AM CDT

Title: Role of subcutaneous drains in obese patients undergoing elective cholecystectomy: A cohort study

Date: 9/21/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Understand surgical drains

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** N. A. Chowdri, S. A. A. Qadri, F. Q. Parray, and M. A. Gagloo, “Role of subcutaneous drains in obese patients undergoing elective cholecystectomy: a cohort study,” Int. J. Surg., vol. 5, no. 6, pp. 404–407, 2007.
- This study was looking at whether surgical drains were actually necessary in obese patients that had undergone a cholecystectomy. This surgery is a removal of the gallbladder. The results that they saw were that the dead space created by this surgery was filled with seroma (fluid) in patients who did not have surgical drains. This gave evidence that surgical drains did help keep the dead space created from the surgery empty and not become infected
- Some questions I had from the reading:
    - N/A

Conclusions/action items: Overall this reading was done to see the efficacy of surgical drains. There is still evidence against surgical drains, but this is just one side. My action items is to continue research to better understand surgical drains.

Role of subcutaneous drains in obese patients undergoing elective cholecystectomy: A cohort study

Download

Role_of_subcutaneous_drains_in_obese_patients_under_going_elective_cholecystectomy_A_cohort_study.pdf (152 kB)

2022/09/21 - Exercises after breast cancer surgery

ABDOULAHI BAH (anbah@wisc.edu) - Sep 22, 2022, 2:50 AM CDT

Title: Exercises after breast cancer surgery

Date: 9/21/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Understand surgical drains

Content:

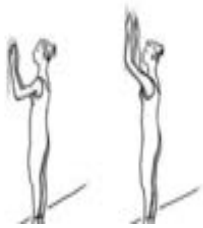
- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** “Exercising after breast cancer surgery,” Cancer.org. [Online]. Available: https://www.cancer.org/cancer/breast-cancer/treatment/surgery-for-breast-cancer/exercises-after-breast-cancer-surgery.html. [Accessed: 19-Sep-2022].
- These exercises were made to decrease the amount of stiffness in arm and shoulder movement which occurs after surgery due to breast cancer
- Important: Some of the exercises were not to be done while drain and sutures were in place
- Exercises include: deep breaths, Basic Mobility Exercises: raising arms to shoulder height and lowering them, straightening elbow, shoulder blade squeeze and stretch, side bends, etc.
    - These exercises mainly to gain full range and mobility of shoulders and arms
- They also recommended aerobic exercises to improve heart lung capacity
- Pictures of exercises:
    - 

    - 

- Shoulder blade stretch

- Side bends

- Shoulder stretch



Conclusions/action items: This reading was done to understand the exercises done after mastectomy surgery. The client had mentioned that they were required to do P.T. post surgery, so I wanted to understand this better and see how

2022/09/21 - Surgical Drains After Breast Surgery

ABDOULAHI BAH (anbah@wisc.edu) - Sep 22, 2022, 2:51 AM CDT

Title: Surgical Drains After Breast Surgery

Date: 9/21/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Understand surgical drains

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** M. S. Jean Campbell, “How to take care of your drains after breast surgery,” Verywell Health, 05-Apr-2016. [Online]. Available: https://www.verywellhealth.com/managing-your-surgical-drains-following-breast-surgery-4021630. [Accessed: 19-Sep-2022].
- If fluid (seroma) builds up in breast it can cause discomfort and scarring
- However a negative about drains is that bacteria can enter the body through the drains if not taken care of
- You can have up to five or more drains attached to you at once
- The length of the tube is about 14 - 18 in but can be longer
- If you have too much drainage it could mean you are too active
- Drain management garments can help with holding drain reservoirs and tubes in an organized matter. All in all lessen the pulling of sutures on the wound site and drains getting caught on something
- Doing certain activities will be difficult (showering, driving, stretching and pulling)
- Also can not soak in a tub or entering a hot tub is not recommended
- Drains are removed once less than 25 - 30 cc of fluid is being collected by the drain
    - This seems to be in consensus with other readings I have done
- Some questions I had from the reading:
    - N/A

Conclusions/action items: The reading was done to help me understand more about surgical drains and the certain constraints they have. This can help with the PDS and when brainstorming to check our design.

2022/10/05 - Impact of Clothing on Exercise in the Heat

ABDOULAHI BAH (anbah@wisc.edu) - Oct 06, 2022, 6:07 PM CDT

Title: Impact of Clothing on Exercise in the Heat

Date: 10/05/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Identify materials that can be used on the design

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** J.-K. Davis and P. A. Bishop, “Impact of clothing on exercise in the heat,” Sports Med., vol. 43, no. 8, pp. 695–706, 2013.
- This was a review article that looked at clothing material and construction affected the ability for someone to stay cool, dry and comfortable during exercise. Clothing creates small environments between the clothing and the skin and this environment is basically what determines how the person will feel when wearing the piece of clothing. So in terms of clothing for exercise, it would be required to have a piece of clothing that keeps a person dry, cool and does not irritate the skin.
- Some ways a person can stay cool was by having air flow through the clothing. It would basically work like an exhaust for the small environment created by the clothing and skin, letting out the hot air that would build up in this environment.
- Another way clothing was studied for cooling was how permeable the fabric was, how well was air able to move through the clothing.
    - A determining factor for this was the knit size of the material, the larger the knit size, the greater the permeability, more air flow which led to cooling.
- Moisture absorption was important and the aftermath.
    - For example cotton and wool were able to absorb a lot of moisture but it had to dry.
    - This was different from synthetic fabrics which did not absorb as much moisture but were able to move this moisture on the clothing.
        - mixing fabrics to get a hybrid material that is both good at absorbing moisture and moving moisture around
- A popular material to do research on would be polyester since majority of exercise clothes is made out of this material
- Taking this research into consideration for materials for design would help us find the right materials especially since the material is at most stress
- Some questions I had from the reading:
    - N/A

Conclusions/action items: This article was a good start for looking for materials for a belt that would hold the surgical drains. Some action items would be to do more research on polyester and is it safe to be worn for long periods of time

2022/10/05 - Silicone-based biomaterials for biomedical applications: Antimicrobial strategies and 3D printing technologies

ABDOULAHI BAH (anbah@wisc.edu) - Oct 06, 2022, 3:30 PM CDT

Title: Silicone-based biomaterials for biomedical applications: Antimicrobial strategies and 3D printing technologies

Date: 10/05/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Identify materials that can be used in teams design

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** M. Zare, E. R. Ghomi, P. D. Venkatraman, and S. Ramakrishna, “Silicone-based biomaterials for biomedical applications: Antimicrobial strategies and 3D printing technologies,” J. Appl. Polym. Sci., vol. 138, no. 38, p. 50969, 2021.
- This literature review looked at silicone and its use in biomedical implants. Silicone is a very versatile material that can change forms depending on material. Some pros:
    - High elasticity
    - High hydrophobicity
    - Maintain original material properties in temperatures ranging from -40 to 185 degrees celsius
    - Can undergo various kinds of sterilization
    - It can also be inserted almost anywhere in the body - so high adaptability
    - Firm but flexible - good materials in terms of the flaps idea
    - Is used in surgical drains already
    - Can also be used in 3D printing
- Cons:
    - Can have some bad effects when it comes to bacteria - however they put solutions on the surface to help them fight against bacteria
    - There is not that much you can do with silicone material when it comes to 3D printing
- Some questions I had from the reading:
    - What is the importance of high hydrophobicity for a silicone material?
    - What is hemocompatibility and encrustation?
    - Polyethylene was used as a material for a shunt catheter, why was silicone better than polyethylene?

Conclusions/action items: I think silicone should be used within the team's design because of its many properties and much evidence of it being a good material. Some action items will be to look for answers for the questions above and do some research on polyethylene and shunt catheter.

ABDOULAHI BAH (anbah@wisc.edu) - Oct 12, 2022, 10:45 AM CDT

Title: Follow Up on Questions

Date: 10/12/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Answer some of the questions generated above

Content:

- **Citation:**
- [1] "Hemocompatibility," Hemocompatibility. [Online]. Available: https://www.eurofins.com/medical-device/services/biocompatibility-testing/hemocompatibility/. [Accessed: 12-Oct-2022].
- [2] N. Tomer, E. Garden, A. Small, and M. Palese, "Ureteral Stent encrustation: Epidemiology, pathophysiology, management and current technology," J. Urol., vol. 205, no. 1, pp. 68–77, 2021.

- What is the importance of high hydrophobicity for a silicone material?
  - Come back to a lot research going against hydrophobicity because more bacteria able to attach on
- What is hemocompatibility and encrustation?
  - Hemocompatibility is a test that looks at how well a medical device interacts with the blood [1]
    - this might not need to be considered since the team will not be using silicone flaps under the skin
  - Encrustation in application to implants is when a hard surface develops over it
    - an example of this is with ureteral stents which can lead to health complications - this gives evidence that encrustation is not a good thing
    - in terms of ureteral stents encrustation occurs due to high amounts of minerals present [2]
  - Question: Could encrustation occur with surgical tubes? And if not, why does it not occur with surgical tubes?
- Polyethylene was used as a material for a shunt catheter, why was silicone better than polyethylene?
  - come back more research needed to be done

2022/10/06 - Foreign body reaction to implanted biomaterials and its impact in nerve neuroprosthetics

ABDOULAHI BAH (anbah@wisc.edu) - Oct 06, 2022, 3:30 PM CDT

Title: Foreign body reaction to implanted biomaterials and its impact in nerve neuroprosthetics

Date: 10/06/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Identify materials that can be used in teams design

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** A. Carnicer-Lombarte, S.-T. Chen, G. G. Malliaras, and D. G. Barone, “Foreign body reaction to implanted biomaterials and its impact in nerve neuroprosthetics,” Front. Bioeng. Biotechnol., vol. 9, p. 622524, 2021.
- This reading talked about the foreign body reaction that occurs when a some sort of device is implanted into the body. Something that is worth highlighting is that this reaction is unavoidable and will occur no matter what. However, this reaction can be maintained so that it does not have as long and big of an affect when it occurs.
- This is very important when thinking of designs and the materials that we are using because we want to minimize reactions like these as much as possible
    - More research is needed on this topic, in terms of what materials minimize this reaction and what can be done to materials to minimize this reaction
- Questions for Dr. Wilke:
    - Did you ever notice FBR occurring when it came to inserting surgical drain tubes into the skin?
    - How did/would minimize this reaction?

Conclusions/action items: This is a very important factor in when we pick a design and materials since we want to minimize this as much as possible. My action item will be to do more research on FBR and what can cause it to maximize and minimize.

2022/10/20 - Silicone-based adhesives for long-term skin application

ABDOULAHI BAH (anbah@wisc.edu) - Oct 20, 2022, 10:21 PM CDT

Title: Silicone-based adhesives for long-term skin application

Date: 10/20/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Research Silicone Adhesives

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** [22] L. Liu, K. Kuffel, D. K. Scott, G. Constantinescu, H.-J. Chung, and J. Rieger, “Silicone-based adhesives for long-term skin application: cleaning protocols and their effect on peel strength,” Biomed. Phys. Eng. Express, vol. 4, no. 1, p. 015004, 2017.
- This was a study that looked at silicone adhesives and how their peeling force was affected using different kinds of adhesive gels, different thicknesses of the adhesive layer, aging and washing the adhesive pads. The peel force describes how well the adhesive is bonded to the surface.
- Silicone adhesives have many advantages:
    - They have great contact with the skin, even though human skin is known to be rough
    - Residue free and don’t move much once applied
    - Have high moisture vapor transmission rate and fluid handling capacity
- **Key Points from Study:**
    - After performing the study they concluded that Silbione RT 4717 had the max peel strength. This could perhaps be a gel we could look into purchasing when prototyping our device
    - Peel strength also increased when adhesive thickness increased. However, there was max thickness, once that thickness was passed it would leave residue when adhesive pad was peeled and peel strength decreased
    - For peel strength due to aging - Silbione RT 4717 peel strength stayed the same for about 5 days and then decreased after
        - These changes due to oxidation and water
- **Some Other Applications of Study:**
    - The study used pig skin to perform the peel strength test. This is because pig skin modeled human skin well because the anatomy, roughness, texture and biochemical properties were very similar to skin
        - We can apply this to our project, by using Pig skin to model and test our device
    - The study also used commercial fabric for the adhesive to be applied onto - we should probably do more research on material to use for the outer part of the bandage if we will make our own adhesive bandage using the Silbione RT 4717 for example
- Some questions I had from the reading:

- N/A

Conclusions/action items: This was a good start in looking at silicone adhesives. It provided me with potential adhesive gels we could potentially use to make our own adhesive bandage and they even have a recipe we could possibly change and use for our design. Action items would be to look more into silicone adhesives and where we could purchase Silbione RT 4717 from.

2022/10/20 -The use of gauze: will it ever change?

ABDOULAHI BAH (anbah@wisc.edu) - Oct 20, 2022, 10:22 PM CDT

Title: The use of gauze: will it ever change?

Date: 10/20/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Understand the use of gauze

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** V. J. Jones, “The use of gauze: will it ever change?,” Int. Wound J., vol. 3, no. 2, pp. 79–86, 2006.
- This article described a brief history of gauze and prevalence of it in the healthcare sector during 2006, however still has some application today. It discussed some potential problems such as:
    - Linting and shedding so can remain in wound after gauze has been removed
    - Wet-to-dry dressing, so the gauze will be very difficult to remove and painful for the patient
    - Evidence of shorter healing times and frequent dressing changes
    - Could also cause foreign body reactions if used to pack a surgical wound
- The major alternative discussed in the article was hydrocolloid dressings. They do a good job of absorbing the wound fluid and allow the wound to be in a controlled moist environment promoting wound healing
- Some reasons why gauze is still being used is that it is very cheap compared to other dressings. This is especially important for areas that can’t afford dressings like hydrocolloid. In addition, the education of other dressings is pretty minimal
- Some questions I had from the reading:
    - N/A

Conclusions/action items: This article provided me with some reasons why gauze should not be used, but I should find more sources to back that up. Also, I should look into hydrocolloid dressings and other alternative dressings and weather there has been efforts to reduce their cost

2022/10/27 - Product File on Foam Dressings

ABDOULAHI BAH (anbah@wisc.edu) - Oct 27, 2022, 4:59 PM CDT

Title: Product File on Foam Dressings

Date: 10/27/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Research foam dressings

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** “Product file: Foam dressings : Advances in Skin & Wound Care,” LWW. [Online]. Available: https://journals.lww.com/aswcjournal/Fulltext/2003/11000/Product_File__Foam_Dressings.3.aspx. [Accessed: 27-Oct-2022].
- **Advantages of Foam dressing:**
    - They are nonlinting and very absorbent - the nonlinting is important because I researched that gauze can be linting (basically lint from gauze is left in the wound)
    - Have a non adherent layer so easy to be removed
    - Can repel contaminants from going in to the wound
    - Can absorb lots of exudate - but not too much otherwise it will be disadvantaged
    - Very pliable soft material that can conform to many different regions of the body
- **Disadvantages:**
    - Can not be used on scared or dry skin
    - If to much exudate is absorbed into it can cause more problems
    - Require something to hold it in place like tape
- **Some questions I had from the reading:**
    - I know from experience foam is very pliable and when compressed and then decompressed it absorbs more things. So it could be used as a negative pressure wound therapy?

Conclusions/action items: I did some research on foam dressings and how they can be advantages. I think this is a pretty good alternative to use for gauze as a wound dressing. An action item would be to look at foam dressings and negative pressure and potential suppliers.

Download

Product_File__Foam_Dressings.3_1_.pdf (169 kB)

2022/10/27 - Fact Sheet on Silbione RT 4717

ABDOULAHI BAH (anbah@wisc.edu) - Oct 27, 2022, 5:00 PM CDT

Title: Fact Sheet on Silbione RT 4717

Date: 10/27/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Research Silicone Adhesives

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** “Silbione ® RT Gel 4717 A&B,” Pdf4pro.com, 2011. [Online]. Available: https://pdf4pro.com/cdn/silbione-rt-gel-4717-a-amp-b-184dcc.pdf. [Accessed: 27-Oct-2022].
- **Advantages of Silbione RT Gel 4717:**
    - Has applications for adhesive wound dressings
    - Has applications for adhesive sheeting used to treat scars
    - Has very good adhesion on dry skin
        - Has a probe tack of 600 g/cm^2
            - Tack describes how quickly an adhesive bond is formed when two forces are brought together
    - Following EN/ISO 10993 & Class 1 medical devices this product do not make the skin sensitive or irritated - proves biocompatibility
- **Disadvantages:**
    - No adhesion on moist wounds - so I am not sure what that would mean if the material came in contact with moisture due to environment or just skin
- **Some questions I had from the reading:**
    - What is a probe tack test? - could possibly use it to test our bandage clip adhesive

Conclusions/action items: I completed some more research on Silbione RT4717 which I had found from another research article by looking at its data sheet. An action item would be to look at probe tack testing. We could potentially use this to test parts of our design.

ABDOULAHI BAH (anbah@wisc.edu) - Oct 27, 2022, 5:01 PM CDT

Silbione® RT Gel 4717 A&B

Solventless Biocompatible Adhesives for Wound & Scar Care

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silbione-rt-gel-4717-a-amp-b_2_.pdf (55 kB)

ABDOULAHI BAH (anbah@wisc.edu) - Oct 27, 2022, 5:00 PM CDT

2022/10/27 - Vacuum assisted closure (VAC)/negative pressure wound therapy (NPWT) for difficult wounds: A review

ABDOULAHI BAH (anbah@wisc.edu) - Oct 28, 2022, 11:58 AM CDT

Title: Vacuum assisted closure (VAC)/negative pressure wound therapy (NPWT) for difficult wounds: A review

Date: 10/27/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Understand wound vac therapy

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** P. Agarwal, R. Kukrele, and D. Sharma, “Vacuum assisted closure (VAC)/negative pressure wound therapy (NPWT) for difficult wounds: A review,” J. Clin. Orthop. Trauma, vol. 10, no. 5, pp. 845–848, 2019.
- This review article looked at wound vacuum therapy. The one mentioned in the article used a foam dressing, which had a vacuum connected to it, and then covered and sealed by an adhesive drape. There are many benefits:
    - Causes tissue expansion which releases growth factor
    - Expansion of cells also causes granulation tissue to grow and reducing the wound size
    - The lack of oxygen due to the vacuum causes tissue hypoxia which caused more blood vessels to be built and vasodilation of blood vessels
    - Stabilized wound environment, decreased edema and removed exudate
    - Decreased financial burden and hassle to keep going back to hospital
        - However current methods are expensive - but can make a low cost one

Fig. 1. Locally available material to assemble VAC dressing.

        - Used cling drape, abdominal drain, bactigras and foam to create a dressing that was connected to a wall mounted suction
- Some cons:
    - Can cause mechanical deformation of tissue if used at really high pressure
    - If sessions of wound vac therapy are not consistent can cause even more problems for the wound

    - Some wound vac procedure are expensive - $85/ a day
    - Have to have intermittent negative pressure
- Some questions I had from the reading:
    - N/A

Conclusions/action items: This review article looked at Wound vac therapy and the benefits of using it. This would be something the team should consider in case our design does not follow through as expected. Action items would be to look at just using foam for negative pressure therapy.

2022/10/30 - Test Methods to Evaluate Tack

ABDOULAHI BAH (anbah@wisc.edu) - Oct 30, 2022, 8:48 PM CDT

Title: Test Methods to Evaluate Tack

Date: 10/30/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Understand how to measure tack

Content:

- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** "Test methods to evaluate tack," Specialchem.com. [Online]. Available: https://adhesives.specialchem.com/selection-guide/test-methods-to-evaluate-tack. [Accessed: 31-Oct-2022].
- This article summarized different ways to measure tack. Tack is the property of an adhesive that allows it to adhere to another surface. This is very important in the function of our design since we will be using an adhesive bandage to attach the surgical drain to the patient. Finding ways to test this will help us understand whether our device is doing a well enough job in securing the surgical drains and we can add more situations to our test (like for example having the test run under high temperatures to see if tackiness of the adhesive is able to still hold at ranging temperatures)
- **Rolling Ball Tack Test**: will have an adhesive on which the ball will roll and tell you how well the adhesive is able to stop the ball from rolling
    - Advantages:
        - The bigger distance traveled by the ball the less the tack of the adhesive
    - Disadvantages:
        - It is low cost and easy to use and understand
        - There is not much precision and consistency - so would require multiple tests to get sound data
- **Loop Tack Test**: looping of adhesive which will be held by the grips of the tensile machine. The adhesive will touch the test surface and then be pulled away
    - Advantages:
        - Good precision and reproducibility
    - Disadvantages:
        - There could be difficulty in getting consistent contact between the surface and adhesive
        - If the adhesive is too stiff or slippery might not be able to loop and even perform the test
        - Require an ATSM machine
- **Peel Tack Test**: test how easy it is to peel the adhesive from a surface
    - Advantages:
        - Good precision and reproducibility

        - Can make sure there is good contact with the surface
    - Disadvantages:
        - Figuring out how to conduct this test in which each trial is the same
- **Probe Tack Test**: adhesive is placed on a surface and a probe is brought into contact with the adhesive surface. Then measure the amount of force necessary to pull the probe away from the surface
    - Advantages:
        - A lot of information can be gained from a single test
        - Can change a lot of variables to test different things (temperature, wetting of bond, etc.)
    - Disadvantages:
        - Prone to human error which can bias the results
        - Require an ATSM machine

- Some questions I had from the reading:
    - What is the difference between the loop tack and probe tack testing? - They seem to be doing the same thing.

Conclusions/action items: This article provided me with insight into certain tests the team could utilize to test our device. My action items will be to do more research into each testing method to see which one would be more applicable to our device and whether it is an easy test and is accessible to use.

2/11/2022 - Loop Tack Test

ABDOULAHI BAH (anbah@wisc.edu) - Nov 02, 2022, 9:40 PM CDT

Title: Loop Tack Test

Date: 11/2/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals: Understand how to measure tack

Content:

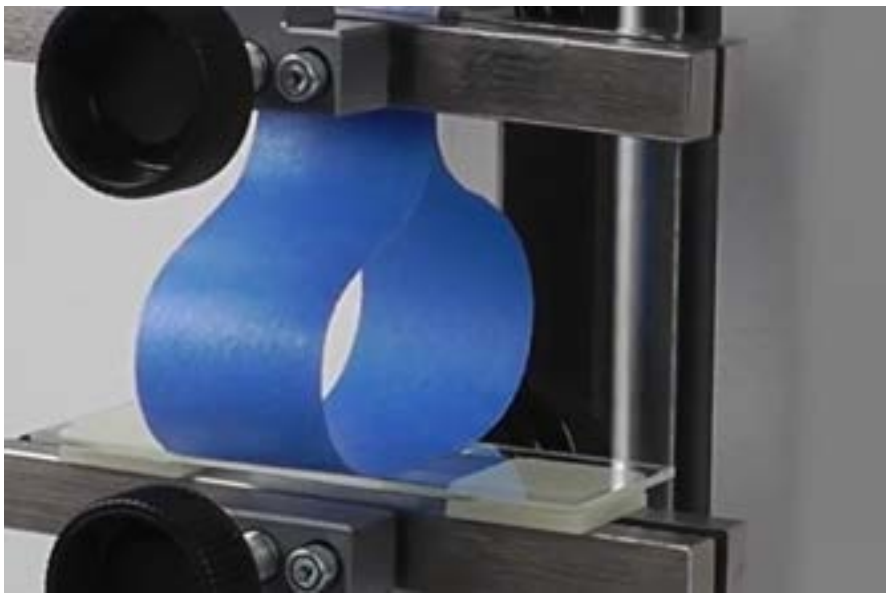
- **Search Terms: N/A**
- **Search Engine:** Google
- **Citation:** Krystyna, “Test standards ASTM D6195-03 for loop tack test – Method A,” Mecmesin.com. [Online]. Available: https://archive.mecmesin.com/test-standards-astm-d6195-03-for-loop-tack-test-method-a. [Accessed: 03-Nov-2022].
- This article summarized the test methods for a loop tack test. This is one of the tests used to measure tac force or in general the quality of the adhesive.

Test Overview:

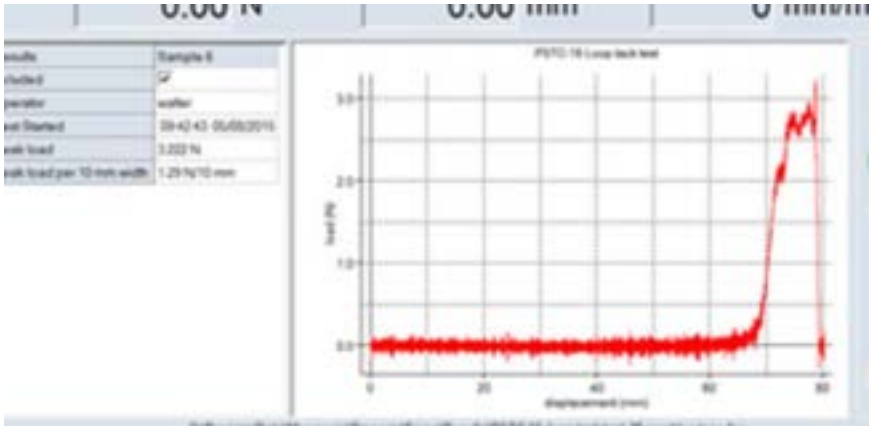
- Adhesive will be on the outside of the loop, and the tensile tester grips will hold onto the top of the loop
- The loop will be lowered onto the test surface until it is in full contact with the surface
- Then the tensile tester will pull upwards - (**12in/min that is what the tester used**) - but until the the loop detaches
- Will then be left with the maximum force necessary to completely separate the loop from test surface - so will start recording once loop is in full contact with the surface and starting to pull up
- Do the average of the forces to get a more accurate understanding - article recommends **average of three times**

- Some Ideas from the reading:
    - To test adhesive quality with water - can attach adhesive to surface and wet it, perform test and compare to the max force to achieve separation
    - To test adhesive quality on durability - can apply adhesive to surface and leave it for a couple days, perform test and compare to the max force to achieve separation
    - And then could implement the pig skin to simulate adhesion to human skin
    - Also ask the team?? **Will the surface of the skin be shaved or not?**

- Adhesive loop before being attached to the surface. The adhesive is on the outside



- The adhesive loop coming in full contact with the surface



- An example of what the graph would look like

Conclusions/action items: This is a test to consider, however, I will need to compare it to the probe tack test because they seem very similar and do the same thing. In addition, I will do more research on probe tack testing and peel testing.

2022/09/22 - Design Idea 1

ABDOULAHI BAH (anbah@wisc.edu) - Sep 23, 2022, 11:13 AM CDT

Title: 1st Design: Attachment Site

Date: 9/22/2022

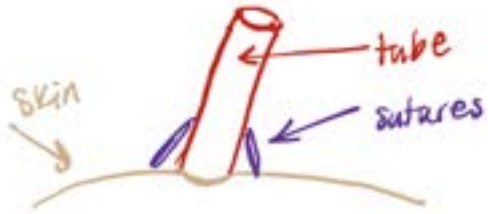
Content by: Abdoulahi Bah

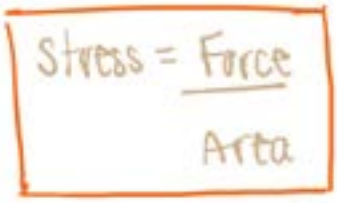
Present: Abdoulahi Bah

Goals: Create some design for the design matrix

Content:

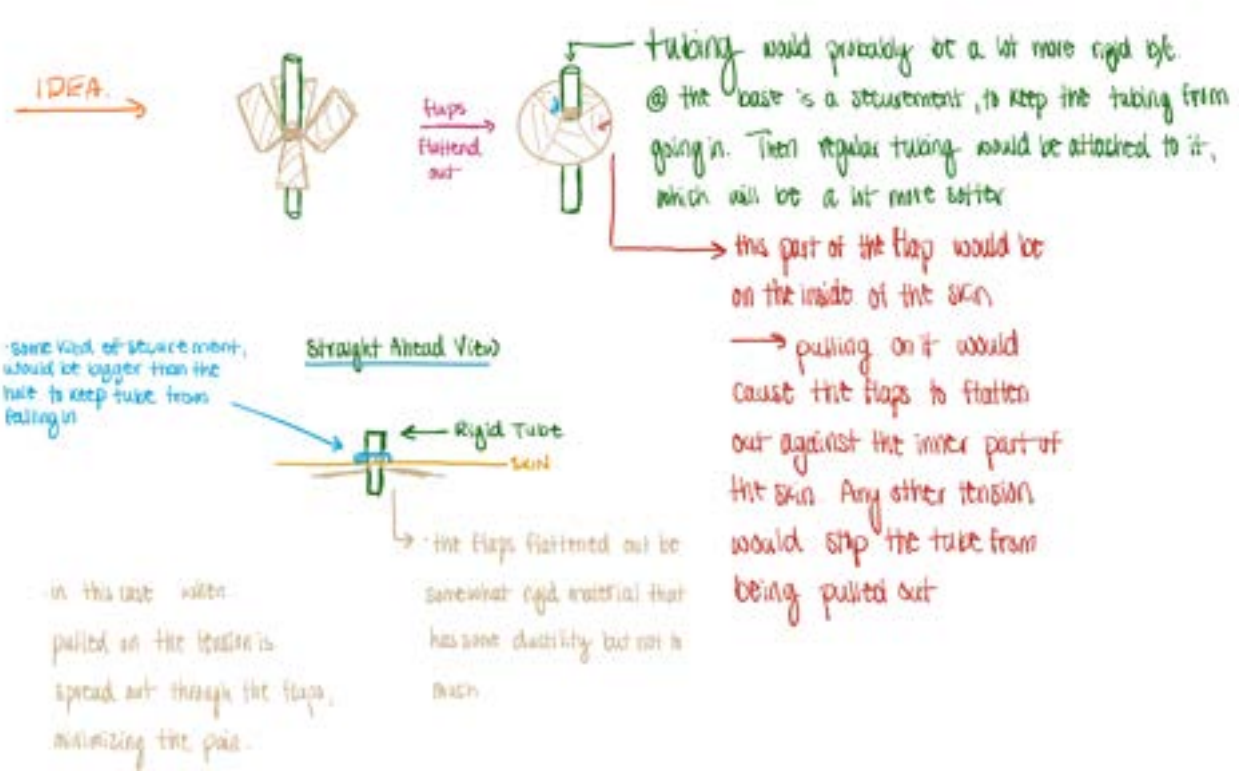
Analysis of Original Attachment:



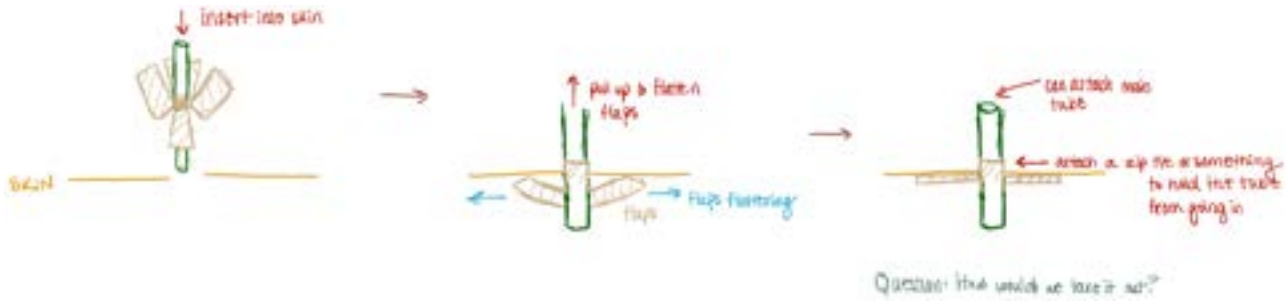


- The high amount of pain is due to the small surface area of contact that the suture attaches to the skin. So when the force is generated there is a small surface area which creates high amounts of stress → a lot pain

Design Idea:



Steps on how to install:



Conclusions/action items: This was one of my ideas to reduce the amount of stress at the attachment site. The problem that I see with the current attachment design, just using a suture is that the force when tube is pulled or is moved, it is dispersed a very small area. So with this design the force can be dispersed on a bigger area so a lot less stress and pain. Something that I have not figured out yet, is how to take it out once the surgical drain needs to be removed. My action items will be to find pros/cons of this design, figure out how we could take it out once in, and brainstorm more ideas.

2022/11/15 - Clip Design

ABDOULAHI BAH (anbah@wisc.edu) - Nov 15, 2022, 10:27 PM CST

Title: Clip Design

Date: 11/15/2022

Content by: Abdoulahi Bah

Present: Abdoulahi Bah

Goals:

- brainstorm some clip designs drawbacks of each idea

Content:

Conclusions/action items:

ABDOULAHI BAH (anbah@wisc.edu) - Nov 15, 2022, 10:28 PM CST

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Clip_Design_.pdf (4.34 MB)

2014/11/03-Entry guidelines

John Puccinelli - Sep 05, 2016, 1:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity, subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

Title: Descriptive title (i.e. Client Meeting)

Date: 9/5/2016

Content by: The one person who wrote the content

Present: Names of those present if more than just you (not necessary for individual work)

Goals: Establish clear goals for all text entries (meetings, individual work, etc.).

Content:

Contains clear and organized notes (also includes any references used)

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.

2014/11/03-Template

John Puccinelli - Nov 03, 2014, 3:20 PM CST

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items: