Improving the precision of small human tissue biopsy processing

Date: 9/18/25-9/25/25

Client: Dr. Angela Gibson
Advisor: Dr. Tracy Jane Puccinelli
Team:

Ruhi Nagarkatte (Team Leader)
Ella Lang (Communicator)
Gianna Inga (BSAC)
Simon Nam (BWIG)
Sarah Raubenstine (BPAG)
Grace Spiegelhoff (Medical Student)

Problem Statement

In the treatment of extensive burns or wounds, patients rely on emerging treatment research in the field of tissue growth and healing. Currently, studies into the healing properties of porcine skin are conducted to visualize how viable epidermis cells migrate over the site of the wound to promote cell regrowth. However, once in a culture, the porcine tissue samples cannot remain viable unless all fat is removed and the cells are able to absorb the culture media. Additionally, this process of creating samples is not standardized, resulting in samples of varying sizes with jagged edges, which limits the efficiency of sample preparation. To solve this, fabricating a tool that incorporates multiple sample slots, with uniform sizing, and a fixed blade will help to streamline research efficiency and produce more viable samples that can be successfully imaged.

Brief Status Update

The team narrowed down the top 3 design ideas and finalized the design matrix. Additionally, the team continued to research competing designs and planned to pick up the biopsy tools for preparation of the preliminary presentation in the upcoming week. Finally, the team discussed starting fabrication on Friday, 9/26, to get started on the 3D printing process.

Summary of Weekly Team Member Design Accomplishments

- Team
    - Met as a group completed the design matrix with scoring of the criterias for each selected design
    - Continued researching on physiology, biological interactions with specific type of materials, fabrication methods of biopsy cutting tools, etc
    - Began preparing for the oral preliminary presentation in the coming week
- Ruhi Nagarkatte
    - Organized design matrix and finalized criteria & scoring with the team
    - Continued research on market analysis and global impact
    - Met with team to discuss design ideas, 3D printing, and the preliminary presentation

    - Prepared progress report #3
- Ella Lang
    - Modeled the Biopsy Press design on OnShape and made design tweaks
    - Scored designs in the matrix and completed assigned matrix sections
    - Continued researching fabrication methods
    - Prepared and sent our Progress Report
- Gianna Inga
    - Met with TECH member at kickoff meeting, explained our timeline, project, and meeting schedule
    - Met with group members to discuss and edit CAD models of the designs
    - Participated in scoring the possible designs in the design matrix
    - Finalized the CAD paper cutter and biopsy press design to be 3D printed
- Simon Nam
    - Assisted on finalizing design matrix and scoring of criteria & met with TECH member for the first time
    - Updated the status of the team's BME design page with including design matrix document and weekly report that includes design matrix
    - Met with the team for further discussion on preparing for oral preliminary presentation
- Sarah Raubenstine
    - Continued research on competing designs and preliminary design elements
    - Finalized preliminary designs and determined design matrix criteria with group
    - Drafted CAD drawing of preliminary design for matrix and presentation

Weekly/Ongoing Difficulties

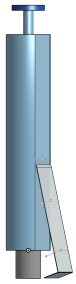
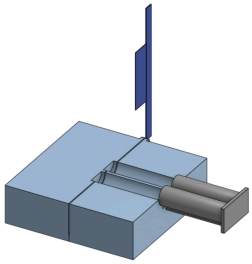
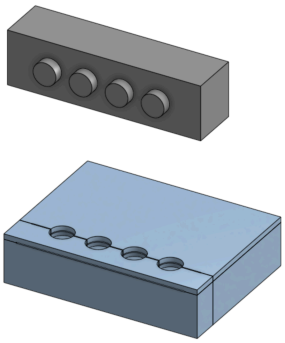
There are no ongoing difficulties facing the team this week. The team drafted the designs on OnShape and completed the design matrix with scoring justifications and explanations provided for design criteria (see below). In the coming week, the team will start printing preliminary designs and pick up the current tools used by the clients.

Upcoming Team and Individual Goals

- Team
    - Plan and distribute roles for working on design fabrication
    - Gather necessary materials and tools for design initial fabrication
    - Prepare for the oral preliminary presentation next week
- Ruhi Nagarkatte
    - Set up meeting with Jesse from TeamLab to discuss design plans
    - Prepare the preliminary presentation and divide it up among team
    - 3D print the top 2 design ideas at the Makerspace
    - Continue research on materials for fabrication
- Ella Lang
    - Begin 3D printing and try various clear resins

    - Update designs and continue to improve CAD models
    - Work on preliminary presentation slides and preliminary deliverables
- Gianna Inga
    - Attend and participate in BSAC meeting
    - Work on individual slides for preliminary presentation
    - Film and embed my section of the preliminary presentation
    - Evaluate the printed designs to determine the shortcomings and what we need to edit on the CAD model for optimal performance
- Simon Nam
    - Prepare for the oral preliminary presentation
    - Figure out the accessible materials and tools for design fabrication
    - Meet with other team members to initiate and plan for design fabrication
- Sarah Raubenstine
    - Prepare for and finalize preliminary presentation
    - Set up and attend meeting with TeamLab design staff to discuss fabrication
    - Continue research on fabrication and testing

Tissue Processing Tool: Design Matrix

Criteria:	 Biopsy Punch		 Paper Cutter		 Biopsy Press	
Ease of Use (30)	5/5	30	4/5	24	4/5	24
Cut Accuracy & Precision (25)	2/5	10	5/5	25	5/5	25
Sterilizability (15)	3/5	9	4/5	12	3/5	9
Security of Biopsy (15)	3/5	9	4/5	12	5/5	15
Ease of Fabrication (10)	3/5	6	4/5	8	5/5	10
Safety for User (5)	4/5	4	4/5	4	5/5	5

Total	**68**	**85**	**88**

Criteria Descriptions and Justifications:

Ease of Use: This criterion evaluates how well the end-user will be able to utilize the design throughout the setup and procedure. The device should provide a more straightforward method of trimming the remaining fat off of the biopsy sample, when compared to the current technique of using a pair of tweezers and a blade to shear the tissue.

Cut Accuracy & Precision: This criterion evaluates how well the device will reliably slice through a biopsy sample. Biopsy samples must be consistently cut down to the defined two millimeter thickness with a clean and straight cut along the biopsy cross section. The accuracy and precision of this cut is a major component of the device's purpose, essential to sample uniformity and therefore experimental outcome.

Sterilizability: This criterion evaluates how effectively the design can be cleaned and sterilized between uses to prevent arising of contamination of samples. Since the device will continuously interact with biological materials, it must also withstand the exposure to common sterilization techniques such as autoclaving, chemical disinfectants, or UV treatment without causing degradation. A design that minimizes openings, moving parts, or materials highly resistive to sterilization will score higher. Ensuring sterilizability is crucial for both experimental validity and user safety to minimize any potential results of biohazard risks before and after usage of design.

Security of Biopsy: This criterion evaluates how well the sample is held in place during tissue preparation, set-up, and cutting. The Tissue Processing Tool must stabilize the cylindrical tissue sample in order to produce cleaner cut results and reduce user-tissue involvement. This criterion ensures that the device chosen contributes to the hands-off goal of the device.

Ease of Fabrication: This criterion evaluates the complexity in the manufacturing of the selected design. Since the preliminary design was modeled using OnShape, a CAD software, a 3D printer will be utilized in fabrication. Additionally, the device must have an area for visibility, either through an opening or through a translucent material to ensure consistent slicing of the biopsy tissue samples. This will allow the user to correctly verify measurements and clean the device for the next use.

Safety for User: This criterion evaluates the measure of minimizing the risk of injury to the user during setup and use of design. The device should reduce the possibility of accidental cuts, pinching, or any form of exposure to the sharp blades when compared to the current manual

method in use for biopsy research. Safety is particularly important given that repetition of cutting tasks can increase the likelihood of user error. A safer design should ensure having protective features such as blade shielding and minimal need for direct manual operation of tissues. Although it has the lowest weight of all criteria, it is still a necessary part for design considerations for basic user safety which is essential for widespread adoption and reliable use in laboratory environments.

Design Scoring:

Ease of Use: Based on the *Ease of Use* criterion, the Biopsy Punch scored the highest at 5/5. This device is designed to be a handheld tool that simultaneously combines the punching and cutting of the biopsy tissue samples. The Paper Cutter and Biopsy Press both scored a 4/5 due to the dynamic mechanisms involved. In the Paper Cutter, the samples need to be loaded into the cylindrical components before the hinged blade can pivot down to cut fat off. In the Biopsy Press, the user needs to ensure that the samples are correctly aligned with the holes before a blade can be used.

Cut Accuracy & Precision: Using this criterion to evaluate the device designs, both the Paper Cutter and the Biopsy Press scored the highest with a 5/5 for cut reliability. The Paper Cutter design has its blade on a hinge located at a two millimeter depth, using a guide to hold the samples in place when cutting. This ensures a straight cut consistently at the desired two millimeter sample thickness. Similarly, the Biopsy Press holds the samples down as the user runs the blade down a track at the desired two millimeter depth. This design will also produce flat and consistently sized biopsy samples with minimal room for error. The Biopsy Punch design scored the lowest in this category, receiving a 2/5 for cut accuracy. With this design, the location of the cut is dictated by the user, using the plunger of the biopsy punch to depress the sample to the desired cut location. This leaves plenty of opportunity for inaccuracies and inconsistencies within the biopsy samples.

Sterilizability: The Paper Cutter scored the highest with a 4/5. Its flat surfaces and relatively simple plain geometry make it easier to sterilize compared to other design choices. However some joints may still trap small amounts of biological debris which made it award a full score. The Biopsy Punch score 3/5, since its cylindrical design and narrow cutting channel make sterilization more challenging, especially after repeated usage. The Biopsy Press as well scored 3/5, because of its complex composition of multiple slots and press interface which can introduce small gaps in between that may prevent complete sterilization.

Security of Biopsy: The Biopsy Press scored the highest, receiving a 5/5 . This design has cylindrical slots to insert the tissue into before cutting, and a fitted press that is pressed down into the tissue slots and on top of the tissue while cutting. This mechanism ensures the samples stay

compact and in place on all four sides. The Paper Cutter design scored the second highest, receiving a 4/5 . The design presses the samples into a wall, allowing for the samples to stay compact and enclosed on three sides. However, with this application of pressure, the tissue samples could bulge on the unenclosed sides, leading to jagged cut edges. The Biopsy Punch came in last, receiving a 3/5 . This is due to the fact that there is no mechanism for the user to apply force onto the samples while cutting, which could lead to jagged edges or the sample falling out if held vertically.

Ease of Fabrication: The Biopsy Press scored the highest with a 5/5 in the *Ease of Fabrication* category. It involves two rectangular blocks with a slit in one, accompanied by circular divots in the main block to hold the tissue biopsy samples. On the other block, there are four circular extrusions that align perfectly with the divots to further contain the tissue samples. For the manufacturing, a 3D printer will be able to fabricate this without additional supports. The Biopsy Punch scored a 3/5 because of the combined mechanism of punching the samples and shearing it together. The Paper Cutter scored a 4/5 because the main body can be easily manufactured, however, it will be difficult to attach the hinge to the side with a blade attached.

Safety for User: The Biopsy Press scored the highest with a 5/5. Its enclosed press mechanism reduces user's direct interaction with the blade and keeps their hands away from the cutting surface, hence making it the safest option out of all the design choices. The Paper Cutter scored slightly lower with 4/5 as its mounted blade provides some protection, but still requires users to position samples close to the cutting trajectory which introduces a moderate level of risk. The Biopsy Punch also scored 4/5 as its design places the user's hand near the blade which increases the potential risk for injury compared to the enclosed press system.

Project Timeline

Project Goal	Deadline	Team Assigned	Progress	Completed
Product Design Specification First Draft	Thursday, 09/18/2025	All	100%	X
Design Matrix Design Ideas	Friday, 09/26/2025	All	100%	X
Preliminary Presentations	Friday, 10/03/2025	All	0%	
Preliminary Deliverables	Wednesday, 10/08/2025	All	0%	
Show and Tell	Friday, 10/31/2025	All	0%	
Poster Presentations	Friday, 12/05/2025	All	0%	
Final Deliverables	Wednesday, 12/10/2025	All	0%	

Materials and Expenses

Item	Description	Manufacturer	Mft Pt#	Vendor	Vendor Cat#	Date	QTY	Cost Each	Total	Link
Component 1										
Component 2										
								TOTAL:	0.00	