BME 400

DEPARTMENT OF

Biomedical Engineering

UNIVERSITY OF WISCONSIN–MADISON

Improving the precision of small human tissue biopsy processing

October 3, 2025

Team Members

Team Leader: Ruhi Nagarkatte

Communicator: Ella Lang

BSAC: Gianna Inga

BWIG: Simon Nam

BPAG: Sarah Raubenstine

Advisor: Dr. Tracy Puccinelli

Client: Dr. Angela Gibson

Client Contact: Bailey Donahue

TECH: Grace Spiegelhoff

Gianna Inga

Overview of Presentation

- Client Description
- Background
- Problem Statement
- Competing Designs
- Product Design Specifications
- Design Ideas
  - Biopsy Punch
  - Paper Cutter
  - Biopsy Press
- Design Matrix Evaluation
- Future Work
- Acknowledgments
- References

Gianna Inga

Client Description

- Angela Gibson, MD, PhD, FACS
- Specialties
  - General Surgery
  - Surgical Critical Care
  - Trauma Surgery
  - Burn & Wound Healing
- Performs research on epithelial regeneration of a burn injury and how to treat / expedite the healing process

Figure 1: Angela Gibson, MD, PhD, FACS [1]

Figure 2: Bailey A. Donahue, BS
Lab Technician/Manager

Gianna Inga

Problem Statement

Our objective is to fabricate a precise cutting device to shear fat off burn biopsy samples

- Gibson's lab creates burns in pig skin, to biopsy, and culture in media
  - Biopsies include, epidermis, dermis, and subcutaneous tissue
- Fat creates a hydrophobic layer that inhibits media absorption
  - Negatively affecting burn healing / tissue viability
- Current method is tedious, variable, and possibly damaging
  - Involves securing the sample with forceps and slicing with a scalpel
- Blades dull quickly because of the durability of pig skin

Gianna Inga

Background

- Biopsies taken after creating small burns on pig skin sheet
- Residual fat remains even after separating skin from underlying tissue
- The Gibson Lab tested viability with vs. without additional fat removal
- Additional fat removal from the biopsy samples significantly improved viability
    - High sample viability is essential for analyzing wound response

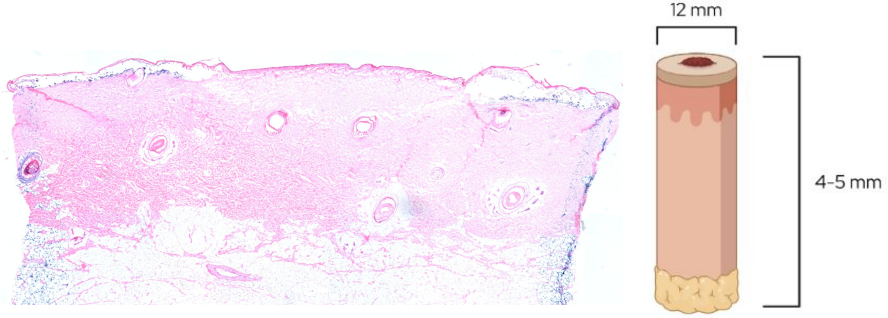


Figure 3: LDH stained pig skin sample *without* additional fat removal; lack of stain indicating poor viability [Bailey Donahue]

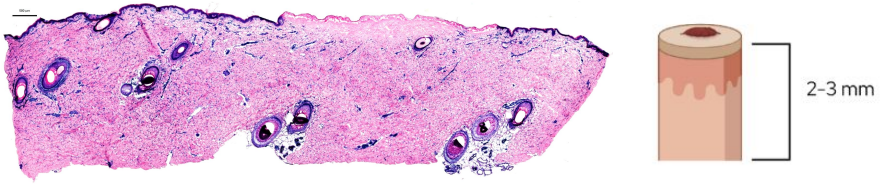


Figure 4: LDH stained pig skin sample *with* additional fat removal; blue LDH stain indicating viability [Bailey Donahue]

Sarah Raubenstine

Competing Designs on Market

- Tissue slicing devices currently on the market not suitable for this process
  - High cost
  - Little adaptability
- Tissue slicing matrices [2]
  - Made to hold variety of irregularly shaped samples
  - Paths for different slice thicknesses
  - Stainless steel matrix
- TedPella Inc.TruSlice System [3]
  - Different options for slice thickness
  - Hold down sample on flat surface
  - Not compatible with common blades

Figure 5: TedPella Inc, Brain, Heart, Tissue & Tumor Matrices $696 to $3630 based on size [2]

Figure 6: TedPella, Inc. TruSlice Specimen Cut-Up Grossing System $1878.75 [3]

Sarah Raubenstine

Client Initial Prototype

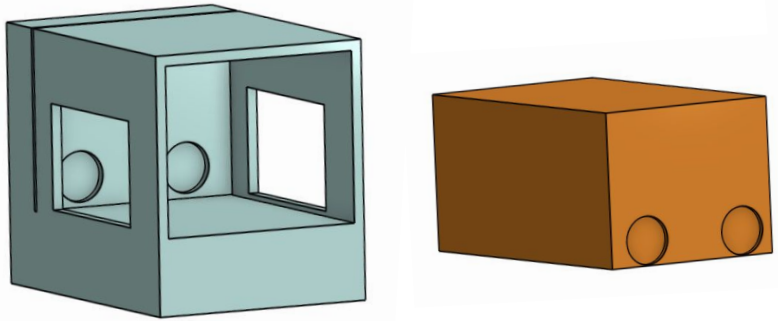


Figure 7: Client prototype parts [Bailey Donahue]

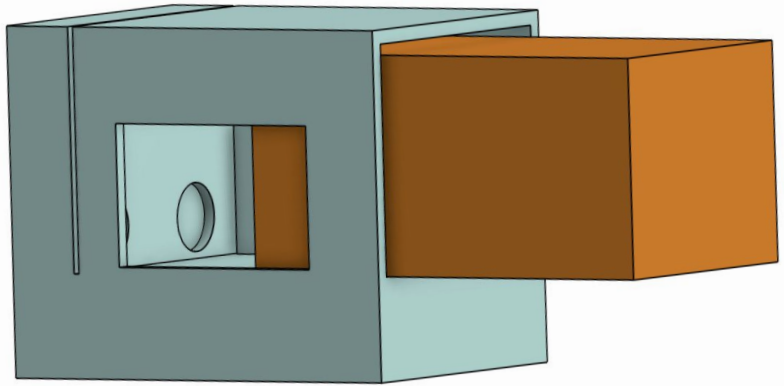


Figure 8: Client prototype assembly [Bailey Donahue]

Sarah Raubenstine

Product Design Specifications

- The Device must:
  - Cut 12 mm biopsy samples to 2–3 mm thickness
  - Maintain perpendicular cuts (≤2° variation)
  - Hold up to 4 samples at once with clear visibility
  - Use fixed, replaceable standard blades
    - Tissue-Tek Accu-Edge High Profile Blades (PTFE-coated) [4]
    - Stanley 11-51 (High carbon steel) [5]
  - Be sterilizable (autoclave, UV, alcohol)
  - Secure firmly on benchtop during use & minimize blade exposure for user's safety [6]
  - ≥95% repeatability across experiments
- Cost target ≤$500 (est. ~$100/unit)

Simon Nam

Design 1: Biopsy Punch

Function: Handheld cylindrical biopsy tool that punches and trims samples through direct manual pressure

Pros:

- Easiest for usage
- Combination of punching & cutting
- Moderate safety (*user has blade control)

Cons:

- Low cut accuracy & consistency
- Limited sample security
- Sterilizing issues
- Fabrication complexity (internal structure)

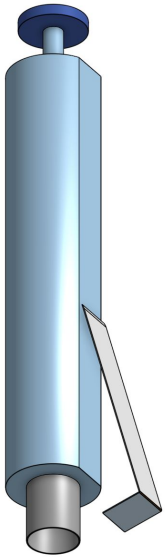


Figure 9: Biopsy Punch

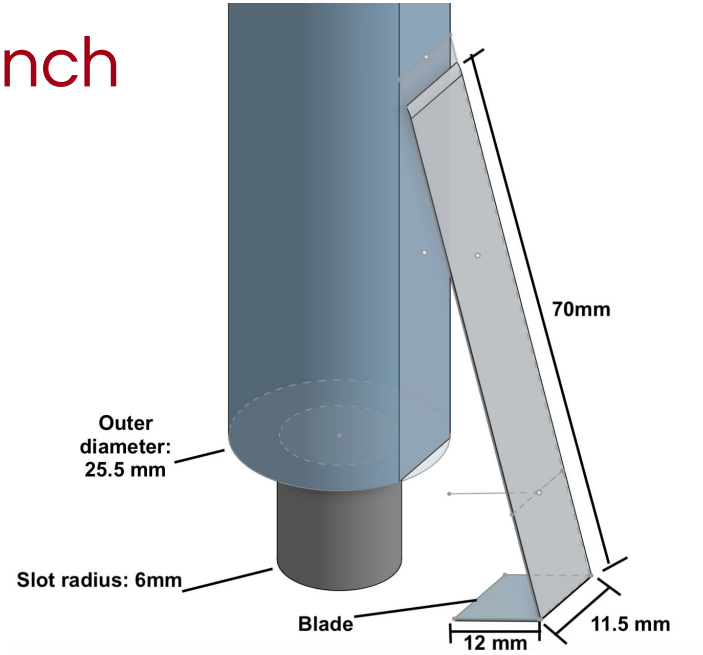


Figure 10: Closeup view of cutter area

Simon Nam

Design 2: Paper Cutter

Function: Benchtop cylindrical biopsy cutter with slots for samples and easy-to-use hinged blade

Pros:

- Easily scalable
- Increased cut accuracy and sample security
  - Pressure application tool
- 2 part base for cleaning

Cons:

- Hinge fabrication
- Open, swinging blade

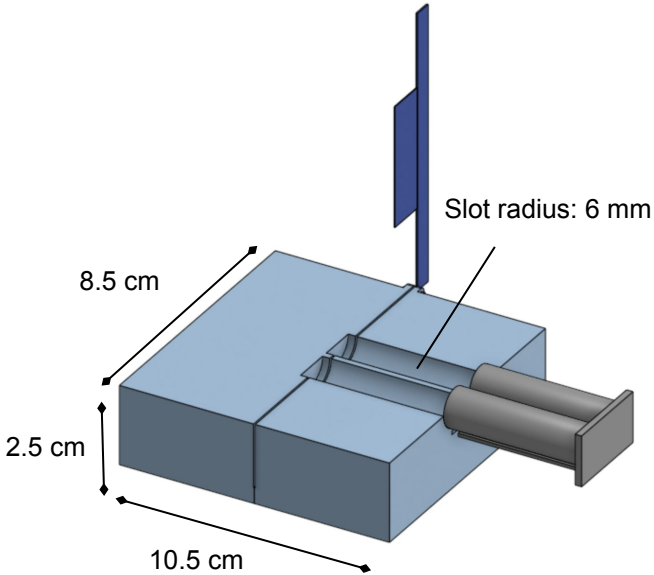


Figure 11: Paper Cutter Design

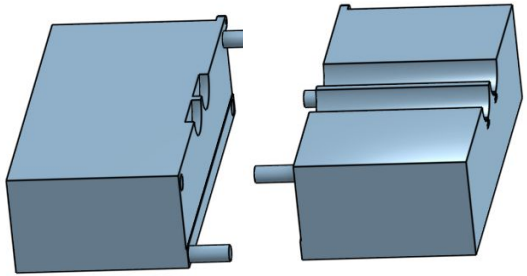


Figure 12: Paper Cutter Assembly

Ella Lang

Design 3: Biopsy Press

Function: Benchtop biopsy cutter with cylindrical slots for samples, and tracks for sample height cutting and halving.

Pros:

- Easily fabricated and scalable
- Increased cut accuracy and sample security
  - Pressure application tool
  - Sample enclosed on all sides
- Blades enclosed during cutting

Cons:

- Harder to clean

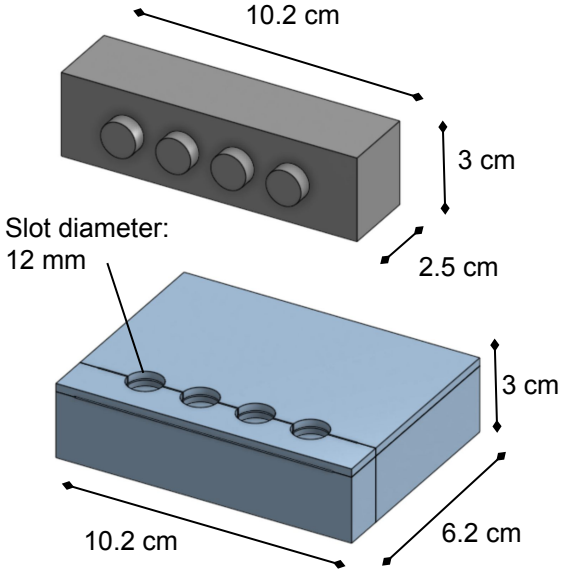


Figure 13: Biopsy Press Design

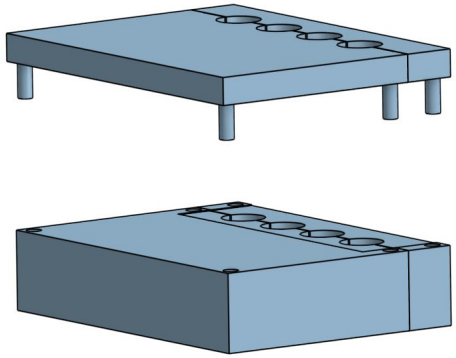


Figure 14: Biopsy Press Assembly

Ella Lang

Design Matrix

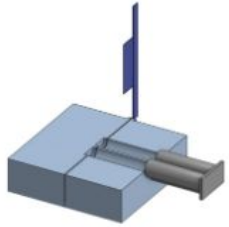
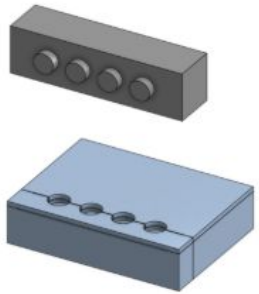
Criteria:	 Biopsy Punch		 Paper Cutter		 Biopsy Press	
Ease of Use (30)	5/5	30	4/5	24	4/5	24
Cut Accuracy & Precision (25)	2/5	10	5/5	25	5/5	25
Maintenance (15)	3/5	9	4/5	12	3/5	9
Security of Biopsy (15)	3/5	9	4/5	12	5/5	15
Ease of Fabrication (10)	3/5	6	4/5	8	5/5	10
Safety for User (5)	4/5	4	4/5	4	5/5	5
Total	**68**		**85**		**88**	

Figure 15: Tissue processing tool design matrix, weighted & scored

Ruhi Nagarkatte

Proposed Final Design

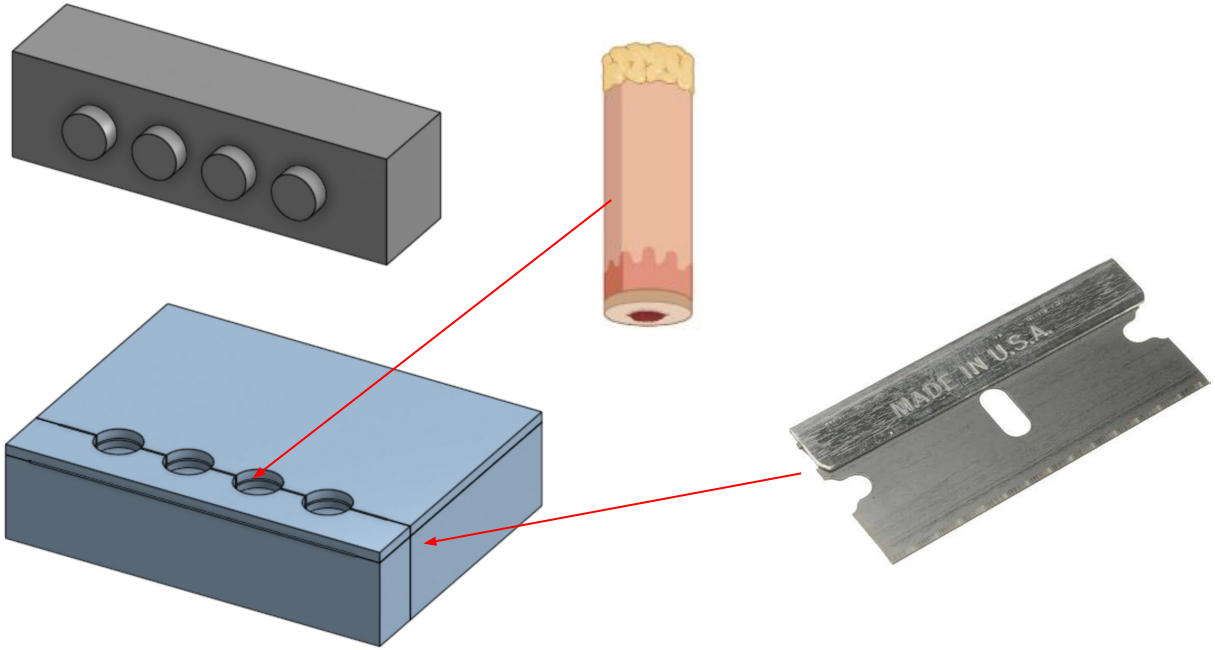


Figure 16: Proposed Final Design with the Biopsy Press

Ruhi Nagarkatte

Future Work

October

- Finalize prototype designs with size and material specifications
- Continue CAD modeling
- Prepare for Show and Tell

November

- 3D print prototypes and make design optimizations
- Begin testing on porcine model and cadaver specimens

December

- Finalize design, testing methods, and reports
- Give poster presentation
- Deliver final design to client

Ruhi Nagarkatte

Acknowledgements

The team would like to extend their appreciation of Dr. Angela Gibson and Bailey Donahue for inspiring this project and their support. Additional thanks to Dr. Tracy Jane Puccinelli for her ongoing support and guidance.

Supporting Organizations:
Department of Biomedical Engineering
University of Wisconsin School of Medicine and Public Health

Ruhi Nagarkatte

References

[1] “Angela Gibson,” Department of Surgery. Accessed: Oct. 01, 2025. [Online]. Available: https://www.surgery.wisc.edu/staff/angela-gibson/

[2] “Brain Matrices, Brain Matrix - for sectioning,” *Tedpella.com*, 2025. https://www.tedpella.com/section_html/brain-matrices.aspx#anchor_ssmatrices

[3] “TruSlice Tissue Slicing Systems,” *Tedpella.com*, 2015. https://www.tedpella.com/dissect_html/TruSlice.aspx#TruSlice (accessed Oct. 03, 2025).

[4]“Tissue-Tek® Accu-Edge® High Profile Blades,” *Sakuraus.com*, 2025. https://www.sakuraus.com/Products/Accu-Edge-Blade-System/Disposable-Microtome-Blades/Tissue-Tek%C2%AE-Accu-Edge%C2%AE-High-Profile-Blades.html (accessed Oct. 03, 2025).

[5]*Turnersupply.com*, 2024. https://www.turnersupply.com/Product/835211515?srsltid=AfmBOor6IJ-GZ-UxETddzOsPoflU57V_62XiogAwLVwdzxSof4-IYyYV (accessed Oct. 03, 2025).

[6] “Cutting Safety – USC Environmental Health & Safety.” Accessed: Sep. 18, 2025. [Online]. Available: https://ehs.usc.edu/research/lab/cutting-safety/

Questions?