Improving the Precision of Small Human Tissue Biopsy Processing

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Problem Definition

Project Motivation:

- Annually 1,000,000 burn related injuries in the US [1]
- Client's **RENEW Lab** studies wound healing to work towards advancing burn treatment therapies [2]
- Contact burns on **pig skin biopsy samples** are cultured, imaged, and analyzed for wound behavior
- **Removal of additional fat** from the biopsy samples dramatically **increases sample viability**

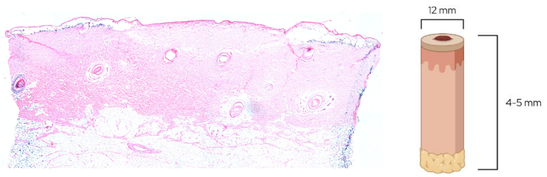


Figure 1. LDH stained pig skin sample without additional fat removal; lack of stain indicating poor viability [Bailey Donahue]

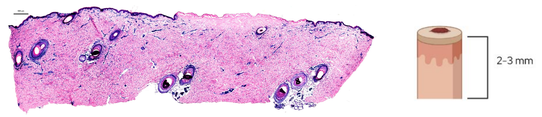


Figure 2. LDH stained pig skin sample with additional fat removal; blue LDH stain indicating viability [Bailey Donahue]

Competing Designs:

Figure 3. Ted Pella Inc. 12 mm tumor matrix, $299 [3]

Figure 4. Ted Pella Inc. TruSlice Specimen Cut-Up Grossing system $1878.75 [4]

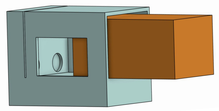


Figure 5. OnShape CAD drawing of client initial prototype [Bailey Donahue]

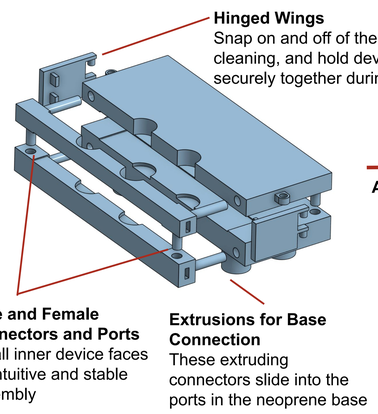
Objective: Design a device to **efficiently and accurately slice** burn biopsy samples to improve their viability for further culturing, imaging, and analysis.

Design Criteria

- **Ease of Use:** Device use should be intuitive to use with a written protocol
- **Cut Accuracy & Precision:** Variability of the cut must be within 2.5±.2 mm and ±2°
- **Maintenance:** Must be cleaned and sterilized with minimal material breakdown
- **Security of Biopsy:** Sample should be contained within the device while in use
- **Ease of Fabrication:** Device should be easily fabricated by the user for future replacement
- **Safety:** Minimize risk of injury to the user

Final Design

Figure 6. CAD Device assembly layout



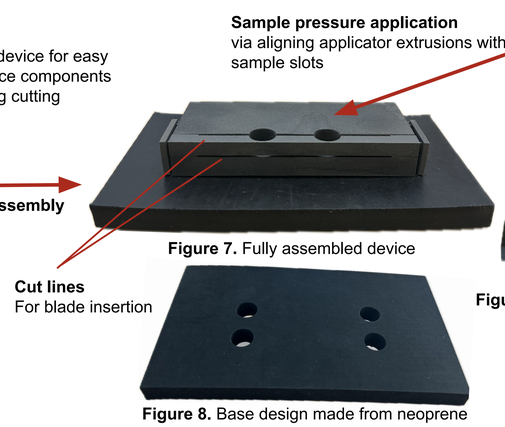


Figure 7. Fully assembled device

Figure 8. Base design made from neoprene

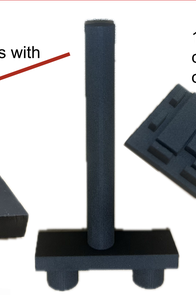


Figure 9. Sample pressure applicator

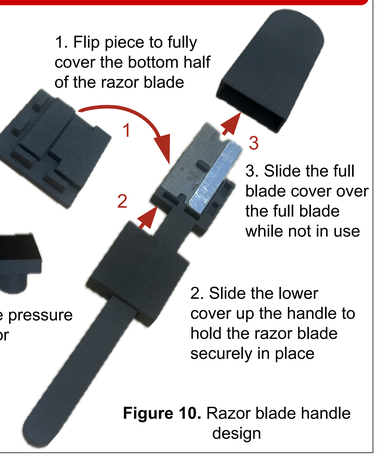


Figure 10. Razor blade handle design

Testing & Results

A. Sanitizing

Before cleaning- GloGerm coated

After wiping down with ethanol

After washing with soap and water

Figures 11-19. Images of design components during sanitization testing

B. Client Usability Survey

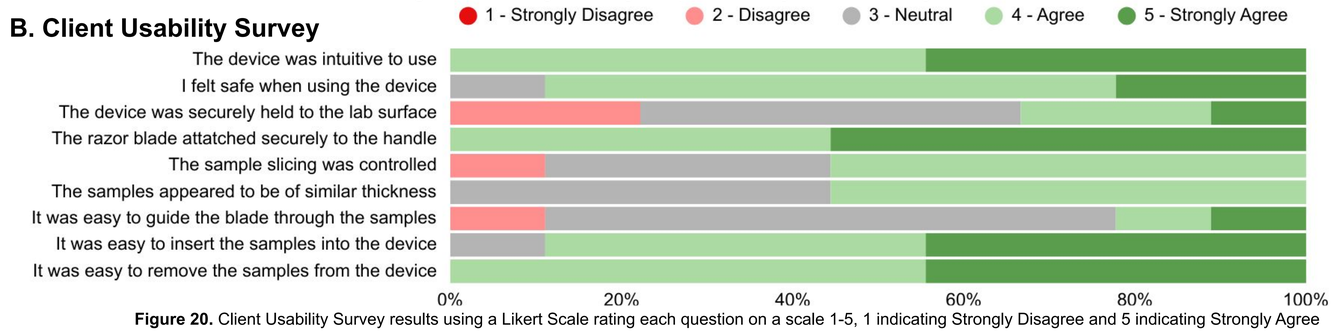
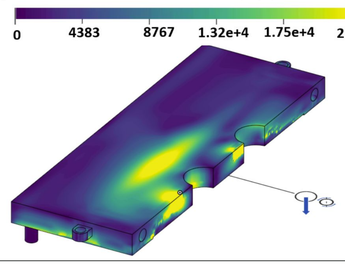


Figure 20. Client Usability Survey results using a Likert Scale rating each question on a scale 1-5, 1 indicating Strongly Disagree and 5 indicating Strongly Agree

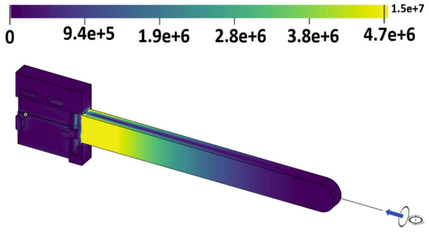
C. FEA Simulation and Analysis

Figure 21. Force simulation on biopsy press body (22 N)



- von Mises stress (Pa) for ductile properties
- Applied force and moment to pegs and handle
- Lateral snap-in pegs at low risk for failure
- Blade handle avoids plastic deformation
- Parts strong enough to withstand user's applied grip strength

Figure 22. Force simulation on razor blade handle (9 N)



Discussion

- Usability survey **yielded >80% positive** for intuitiveness, safety in cutting, & thickness consistency
- **Issues in usability testing:**
  - Difficulty of initial blade insertion
  - Applicator depth hinders sample cutting
  - Setup in vertical cutting
- **Cleaning with soap and water is effective**
- **FEA confirms blade handle withstands user-level forces** without plastic deformation
  - Validates structural reliability of **hinged-peg**
- **Improved preservation of sample** during device operation
- Cost: Nylon print~ $20, PLA~ $2

Future Work

- Test with sharper options:
  - #10 or #11 scalpel
  - Microtome blade
- Shorten pressor pegs to prevent over-compression
- Use threaded bolts for additional security
- Test with realistic materials (artificial skin, porcine samples, etc.)
- Smoothen interior surfaces to reduce residue retention & improve sanitization
- Test to confirm repeatability & long-term usage

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References

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[4] "TruSlice Tissue Slicing Systems." Accessed: Oct. 08, 2025. [Online]. Available: https://www.tedpella.com/dissect_html/TruSlice.aspx#TruSlice