9/27/2024

Print-A-Punch

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Advisor: Dr. Meghan Settell

Overview

- Client Description
- Problem Statement
- Background Research
- Competing Designs
- Product Design Specifications
- Preliminary Designs
- Design Matrix
- Final Design
- Conclusion
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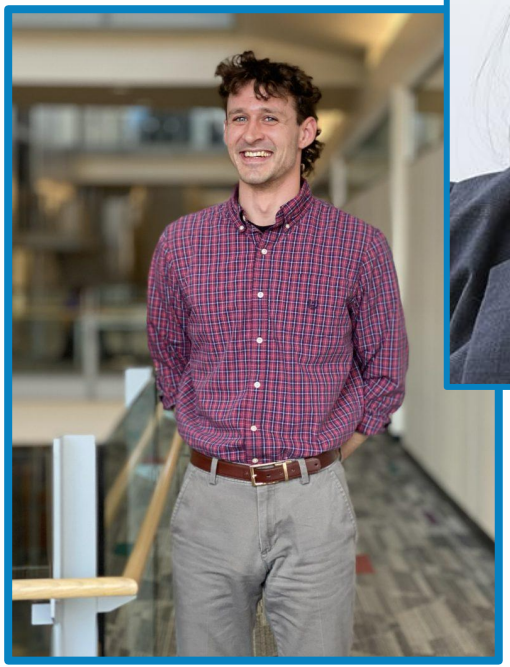
Client Description

- Daniel Pearce-PhD Candidate studying the effects of heart attacks on heart tissue

- Dr. Colleen Witzenburg-Principle Investigator of Cardiovascular Biomechanics Laboratory



Problem Statement

- In order to measure the material properties of tissues, tissue samples are cut into cruciform shapes to perform biaxial testing.
- Asymmetric samples cause inaccuracy in the results of testing.
- The current process often leads to asymmetric and inaccurate results.
- A new cutting process could be developed to produce more uniform and accurate samples for testing.

Background Research

- 4-12N of force is required to start cutting heart tissue[1]
- Afterwards, a constant application of 2-4N is required
- Plastic portions of the design must comply with ASTM: 638[2]
- Asymmetric Cruciforms lead to undesirable high shear forces[3]

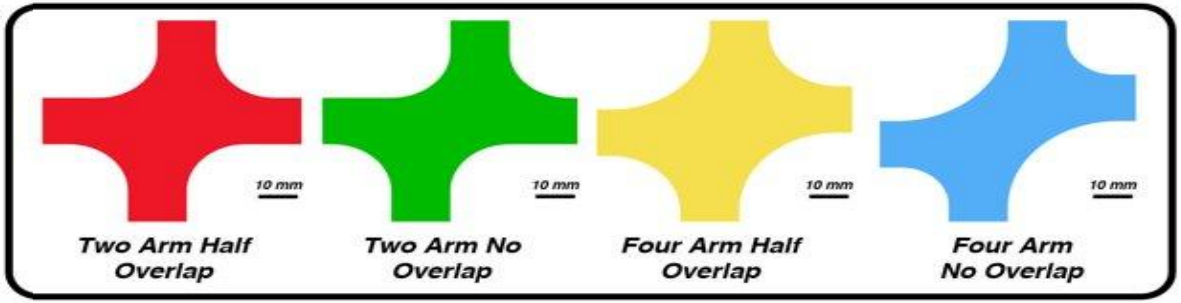


Figure [1]: Computational sample shapes from FEA *(adapted from [3])*

Competing Designs

Print-A-Punch for Uniaxial Testing [4]

- 3D Printed
- Bends razors into dumbbell shape with clamp
- Protective cover over razor blades for safety

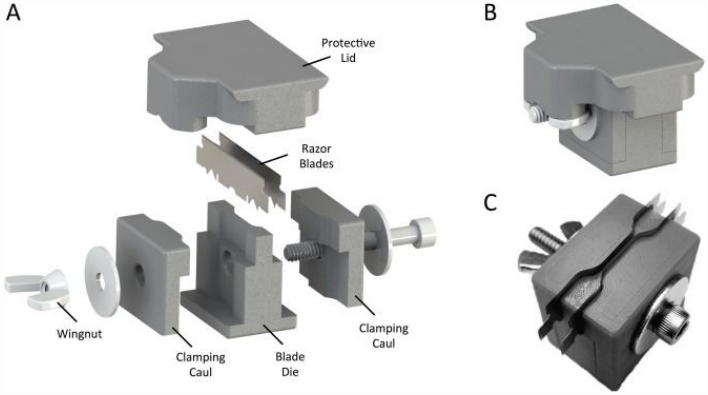


Figure [2]: Print-A-Punch (Uniaxial) *(adapted from [4])*

Novel Tissue Cutting Apparatus [1]

- Uses 3 linear actuators, 2 load cells, and tissue holding fixture.
- Blade is sterilized after each cut
- 2 actuators control lateral movement, third controls cutting motion

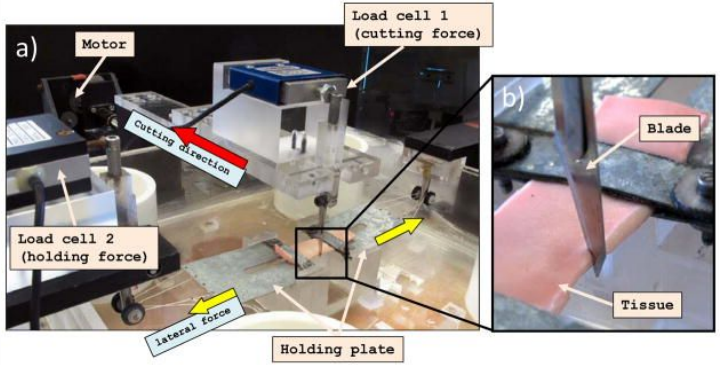
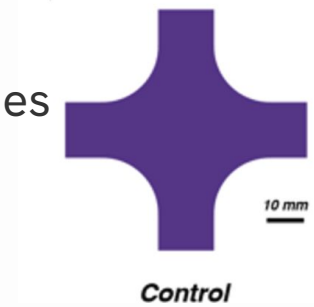


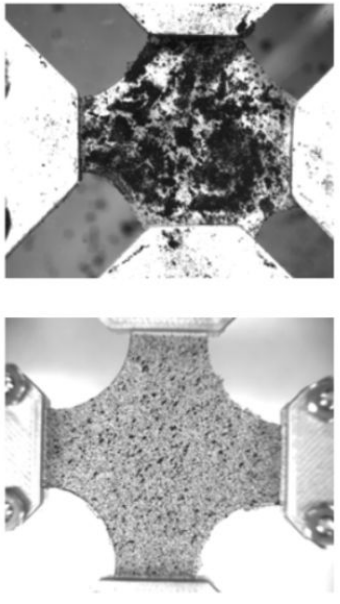
Figure [3]: Novel Tissue Cutting Apparatus *(adapted from [1])*

Product Design Specifications / Evaluation Criteria

- Utilize razor blades or biopsy punches
- Able to cut a symmetric cruciform shape of soft tissue
- Must produce uniform, reproducible results
- Must be able to cut through various thicknesses of tissue samples
- Follow ASTM regulations and FDA guidelines
- Easy to set up
- Budget of $250
- Reusable



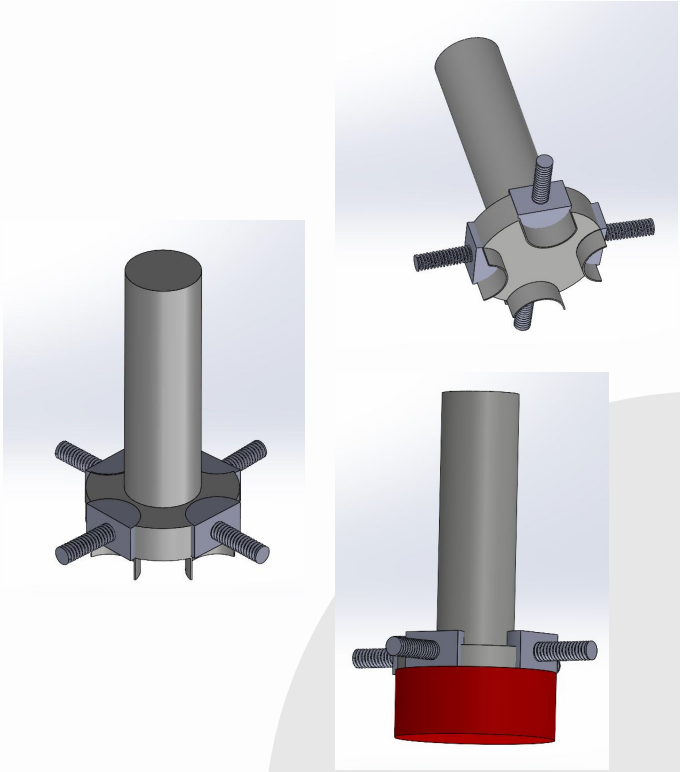
Figure[4]- Cruciform shape



Figure[5]- non symmetric cut (top) and symmetric cut (bottom)

Design 1: Razor 1-Step

- Uses 1 cutting devices
- Made using 3D printed PLA plastic
- Easy to bend blades due to the screws and the punch shape
- Will cut out a crucifix shape from a circular shape
- Overall shape somewhat inaccurate due to having two separate cuts



Figure[6]- CAD design of Razor 1-Step

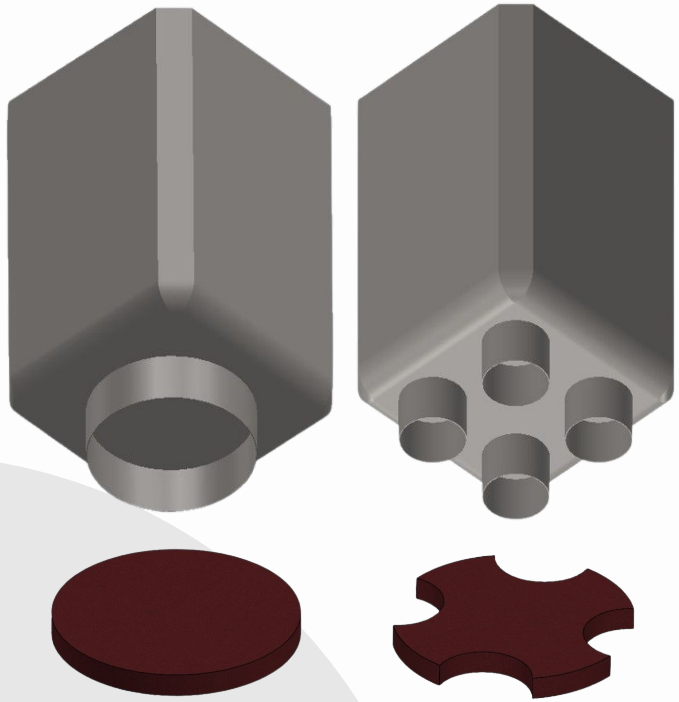
Design 1: Evaluation

- Benefits
  - Easier to form
  - Low cost due to needing fewer razor blades and 3D printed material
- Constraints
  - Bending razors
  - Needs more than one punch to create the sample
  - Doesn’t secure sample

Figure [7]: Razor blades *(adapted from [5])*

Design 2: Razor 2-Step

- Uses 2 separate cutting devices
- First step cuts uniform circle, second step cuts uniform cruciform
- Bends razor blades into precise geometry
- Stamping motion for cut
- 3D printed from PLA



Figure[8]- CAD design of Razor 2-Step

Daniel 10

Design 2: Evaluation

- Benefits
  - Accuracy and precision
  - Time efficient - single punch for all 4 apertures
- Constraints
  - Bending razors
  - Relatively high cost to manufacture
  - Doesn’t secure sample to cutting station

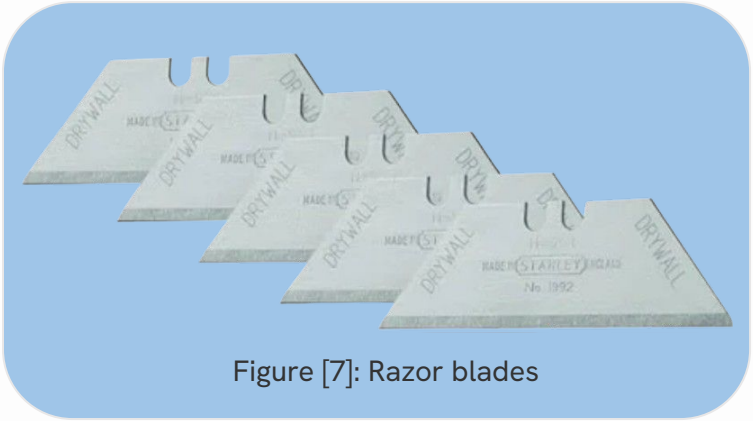
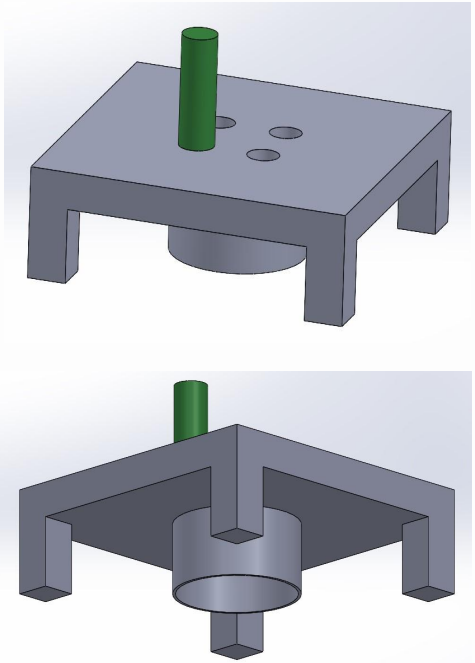


Figure [7]: Razor blades

Design 3: Biopsy Punch Jig

- Uses biopsy punch instead of razor blades
- Jig has guide holes for biopsy punch each 90° apart to create symmetric cuts
- Circular holder on bottom to secure tissue samples in place
- Created using clear laser cured resin



Figure[9]: CAD model of Biopsy Punch Jig

Figure[10]: Biopsy Punch *(adapted from [6])*

Design 3: Evaluation

Benefits:

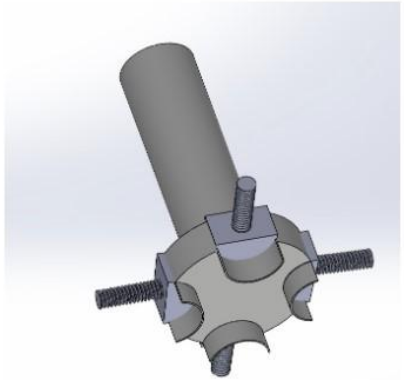
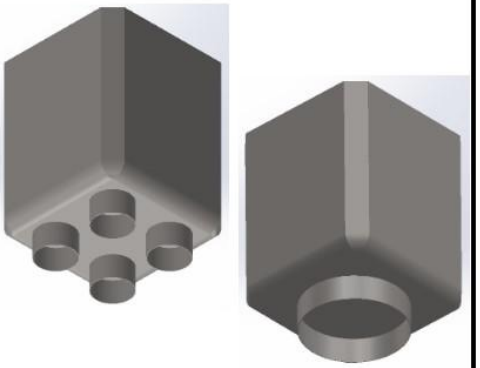
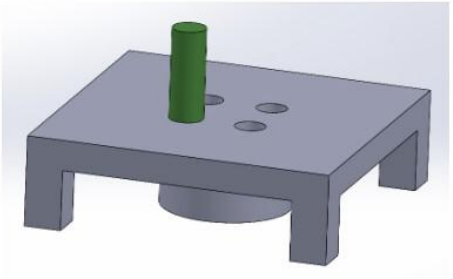
- Easier to set up
- More symmetric samples - better stress test results
- Greater reproducibility

Constraints:

- More expensive to maintain
- Less time efficient - cuts each hole individually

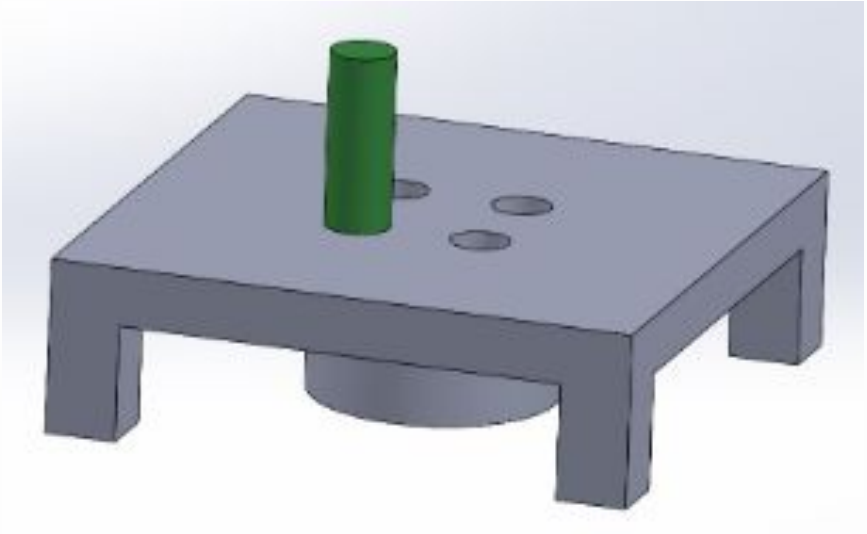
Figure[11]: Various size biopsy punches *(adapted from [7]).*

Design Matrix

	 Razor 1-Step		 Razor 2-Step		 Biopsy Punch Jig	
Criteria (weight)	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Accuracy/Reproducability (30)	3/5	18	4/5	24	5/5	30
Cost (20)	4/5	15	3.5/5	14	1/5	4
Ease of Use (20)	4/5	15	4.5/5	18	5/5	20
Reusability (15)	3/5	9	3/5	9	2.5/5	7.5
Ease of Fabrication (10)	2.5/5	5	2/5	4	5/5	10
Safety (5)	1/5	1	4/5	4	5/5	5
	Sum	63/100	**Sum**	73/100	**Sum**	76.5/100

Conclusion

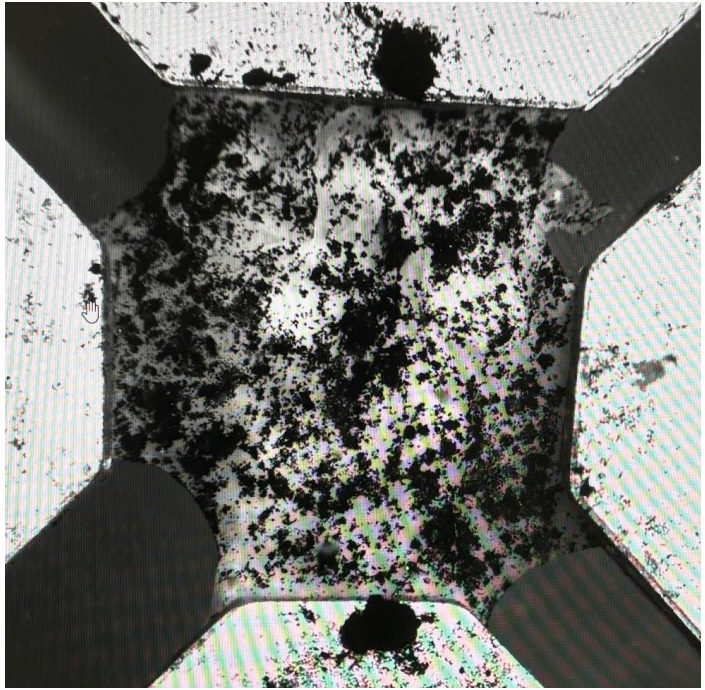
- Selected Biopsy Punch Jig concept
  - Accuracy of Sample
  - Feasibility of Fabrication for micro-sized sample
  - Simplicity of Operation
- Continue Improving and Revising Design



Figure[9]: CAD model of biopsy jig

Future Work

- Develop a physical prototype using CAD software
- Test the prototype on various tissue samples
- Analyze dimensional results using statistical software



Figure[12]: Cruciform Shaped Tissue Sample

Acknowledgements

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Thank you to our advisor Dr. Meghan Settell!

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