PRINT-A-PUNCH

Team: Daniel Pies, Colin Bailey, Kendra Ohde, Emmett Jones, Cole Miller

Client: Dr. Colleen Witzenburg, Mr. Daniel Pearce

Advisor: Dr. Megan Settell, PhD

December 6, 2024

Abstract

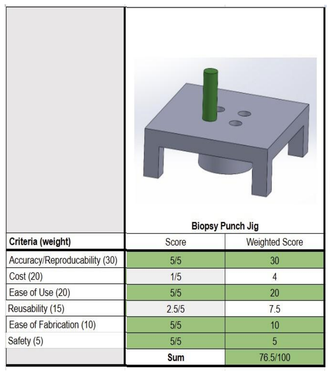
The Print-A-Punch project addresses inaccuracies in biaxial tensile testing by creating a 3D-printed jig for cutting precise cruciform shaped specimen. Designed for ease of use, cost-effectiveness, and reproducibility, the jig outperforms manual methods, improving symmetry and reducing shear stress in tensile testing. Future iterations will refine stabilization techniques and test lab-specific materials, advancing cardiovascular baxial testing research reliability.

Background and Motivation

Problem Statement: This project aims to develop a simple, cost-effective method, using factory-made razor blades and biopsy punches, to uniformly cut symmetric cruciform tissue samples for precise biaxial tensile testing, addressing the lack of existing products for this purpose.

Mr. Daniel Pearce, under Dr. Colleen Witzenburg, studies how heart attacks affect cardiovascular tissue mechanics by comparing healthy and post-heart attack samples. His research uses biaxial tensile testing to analyze specific tissue mechanics and time-dependent response [1]. The Print-A-Punch creates precise cruciform samples, enhancing biomechanical research quality and cardiovascular research methods.

Design Specifications



Biopsy Punch Jig

Criteria (weight)	Score	Weighted Score
Accuracy/Reproducability (30)	5/5	30
Cost (20)	1/5	4
Ease of Use (20)	5/5	20
Reusability (15)	2.5/5	7.5
Ease of Fabrication (10)	5/5	10
Safety (5)	5/5	5
	Sum	76.5/100

Figure 1. Design Matrix

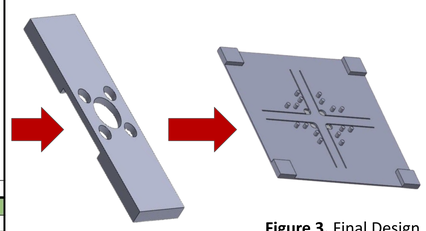


Figure 2. Intermediary Design

Figure 3. Final Design

- Design must produce symmetric cruciform shapes [2]
- Materials must abide by ASTM-638 [3]
- Device must be compatible with generic Stanley brand razor blades and biopsy punches
- Device must allow cutting through thicknesses from 0.5-3mm

Final Design

- Incorporates the following features:
  - Four symmetric holes
  - Twin slits for arm trimming
  - 4 support pegs per quadrant
  - Ample surface area for stabilization while cutting

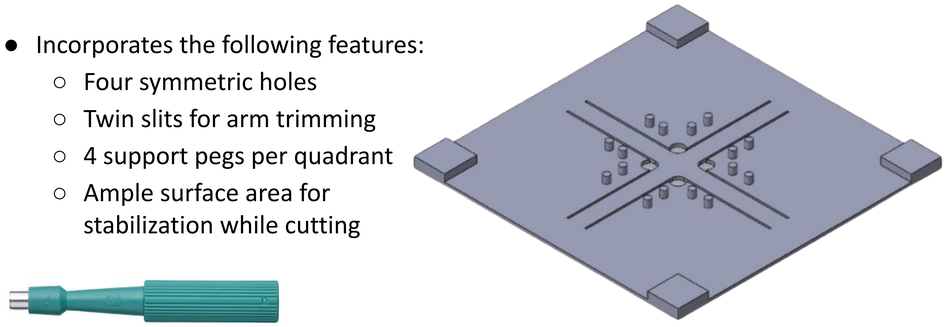


Figure 4. Bottom View of Final CAD Model

Figure 5. Biopsy Punch

Figure 6. Razor Blade

Materials

- Resin printed from UW Makerspace Formlabs
- $0.24/ml [5]

Testing

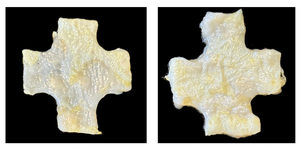
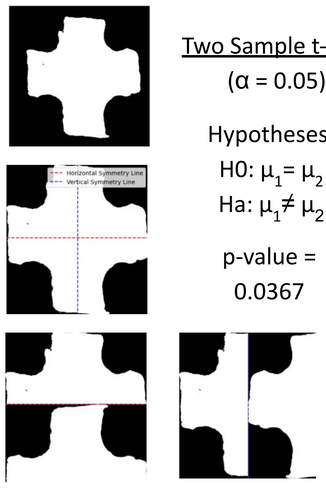


Figure 7a/7b. Cut with guide & cut by hand



Two Sample t-test

($\alpha = 0.05$)

Hypotheses:

H0: $\mu_1 = \mu_2$

Ha: $\mu_1 \neq \mu_2$

p-value = 0.0367

Figure 8. Symmetry Analysis Output

Horizontal Sym: 88.53%

Vertical Sym: 95.09%

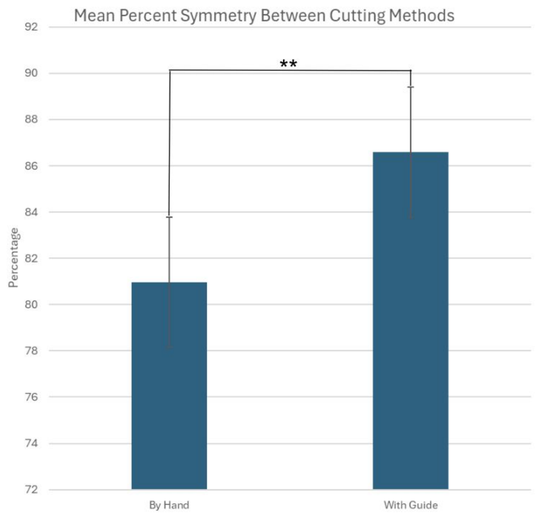


Figure 9. - Graph of average symmetry values

Fail to accept null hypothesis

Suggests cutting with the guide yields more symmetric results

Limitations

- The current design is limited to producing cruciform with 8mm wide arms from approximately 15-20mm large starting samples
- Testing was conducted on chicken skin while actual tissue includes pig aorta and bat myocardium whose different mechanical properties may allow for alternate results and symmetry
- The number of trials during testing was small due to limited sample tissue and time restraints

Future Work and Conclusion

Future Work

- Convert design to produce various sizes of cruciform specimen
- Develop more secure tissue attachment system to limit movement of sample during cutting further (ex. Vacuum, tissue adhesive)
- Publish a paper containing goals and guidelines, with CAD files for universal use

Figure 10. Tissue Adhesive[4]

Conclusion

The use of the design produced cruciform specimen that were statistically more symmetric that specimen cut by hand. The team determined that the design will reduce unwanted shear forces in biaxial tensile testing allowing for more accurate results while future work involving modifying the scale of the cruciform could be done to allow for greater scope of usage.

Acknowledgements

The team would like to thank Dr. Settell for her guidance and support throughout the course of this project. The team would also like to acknowledge Dr. Witzenburg and Mr. Pearce for their flexibility, input, and involvement in the project. Finally, the team thanks the UW Makerspace team for their help throughout the fabrication process.

References

[1] D. P. Pearce, et al., "Asymmetric Sample Shapes Complicate Planar Biaxial Testing Assumptions by Intensifying Shear Strains and Stresses," SSRN. Accessed: Oct. 3, 2024. [Online]. Available: https://papers.ssrn.com/sol3/papers.cfm.

[2] Product Design Specification Report - Team Print-A-Punch

[3] "ASTM: 638: Standard Test Method for Tensile Properties... - Google Scholar." Accessed: Sep. 17, 2024. [Online]. Available: https://scholar.google.com/scholar_lookup.

[4] "Surgibond surgical adhesive glue." Accessed: Dec. 03, 2024. [Online]. Available: https://www.medcareproducts.com/Surgibond-Adhesive-25ml/productinfo/SB/

[5] "3DP Cost Calculator…Makerspace." Accessed: Sep 14, 2024. [Online]. Available: 3D Printer Cost Calculator – Design Innovation Lab – UW–Madison