

Human Factors Needle Driver Redesign

Niharika Dangarwala, Gianna Elias, Iksha Handa, Grace Huberty, Thushara Sanjeev
Bioengineering Department, Grainger College of Engineering, University of Illinois Urbana-Champaign

INTRODUCTION

Background

- Constant use of needle drivers causes fatigue and discomfort especially for smaller hands (male designed)
- Common needle drivers are Mayo Hegar and Mathieu
 - Mayo Hegar has several grips [1]
 - Finger grip
 - Palming grip
- Finger grip causes stress at the carpometacarpal (CMC) joint
 - CMC arthritis is seen in 25% of women over the age of 50 [2]
 - Treatment includes splints, medication, surgery
- Needs: inclusivity for all hand sizes, ergonomic adjustments for comfort



Figure 1: Mayo Hegar (left) and Castroviejo (right) Needle Drivers
Figure 2: Pain at the CMC Joint Caused by Needle Drivers

DESIGN CRITERIA

Criteria	Requirements
Functionality	Pass the ASTM standard needle retention test
Ease of Use	Decrease time of repetitive suturing by 10% to measure reduction in fatigue compared to Mayo Hegar and Castroviejo
	Have the EMG signal of locking the needle driver be less than 95% MVIC
Cost	Cost less than the average needle driver (\$60 - \$80)
Universal	Can be manufactured in 2 sizes (5", 6.5")
Simplicity	Reduces training time by 10%

PROTOTYPE

Prototyping Iterations:

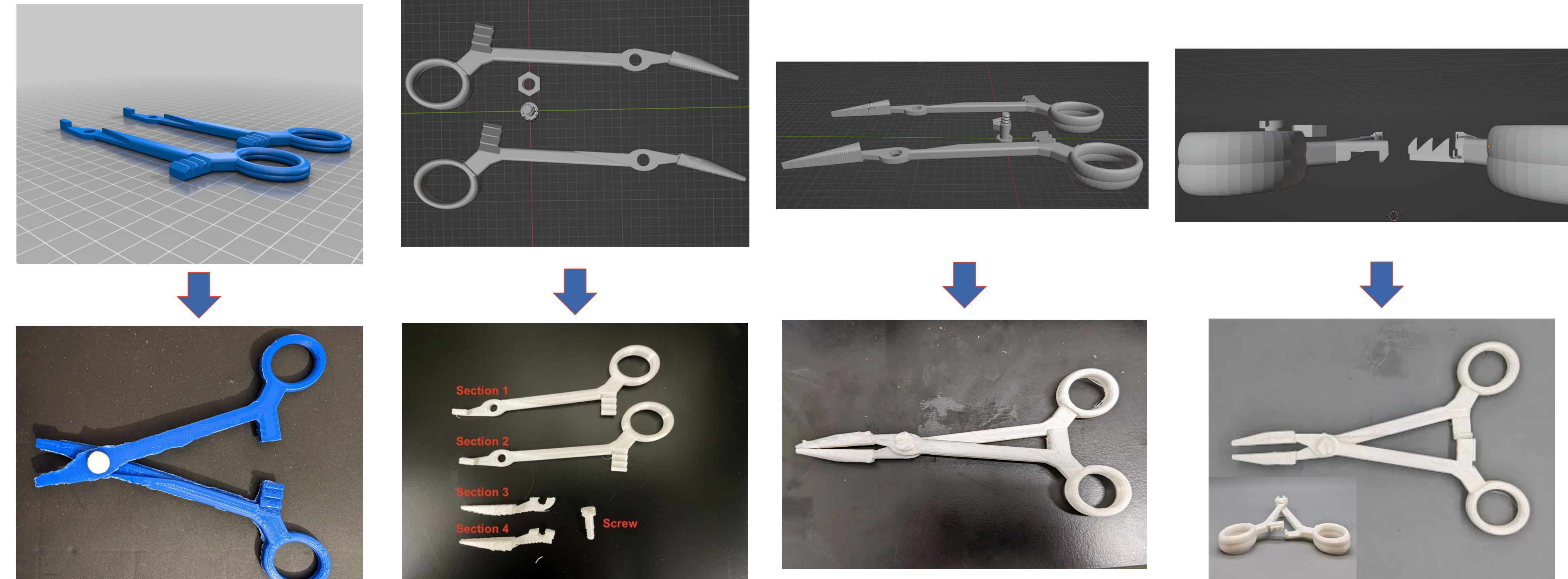


Figure 3: 3D Printed Mayo Hegar

Figure 4: Prototype #1 - Modular Needle Driver with Large Rings

Figure 5: Prototype #2 - Connected Needle Driver with Large Rings

Figure 6: Prototype #3 - Connected Needle Driver with Large Rings and Circular Locking Mechanism

Current Prototype:

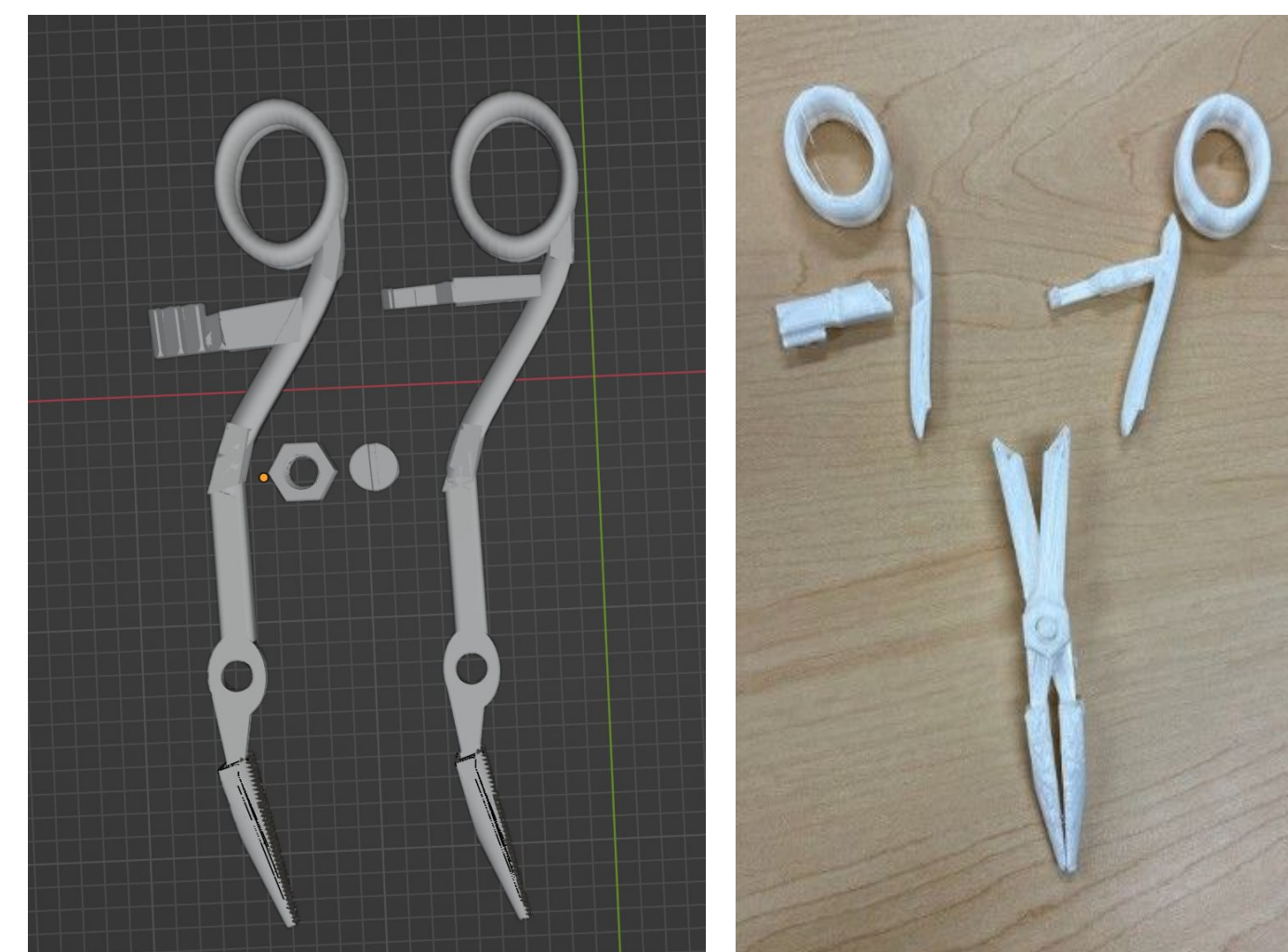


Figure 7: Current Prototype with Ergonomic Body and Offset Circular Locking Mechanism

Design Elements

- 3D Printed with PLA for rapid prototyping for proof of concept
- Large Rings to distribute force generated by CMC joint
- Ergonomic body near rings for more grip options and comfort
- Circular locking mechanism to allow left and right handed users to use the needle driver in the same manner
- Grip tips connected to allow for stronger grip of the needle
- 3 different locking positions

TESTING

- Current testing is preliminary
- Test 1: Mathieu vs Mayo-Hegar
 - Metal
 - 30 consecutive cycles of locking and unlocking (60s)
 - Measure EMG signal for forearm and CMC joint
- Test 2: Same as Test 1 but utilizing printed Mayo-Hegar and our design
- Test 3: Repetitive suturing with printed Mayo-Hegar and our design
 - 20 consecutive square knots using silk suturing thread

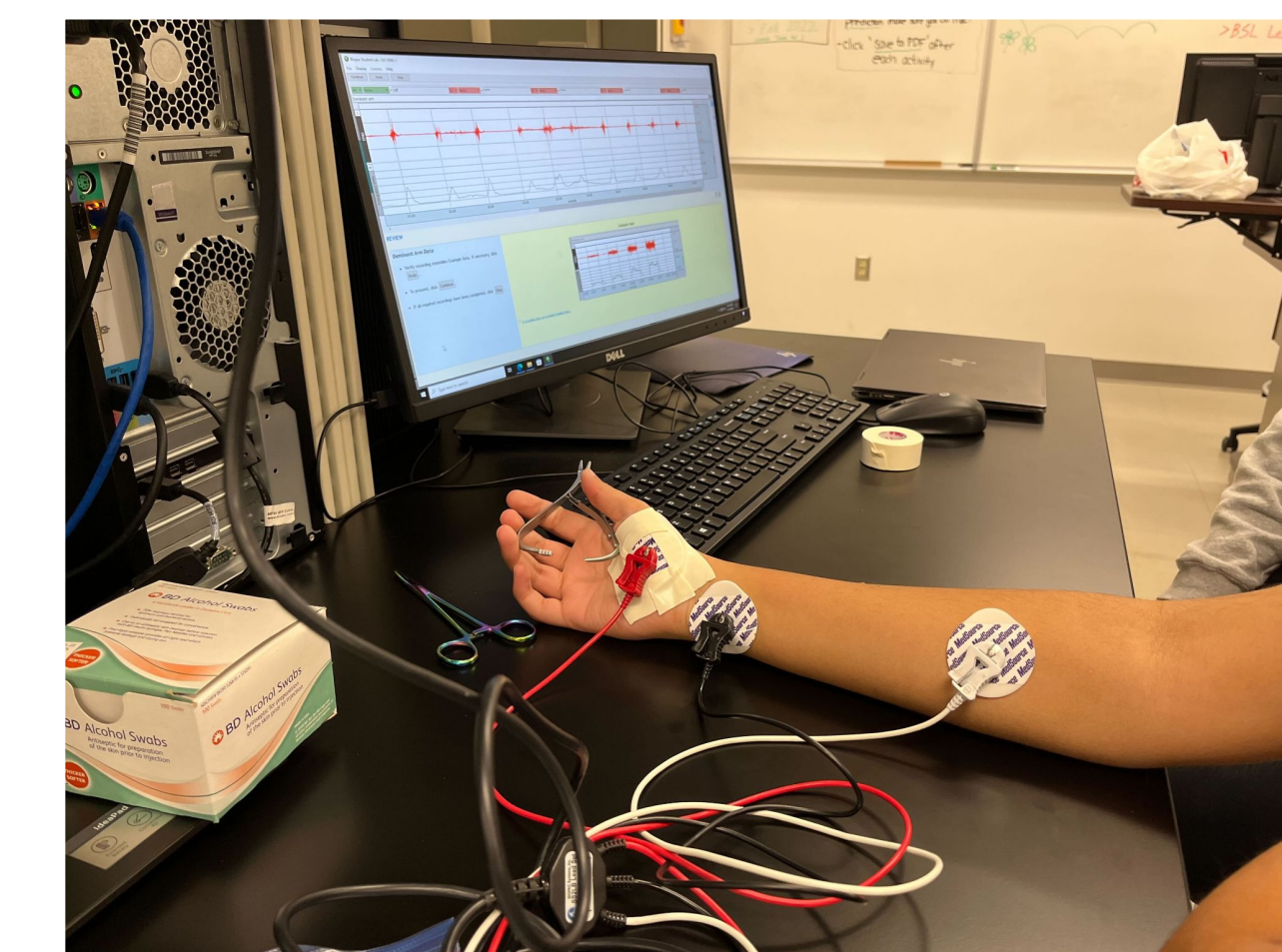


Figure 8: Preliminary EMG testing with Mathieu Needle Holder

STANDARDS

- Most standards address materials, not shape of needle driver
- ASTM Standard Specification for Stainless Steel Suture Needle Holders [3]
 - Surface uniform, not sharp
 - Rings well rounded
 - Pin or screw fixed, peened and flush
 - Passes Needle Retention Test
 - No needle movement with pull and torsion
- FDA Class I device [4]
 - No premarket notification procedures

FUTURE DIRECTIONS

- Modify locking mechanism to be a smooth circular motion
- Increase support for stability of the needle driver
- Grooves or grips on outside edges for thumbs and additional support
- Print final needle driver prototype with SLA printer
- Create a stainless steel or other high fidelity prototype
- Perform tests such as:
 - More accurate EMG
 - Timed training and suturing
 - ASTM Needle Retention Test [3]

ACKNOWLEDGEMENTS

Funding for this project was provided by the Carle Illinois Capstone Project Fund and Bioengineering Senior Design. We would like to thank our sponsors Joe Policarpo and Katy Stauffer for their support throughout this project.

REFERENCES

- [1] "Lab 1 - Part 4 - Needle Holders - VSAC - WCVM - University of Saskatchewan." <https://wcvm.usask.ca/vsac205/Lab1/needle-holders.php#Basics> (accessed Sep. 26, 2022).
- [2] O. Schult, J. Powers, W. Merritt, and N. Blanchet, "Resolution of Thumb Pain following Adoption of Mathieu Needle Holder: An Ergonomic Analysis," *Plastic and Reconstructive Surgery - Global Open*, vol. 8, no. 4, p. e2768, Apr. 2020, doi: 10.1097/GOX.0000000000002768.
- [3] Standard Specification for Stainless Steel Suture Needle Holders-General Workmanship Requirements and Corresponding Test Methods, ASTM F1325-91, ASTM International, Washington, D.C., USA, Dec. 27, 2016.
- [4] Manual Surgical Instrument for General Use, 21 C.F.R. § 878.4800 (2021).