Deliverable E: Prototype 1, Project Progress Presentation, Peer Feedback, and Team Dynamics

Group 2.3: Zachary Chaloux, Steven Dunbar, Farah El Siss, Valentin Mugabo, Aaditya Shah

Table of Contents

E.1 Prototype 1

Introduction

This deliverable covers the documentation of Prototype 1 and analysis of Prototype 1. In order to develop an efficient and ergonomic tool, it is essential to create prototypes and test them to validate the design assumptions. The objective of Prototype 1 was to assess the hand grip subsystem and refine the design specifications focusing on dimensions, weight, and shape. By creating physical models through 3D printing, we plan to evaluate the comfort, weight, and overall ergonomics of the device. Additionally, we will get feedback from an external focus group to provide insights for further improvements.

Prototype 1 Objective and Plan

In order to address the ergonomic needs of our device, we have decided to focus on the hand grip subsystem for the first prototype. The primary goal is to test and refine our design specifications, specifically in terms of dimensions, weight, and shape. We also want to validate our assumption that this device will provide an ergonomic solution to closing clips. While our design specifications were initially based on the maximum allowable values, it is important to note that these values may not necessarily represent the ideal specifications for the device. Therefore, with prototype 1, our aim is to identify the design specifications that will optimize the ergonomics of the device.

To effectively analyze the ergonomics, a physical model is required for prototype 1 as it allows for a hands-on evaluation. We will utilize 3D printing to materialize our CAD design. With the physical model, we will assess the comfort, weight, and overall shape of the device. This will enable us to identify areas where material can be removed to reduce weight without compromising strength.

Because our device should work for a diverse range of hand sizes and shapes, achieving universality is crucial. To further understand how we can enhance the comfort of the device, we will present our prototype to an external group. Their feedback will provide insights and suggestions on potential improvements that can be made to enhance comfort.

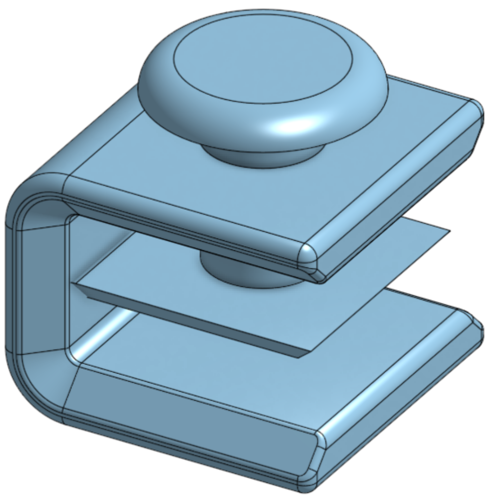
Finally, by having a physical model we can simulate the movement necessary required by our device to close the clips. This is important as one of the main reasons we chose this design was the complete reduction of the thumb joint. However, because this idea has not been used in any of our benchmarking we need to validate our assumption that our device will be more ergonomic.

Prototype Documentation

For our prototype, we ended up making two models because our first model was too large to effectively evaluate the ergonomics of the device. We used test 1 to determine the overall size of the renal tool while test 2 was used to analyze the comfort and ergonomics of the device.

Test 1 - Dimensions of Tool

The primary goal of test 1 was to determine the dimensions of the renal device. We wanted to ensure that the tool would fit comfortably in the palm of the user's hand. This would be accomplished by using a test group of people to see if they thought the tool was too large or too small for their hand. We then would use this data to find the dimensions of the tool to provide a universal fit for different sizes of hands.



CAD Design for Test 1

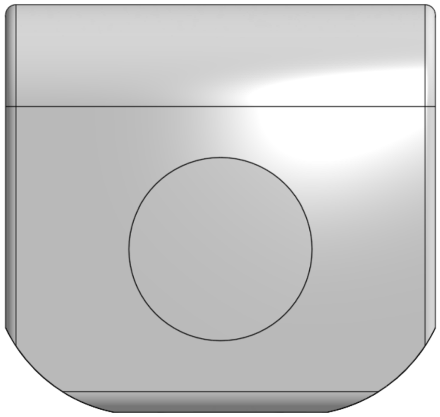
Test 1

Different Angle of Test 1

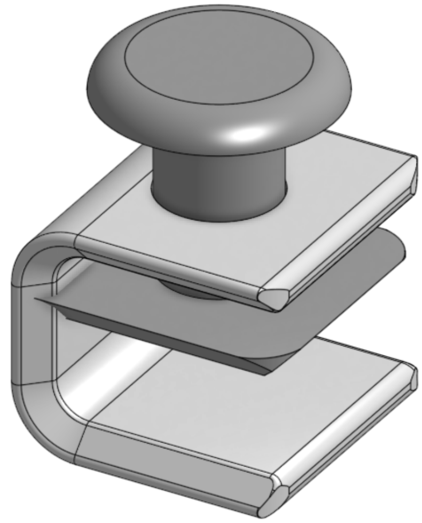
Different Angle of Test 1

Test 2

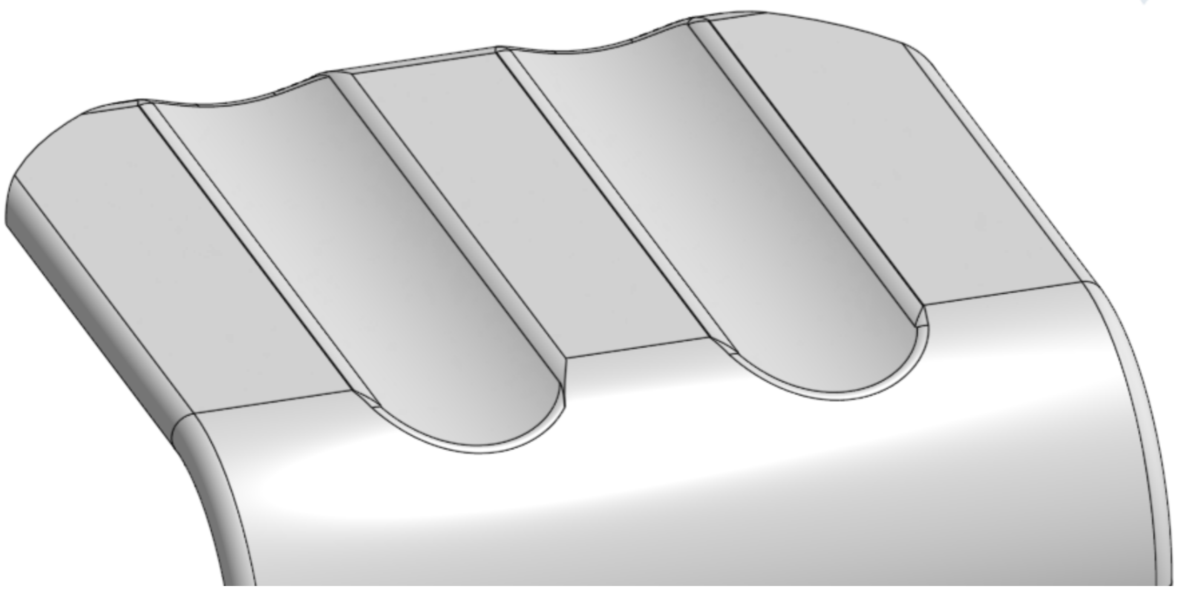
After editing the CAD design based on what we learned from test 1 we made test 2 so that we could evaluate the ergonomics of the device. We would evaluate the device on the overall weight, pressure points, and ease of maneuverability. For the weight, we wanted to know the minimum amount of plastic needed to ensure the strength of the device in operations. Test 2 also will be used to test for ergonomics of the repetitive motion of the plunger and the maneuverability of the tool.



Curved Corners



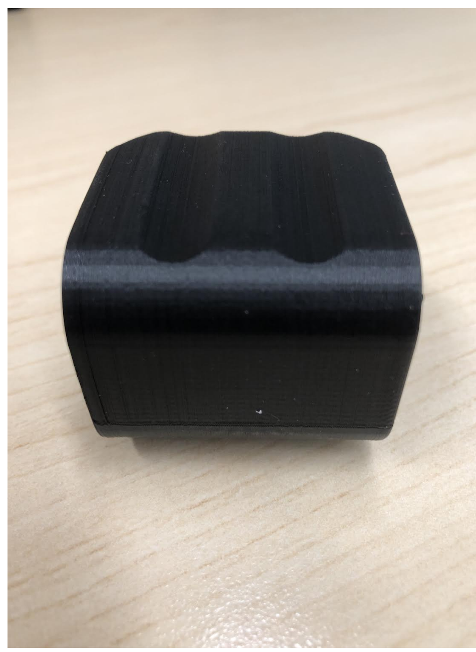
CAD design for Test 2



Finger Groves

The following are images of our most recent prototype:



Testing Methods

To test the device for ergonomics we need to repeat the motion required by our device to close the clips. In order to make the test as real life as possible we 3D printed a renal clip to simulate the closing action. We were unable to obtain any of the tubing which would also increase the force required to close the clip. We then tried closing the clip 40 times with our thumb then after a break we repeated the process but with our tool. This test proved that the clips were in fact easier to close with our tool than opposed to using just your thumb. On a side note, we noticed that the hard plastic surface of the clip on the tool created for the clip to slide around as you applied force. So we noted this behavior as something to look into when we analyze the grip subsystem of the device. After doing this test we noted all the pressure or sore spots that we got when using the device. One such spot was the round top of the plunger did not fit that well in the hand so over time it created a sore spot.

Repetitive Motion Test

For the next test, we wanted to see how easy the device was to maneuver. We did this by using the clip in a small space. We found an area where only our arm could reach through then using the tool we attempted to maneuver the tool over the clip in the small space. This test was extremely successful as the tool seemed to work like an extension of your hand. One thing we learned from this test was that any slightly sharp edges on the tool cause discomfort to the hand when in tight spaces. To solve this we sanded down the edges of the design.

Our final test was easy for portability and use. We wanted to get an idea of how easy this tool would be to carry around while you worked on other tasks. This test was done by carrying the device in our pockets while performing daily tasks. After doing this for a day we found that while the tool was pocket size the corners of the tool were rather uncomfortable if they were pressed against in your pocket. Also, we found that the top being extended out made the device harder to transfer than when it was in its square form. This promoted talk about how we could go about curving the edges of the design and potentially design a way for the plunger to be locked down into place when the device was not in use.

Analysis

For both test 1 and test 2 we compared the prototypes to the design specifications.

Design Specification	Units	Design Value	Test 1	Test 2
Reduction in thumb joint stress (compared to manual operation)	%	>75	80	80
Compatibility with different hand sizes (e.g., can be used with X% of adult hand sizes)	%	>95	10	90
Total volume of the device	cm^3	<200	63	26
Total weight of the device	g	<300	63	48
Number of operations using thumb (should be 0)	#	0	0	0

Many of the design values for this prototype are higher than the prototype value because of the design that we went with. Our design specifications were based on the maximum value that our device could have. However, because of the complex nature of the design the metrics like volume and weight were significantly lower than expected.

The value for the reduction of thumb joint stress is calculated based on how much of the thumb joint and muscle is used for the operation of the clip. As seen in test 2 the thumb is not used for the operation of the device. However, the plunger could be compressed by part of the thumb muscle thus we averaged that you would be using 10 percent of your thumb joint and muscle to operate the device.

Compatibility for different hand sizes was based on a control group of ten people. Out of 10 people, 2 people thought that the device was too big for their hand. We do realize that by only having ten people in our test group this value has a high error probability. What we were able to conclude from this test was that for the average hand size this device works.

The volume and weight of the device were calculated by Onshape by setting the CAD design material and using the metric features.

Since this device does not require the movement of the thumb, both test 1 and 2 were 0.

Updated Design Specifications

After completing test 1 and test 2 it became apparent that our original design specifications did not fit our design. Thus, based on feedback and analysis we determined the following values.

Design Specification	Units	Original Value	New Value
Reduction in thumb joint stress (compared to manual operation)	%	>75	>75
Compatibility with different hand sizes (e.g., can be used with X% of adult hand sizes)	%	>95	>85
Total volume of the device	cm^3	<200	<45
Total weight of the device	g	<300	<50
Dimensions of the device	mm	undetermined	<50x50x50
Number of operations using thumb (should be 0)	#	0	0

Reduction in thumb joint stress and number of operations using the thumb remains the same as the original specifications. We changed compatibility because our design fits in the palm of the user's hand. It is impractical to think that we can make a device that will fit the majority of hands perfectly. If we were making a scissors design then 95% would be a reasonable goal. Instead, once we have the max and min dimensions of the clips we can design a device that has the smallest opening possible. Since, this device might be too small we will look into figuring out how the device could be scalable to allow maximum comfort.

The volume was changed because the design uses less material than previously benchmarked designs. The dimensions were found by measuring the length of one of our hands and then dividing the value by 3. This gave a good estimate of the max length the sides of the cube could be before it would stretch the hand past is natural size.

Finally, the weight of the device was determined to be under 45 grams. After holding test 2 we found that 48 grams while light was slightly heavy if we were able to get under 45 without compromising the structural integrity of the tool then we could increase the ergonomics of the tool.

Lessons Learned

Our initial CAD design dimensions for test 1 were inspired by the size of a Rubik's cube. However, we quickly realized that the tool turned out to be considerably larger than expected during the first trial print. To prevent wastage of material, we made the decision to abort the print. To accurately determine the needed dimensions, we measured the length of one of our hands and divided this measurement by 3. This calculation provided us with the dimensions for a 55x55x55 mm cube, which we used as the basis for remodeling the design.

From test 1, we arrived at a valuable lesson of the importance of finding alternative ways to define design specifications accurately without relying on prototypes. This was because we did not want to waste any more time and effort building prototypes simply because of a bad estimation of the tool's dimensions. Furthermore, we decided that the box shape could be enhanced by incorporating finger grooves on the bottom surface of the tool. These grooves would not only increase the overall grip but also improve comfort during usage.

During the printing process of the device, we chose to use a 10% infill, resulting in a considerable amount of flexibility in the structure. Recognizing this, we made the decision to add more material to test 2. However, to reduce weight, we decided to trim the front edges of the tool and thin out the back portion. We wanted to find a balance between the weight and strength of the device.

In comparison to test one, test two exhibited significant improvement by addressing the size issue and increasing the overall strength of the tool. However, during the evaluation, we discovered that test two was slightly heavy due to the high infill density chosen for the print. This prompted a discussion on finding a balance between strength and weight, as we contemplated reducing more material while considering the potential compromise on the overall strength of the device.

During the evaluation of test two, we found that the device was relatively comfortable to hold in our hands. However, we identified a flaw in the design the finger grooves on the bottom of the device were too small. One team member suggested exploring an alternative shape for the top of the plunger to reduce the pressure points on the palm of the hand.

Once we had evaluated the device, we decided to show our device to our focus group. This step in the process would enable us to refine the design further to avoid oversights in the design.

After seeking feedback from friends and our TA, we discovered several valuable ideas for improvement. The main suggestion was that the tool was too large for their hands, particularly emphasizing its excessive length. This observation was likely due to the fact that we had originally designed the device as a cubic shape, whereas the natural shape of a hand tends to be more rectangular. Additionally, we noticed that the individuals who mentioned the size concern generally had smaller hands.

Another critique we received was that the shape of the tool should align with the natural curvature of the hand, as opposed to its current box-like shape. In considering how to improve the shape, we concluded that by curving the backside of the device, we could not only improve its conformity to the hand's shape but also reduce the amount of material used and create a more rounded overall shape.

Some positive feedback we received indicated that the tool was highly compact and easy to maneuver. Taking the feedback into consideration, we plan to integrate the suggested improvements into our next prototype. By addressing the size concerns by modifying the overall dimensions and incorporating a more ergonomic shape, we will get a device that is better suited for individuals of varying hand sizes.

Conclusion of E1:

The development of Prototype 1 served as a critical step in identifying the optimal design specifications for our ergonomic tool. Through testing and analysis of design specifications, we gained valuable insights into the dimensions, weight, and overall ergonomics of the renal device. Although the initial dimensions of the prototype were larger than expected, we quickly adjusted them based on hand measurements and feedback from the focus group. The incorporation of finger grooves and modifications to the shape improved the grip and reduced pressure points on the hand. Our prototype testing showed promising results in reducing thumb joint stress and eliminating the need for thumb operation. By continually refining and adapting our design specifications based on user feedback, we are confident in creating a universal and efficient tool for individuals with different hand sizes.

E.2 Project progress presentation

Please see the attached PowerPoint slides for the group presentation. In our meeting, we determined who would be presenting each part of the presentation. We tried to let each member of the team present the part of the project with which they were most confident.

- Presentation- 10 minutes long:
    - 1-3 (describe project proposal and needs)
        - Steven
    - 4-6 (benchmarking and design specs)
        - Farah
    - 7 (initial design concepts - shown to client)
        - Farah
    - 8 (customer feedback)
        - Farah
    - 9 (Wrike/ project plan)
        - Valentin

- 10-12 (prototypes after feedback)
    - Aadi
- 13 (target specs for prototype 1)
    - Zach
- 14 (feedback part 2 - control group after prototype 1)
    - Steven
- 15 (client meet 3 questions)
    - Steven

E.3 Peer feedback and team dynamics assessment (completed individually):

After taking the peer feedback and team dynamics for the deliverable we will be doing a debriefing session. We will go over the team dynamic document to see where we could improve and what we are doing well on. In addition, we will address any concerns brought up in the comments of the team report. For our report, we will address how we are going to ensure that we are meeting our deliverable deadlines.

Wrike Link

https://www.wrike.com/workspace.htm?acc=4975842&wr=20#/folder/1222407618/list?viewId=204172984