#### **CARPAL FLEX**

Team: Solo Project

Duration: 15 Weeks Spring 2023 Studio

# **PROJECT STATEMENT**

The aim is to create a Carpal Tunnel Syndrome (CTS) brace using recycled pharmaceutical plastic waste. The design features a dorsal resting wrist splint with a three-way textured rubber grip Velcro strap that stretches key trigger muscles to alleviate compressed median nerve. The brace is designed with ergonomics, ventilation, and nature-inspired aesthetics in mind, allowing limited range of motion while preventing muscle atrophy, and potentially alleviating and treating CTS symptoms.

## **PROJECT TIMELINE**

An estimated project timeline in the span of 15 weeks. There are total of 5 phases. Each phase will be focused on within the allocated time span in order to succesfully complete the project on time with the maximum result.



PHASE 5

Week 13

Week 15

Final prototype

Project Wrap-up



# **ON OUR ENVIRONMENT?**

14,000 TONS of waste is generated daily in US health care facilities, more than 25% is plastic.

### **CONTRIBUTING FACTORS**

Main contributing factors to such a high usage and demand for plastic in medical industries.



### Efficiency

Plastics are indispensable part of the medical industries as they obtain properties favorved by the industries. It is low in cost and easy to process and manufacture.



### **Sterilization**

Due to their high versatility of being one of the easiest materials to sterilize, plastic is utilized in almost every medical device applications.



### **Market Demand**

The recent outbreak of COVID-19 deteriorated the plastic pollution due to the growing demand for single use plastic PPEs around the World.

### **PROBLEMS**



### **Recycling Restrictions**

Plastic waste generated within the medical industries are very tricky to be recycled as it needs to be properly sorted, cleaned, and sanitized in order to be used to manufacture a new product.



### Lack of Coordination

There is not enough coordination between the hospitals and recycling centres. Not all recycling centres obtain high-tech facilities that can easily sort out plastics and clean them.



Due to the cheap and fast manufacturing process of plastics, and high chances of contamination, most of the plastic products in the medical industry are singleuse items.

### Feasibility

## SOLUTION

Once the plastic wastes are collected, sorted, and cleaned they are seperated into four different recycling routes. Primary - the reuse of uncontaminated plastic scraps. Secondary - recovery of plastic waste that was once contaminated. Tertiary - chemical reycling of plastic materials into smaller molecules that generates chemicals and fuels. Incineration - energy recovery from highly contaminated plastic waste by incineration.



COLLECT



ASSORT



CLEAN



RECYCLE



### **POLYPROPYLENE PLASTIC**

Polypropylene is a cost-effective medical-grade plastic material and is used where steamsterilized medical devices are necessary. In addition to resistance to steam sterilization, mechanical performance properties of polypropylene include durability for the number of cycles it can be reused. Its recyclability also makes it an attractive medical-grade plastic.



## **APPROACH**

My apprach is to utilize specific polypropylene plastic products within the medical indutry that can eaily be recyled, and repurposed into a new form of product that will serve it's purpose for a longer period of time whilst improving the lives of others.



### Pharmaceutical Plastic

Pharmaceutical plastic products, especially, the pill bottles are one of the most common medical products that is made from No.5 plastic or polypropylene, which is considered recyclable plastic. In 2019, 4.38 billion prescription bottles were manufactured.



### Recycle

Hospitals and pharmacies coordinate with medical plastic recycling centres. The prescription bottles will be collected, assorted, and cleaned before being recycled.



### Product

The processed prescription bottles will be recycled and repurposed into a new form of medical product that will serve its purpose for a longer period of time whilst improving the lives of others.

## FOR WHO?

Carpal tunnel syndrome is estimated to affect 3 to 6 percent of the adult population in the World. It is also a condition that sometimes cannot fully be treated even after a surgery, requiring the patients to frequently wear splints or braces.



### CARPAL TUNNEL ANATOMY

Carpal tunnel syndrome is a numbness and tingling in the hand and arm caused by a **pinched nerve in the wrist.** 



### **POSSIBLE SOLUTION**

Severe carpal tunnel syndrome can be treated through surgery, however it sometimes cannot fully be treated even after a surgery. Not all braces truly treat the condition as it only alleviates the symptoms temporarily. "The Carpal Solutions" by Dr. Clyde E Morgan however, has 97% success rate in treating the condition by targeting anatomoical areas impacted by CTS.



## **USER INTERVIEW**

I interviewed CTS patients of various professions and stages of symptoms on the common complications that they found within their experiences of wearing the brace. There were 4 major complications as show below.



**Matt** 24 Rock Climber - 7yrs.

Mild - Moderate pain

WEAKER MUSCLES

Wrist joint gets stiff from not being able to move hand for a long period of time.

Severe restriction weakens hand muscles. Especially after wearing it to bed.



**Annie** 27 UX/UI Designer - 4yrs.

Mild pain

**OUTDATED AESTHETICS** The big and clunky size is intruisive

Outdated CMF

Don't feel confident wearing the brace out in public



**John** 34 Woodturner - 12yrs.

Moderate - Severe pain

#### **UNCOMFORTABLE** Bulky and hot.

Painful when palmer spine (metal splint) pressed into the wrist.

Skin irritation from non-breathable fabric.



Wendy 31

Writer - 6yrs.

Moderate pain

### LOW LIFE QUALITY

Difficulty in performing daily tasks

Restricting and uncomfortable during work

Contantly have to take it off when washing hands or to eat.

### **CURRENT CARPAL TUNNEL BRACE**

A breakdown of most common complications found within current wrist splints and carpal tunnel braces from continous application.





#### **NO VENTILATION**

The fully enclosed surface prevents skin from breathing - causing possible infection



### **SKIN IRRITATION**

The use of non-breathable fabric and uncomfortable straps may irritate and breakdown skin



#### LIMITED MOTION

A complete immobility leads to muscle atrophy and joint stiffness



#### **COMPRESSED NERVE**

The palmar splint puts more pressure on the nerve, causing more damage preventing healing process

### **SUITABLE APROACH**

An analysis of more appropriate carpal tunnel brace that has been recommended by researchers and doctors.





breathe

### **COMFORTABLE FIT**

An ergonomic dorsal resting fit keeps the hand in neutral position and speeds up the recovery

Ample ventilation allows the skin to



#### MOBILITY

Allowing some range of motion prevents the muscles and joints from deteriorating



#### **NO PALMER SPINE**

The bottom of the wrist needs to be open keeping the nerve from being compressed.

## MARKET ANALYSIS

The current dorsal splint products in the market provide dorsal support of the wrist while reducing palmar contact. However, they are either bulky in size, does not provide gripping ability, or have no ventilation for skin. Most importantly, they only provide stability and immobilization.



Maintained gripping ability

High strength

No ventilation

Multiple sizes

Aid-entry level price point (\$74) Maintained gripping ability Low strength No ventilation Multiple sizes Mid level price point (\$100) Maintained gripping ability Low strength No ventilation Multiple sizes Mid-high level price point (\$120+) Maintained gripping ability High strength Ventilation Multiple sizes igh level price point (\$158) No gripping ability High strength Ventilation

Adjustable single size



#### Advanced™

High-end price point (\$174)

No gripping ability

High strength

No ventilation

Adjustable single size

### **INCORPORATING NATURE**

As the product is manufactured out of 100% recycled material, incorporating nature into the overall form and aesthetics will provide a greater structural integrity as well as serving a meaningful purpose in telling a compelling story.



PERFORATION

PARAMETRIC STRUCTURE

HAPHAZARDNESS



#### SEEMLESS BLEND

### **AESTHETIC INSPIRATION**

In many architectural structures and products, nature is utilized for better structural integrity, ventilation, systemic flow, and organic aesthetic that fits within modern design.

#### STRUCTURAL INTEGRITY



ORGANIC FORM

EFFICIENT SYSTEMIC FLOW





## **CONCEPT EXPLORATION**

nature, concepts for form t resembles nature, provides



Based on the ideation concept and referencing the inspriations from nature, concepts for form and design were explored. Focusing on the shape and form that best resembles nature, provides ventilation, structure, and ergonomic value.









### **CONCEPT REFINEMENT**

Based on the ideation concept and referencing the inspriations from nature, concepts for form and design were explored. Focusing on the shape and form that best resembles nature, provides ventilation, structure, and ergonomic value.





LIVING HINGE

### FORM EXPLORATION

Model clay was used to rapidly mock-up several concept variations. Through this process I was able to get a better sense of overall size, form, and required ergonomic values.



## **DOWN SELECTION**

Three concept directions were chosen based on form and aesthetic that best represents nature and provides the most ergonomic value.



## DATA COLLECTION

In order to make a universal size design, various hand size data were collected using a 3D scanner. 95th percentile male and 5th percentile female, as well as 50 to 60th percentile hand sizes were scanned and used for reference.







"The Measure of Man&Woman" by Henry Dreyfuss

## **INITIAL PROTOTYPE**

Based on my chosen concept designs and referencing the collected hand size data, initial prototypes were fabricated. 2D scanned clay models were used as an underlay to create more accurate designs on illustrator. The designs were cut out of 1/8" acrylic sheets on a laser cutter. Heat molded the acyrlic cut-outs to comfortably fit over an 50th percentile size hand.













CONCEPT 03

### **USER TESTING**

A user testing was conducted on four patients of different professions. The aim of the test was to collect reviews and feebacks on the overall fit, comfort, aesthetics, and pain points found within designs. Based on the positive and negative feedbacks on each of the concepts, Concept 01 was favoured by the users to be further refined.



#### **CONCEPT 01**

#### PRO:

- 1. Does not dig into the knuckles
- 2. Accessory like design
- 3. Beathing room for forearm movement

#### CON:

- 1. Too pointy digs into index knuckle
- 2. Too tight pinches into forearm



#### **CONCEPT 02**

#### PRO:

- 1. Good ventilation, no pinching on top of the hand
- 2. Breathng room for forearm movement

#### CON:

1. Rubs against and digs into the knuckles 2. Too long



PRO:

- CON:



#### **CONCEPT 03**

1. Comfortable fit - the curves avoid bones and pich points

 Rubs against and digs into the knuckles
Feels too enclosed - limits forearm movement 3. Overall size too long

### REFINEMENT

Based on the feedbacks from the user testing, Concept 01 was chosen to be further refined. Three refinements were made in adjusting the pain point areas discovered during the user testing. Each refinement model varies in number of kerfs to allow different bend radius.









**REFINEMENT 02** 









## EXPERT FEEDBACK

Dr. Karen Craven is an Occupational Therapy Professor at the UC College of Allied Health Sciences, who generously allowed me the opportunity to interview her and provided me with feedbacks and validation on my design.



### **PROFESSIONAL FEEDBACK**

With over 20 years of clinical experience, Sue has focused on adult rehabilitation, neurological and orthopaedic diagnoses in both outpatient and inpatient settings, including fractures, tendinitis, tendon repairs, carpal tunnel syndrome, nerve impingements, amputations and trigger finger.



**Sue Walters** Occupational Therapist

OTR/L , Hand Therapist NovaCare Rehabilitation

#### FEEDBACK

"... the ergonomically designed pattern that avoids and naturally forms molds the bones makes it favorable."

"... it is very less likely that patients will be able to accidentally bend their wrist in their sleep as the product requires intentional force to be bent."

"... the idea of targeting three key muscles tissues does help with alleviating the symptoms and has the potentially to possibly speeding up the recovery."

#### RECOMMENDATION

"...the current needs to get a little longer and should come in different sizes."

"...the foam padding should be optional as OTs only attach them if neccessary."

"... make it economically feasible for the physicians by registering as a customizable brace not a fabricated brace."





### FINAL DESIGN

Final design direction incorporates the most optimal design and size chosen during the validation process.











### **CMF DETAILS**



### **PRODUCT LIFECYCLE**







