GNG2101

Design Project User and Product Manual

Waterproof Cervical Collar
By AquaBrace

Submitted by:

AquaBrace (Group B2.2) – Fall 2024

Noah Aynalem, 300166191

Cyrus Choi, 300344558

Lining Ao, 300354172

Matthew Buentiempo, 300346537

Evan Sterjovski, 300350529

November 25, 2024

University of Ottawa

Table of Contents

Table of Contents ii

List of Figures iv

List of Tables iv

List of Acronyms and Glossary vi

1 Introduction 1

2 Overview 2

2.1 Conventions 4

2.2 Cautions & Warnings 4

3 Getting started 4

3.1 Configuration Considerations 4

3.2 User Access Considerations 5

3.3 Accessing/setting up the System 5

3.4 System Organization & Navigation 6

3.5 Exiting the System 6

4 Using the System 7

4.1 Putting the collar on the neck 7

4.2 Washing the cloth sleeve 9

4.3 Washing the silicone collar (without sleeve) 9

5 Troubleshooting & Support 9

5.1 Error Behaviors 9

5.2 Special Considerations 9
5.3 Maintenance 10
5.4 Support 10
6 Product Documentation 11
6.1 Waterproof Soft Cervical Collar 11
6.1.1 BOM (Bill of Materials) 11
6.1.2 Equipment list 11
6.1.3 Instructions 11
6.2 Testing & Validation 2
7 Conclusions and Recommendations for Future Work 3
8 Bibliography 3
APPENDICES 4
9 APPENDIX I: Design Files 4
10 APPENDIX II: Other Appendices 5

List of Figures

Figure 1: Closed Final Prototype 2

Figure 2: Expanded Final Prototype 3

Figure 3: Flowchart of all possible iterations 4

Figure 4: Collar (Fully Assembled) 6

Figure 5: Cloth Sleeve 6

Figure 6: Collar 6

Figure 7: How to Use (Step 1) 7

Figure 8: How to Use (Step 2) 7

Figure 9: How to Use (Step 3) 7

Figure 10: How to Use (Step 4) 8

Figure 11: How to Use (Step 5) 8

Figure 12: How to Use (Step 6) 8

Figure 13: How to Use (Step 7) 9

Figure 14: Stress Test (Front View) 2

Figure 15: Stress Test (Side View) 2

Figure 16: Stress Test (Back View) 2

List of Tables

Table 1: Glossary vi

Table 2: Components of the Collar 6

Table 3: How to use the Collar 7

Table 4: Contacts 10

Table 5: Bill of Materials 11

Table 6: Stress Testing 2

Table 7. Referenced Documents 4

List of Acronyms and Glossary

Table 1: Glossary

Term	Acronym	Definition
Cervical	N/A	Relating to the neck, or to the neck structure
Polylactic acid	PLA	Natural, recyclable plastic. Common 3D printing filament. Prints to become hard plastic
Polyethylene terephthalate glycol	PETG	Form of printable filament and comes in sheets. Sheets can be heated and formed in the vacuum former.
Thermoplastic polyurethane	TPU	Polyurethane plastics with elastic properties. It can be processed through injection molding, extrusion, and 3D printing.

1 Introduction

This user and product manual is a guide for the usage of a soft-cervical neck collar, designed for those people with neck disabilities to continue living their life to the fullest and most athletic.

Here at AquaBrace, we have designed a soft-cervical neck collar that aims to provide the maximum comfort for athletic people who live with chronic neck injuries in their day-to-day lives. This document is a guide to getting the most out of our soft-cervical collar, so that individuals with chronic disabilities can continue doing athletic activities while not being defined by their injuries. Therefore, we set out to design a product that would meet the needs of both athletes and people with disabilities individually, so that our product would be able to meet the needs of the people who are a part of both groups.

To expand, when designing athletic wear, breathability and washability are key aspects to account for. Athletic wear needs to be able to withstand the sweat and dirt that builds up during athletic activity and continues to function normally. Afterwards, it must be easily washable so that the athlete can use it all over again and not have to endure a putrid smell. Therefore, we at AquaBrace made sure to include washable materials that will allow users of the soft-cervical collar to easily wash their collar after use. Furthermore, the materials we use are breathable and will reduce the sweat buildup in the first place; this will make the collar both more comfortable to use and easier to clean, demonstrating a dedication to ease-of-use on the part of users.

When designing wear for being used by people with disabilities, usability and ease-of-use are of paramount importance. People with chronic neck disabilities live with neck injuries in their day-to-day lives; therefore, our product must make their lives easier. This goal is most easily achieved by providing relief for the user when using our product. Considering this, we designed our collar to provide extra support along the jawline and chin, ensuring that users are adequately supported all along the neckline. This will provide the user with maximum support for their neck and alleviate their pain.

The document starts off with a more detailed overview of the product, with conventions and tips for safe use included. Afterwards, the document explains how to access and use the collar, with step-by-step instructions and pictures to ensure maximum comprehension. Finally, the document goes over common errors in using the collar, troubleshooting tips for encountering these errors, and a bill of materials/parts list. Also included are future considerations for the iterations of the product, so that the next iteration is better than the last!

2 Overview

The problem was that there are no soft cervical collars that allow the user to have all the stability and comfortability they need, while also being waterproof and stylish. This is important as we want users to feel as if their collar is an extension of their personalities and that it is an accessory rather than solely a medical device. This destigmatises accessibility devices, allowing our users to more freely go out without worrying about having to wear their collar to whatever event/place they want to go. This feature of being able to customize the look of the collar and interchange the cover for any event differentiates us from other collars which usually look like a large block is one solid collar, apposed to an accessory.

Figure 1: Closed Final Prototype

Figure 2: Expanded Final Prototype

Key Features:

- Silicone padding is added to the top of the collar to add extra cushioning to the inner jaw and chin area
- Customizable cover can be added and removed to the collar to be viewed more as an accessory rather than a neck brace
- Inner silicone collar is 100% waterproof and chlorine resistant, allowing for use in water and chlorinated pools
- Adjustable Velcro for ease of use and adjustability

Construction of the System

Our product is made of **2 main components**, the inner collar and the customizable cover.

- The inner collar is constructed primarily of silicone along with Velcro strap at the back
- The outer cover is made from a reusable fabric that can be customized to the client's preference

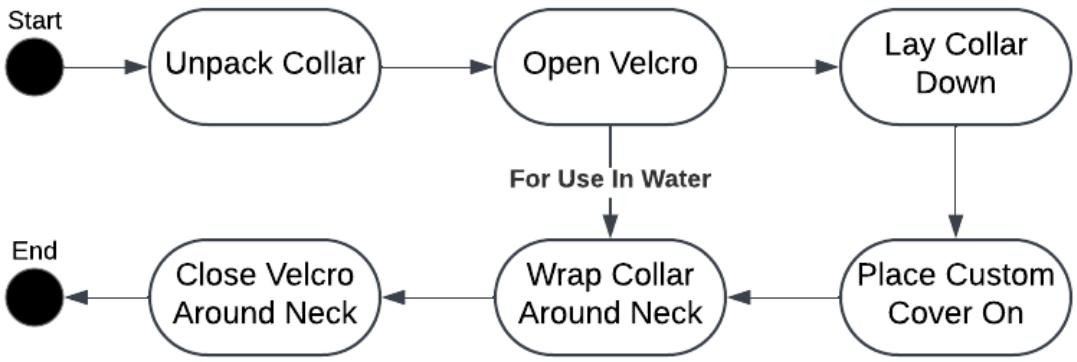


Figure 3: Flowchart of all possible iterations

2.1 Conventions

Action – Will be placed in front of every step that requires the user to perform the mentioned instructions

Note – Will be placed in front of general tips/instructions to keep in mind while handling the brace

2.2 Cautions & Warnings

- Warning: If prolonged use of collar is causing pain on the neck, cease use and revert back to a collar that is proven to aid the stability of the user's neck.
- Warning: If area of contact becomes irritated and itchy, return product and contact your family doctor about a potential silicone allergy

3 Getting started

3.1 Configuration Considerations

No tools are needed. Please only wear one collar at a time. Note that due to the waterproof nature of the collar, it does not consist of thermal insulating properties.

3.2 User Access Considerations

The main group of users that would be using the prototype would be people with chronic neck disabilities. This group of users would range from people with the desire to include sport in their daily activities to those who just want comfortable support for their head in their daily life. Restrictions on the use of this collar are varied; for athletic users, their schedule and ability to wash the collar may impact how often they are able to use it (and withstand the smell). For individuals with chronic disabilities, a consideration may be the frequency with which they can engage in athletic activity.

3.3 Accessing/setting up the System

To set up the system:

1. Take collar out of carrying pouch
2. Lay the collar out on a flat surface
3. Undo the Velcro strap holding the collar together
4. Ensure that the collar is upright, then lift the collar to cover the cervical area
5. Re-attach Velcro when the collar is snug around your neck

3.4 System Organization & Navigation

Table 2: Components of the Collar

Figure 4: Collar (Fully Assembled)

Figure 5: Cloth Sleeve

Figure 6: Collar

3.5 Exiting the System

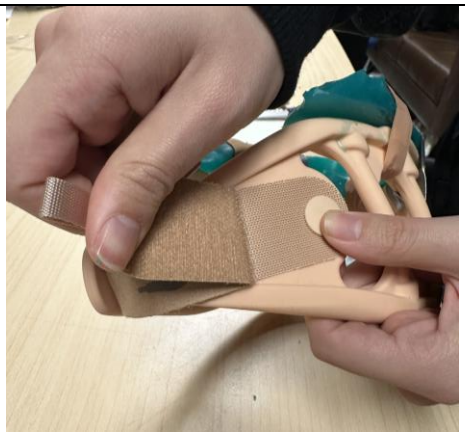
To put away the system:

1. Take off the collar from your neck
2. Roll/fold into its natural curve
3. Place in the carrying pouch for safe keeping

4 Using the System

4.1 Putting the collar on the neck

Table 3: How to use the Collar

Step 1 Note - When you receive the collar, it should be in the strapped position. Action - Pick up the collar in a similar fashion.	 **Figure 7: How to Use (Step 1)**
Step 2 Action - Peel off Velcro strap while placing one finger on the bottom piece.	 **Figure 8: How to Use (Step 2)**
Step 3 Action - Lay the collar out on a flat surface.	 **Figure 9: How to Use (Step 3)**

Step 4 Action - Proceed to slip the collar into the cloth sleeve, ensuring that the white side is facing outwards of the collar.	 **Figure 10: How to Use (Step 4)**
Step 5 Action – Thread the sleeve through the whole collar and ends should stick out.	 **Figure 11: How to Use (Step 5)**
Step 6 Action - Wrap the collar around your neck. (The water bottle is a placeholder for the neck) Note - Ensure that the collar is tightly wound around your neck so that your chin is resting on the top of the collar.	 **Figure 12: How to Use (Step 6)**

Step 7 Action - Secure Velcro pads to each other and wear.	 **Figure 13: How to Use (Step 7)**

4.2 Washing the cloth sleeve

1. Carefully slide out the sleeve from the silicone structure inside.
2. Place in laundry machine and wash with normal cycle.

4.3 Washing the silicone collar (without sleeve)

1. Ensure that the cloth sleeve is removed
2. Take whole collar and carefully rinse under warm water
3. Small amounts of dilute dish soap may be used if desired.

5 Troubleshooting & Support

5.1 Error Behaviors

Silicone pad coming off the lower silicone structure

- If any kind of epoxy or silicone is found on hand, use those bonding materials to adhere both surfaces to each other. If those materials are not found, use any kind of glue. Furthermore, for a quick fix, you may use any kind of sports tape or bandages to wrap the silicone pad.

5.2 Special Considerations

The soft cervical collar is engineered for durability; however, specific precautions can extend its lifespan:

- Avoid leaving the collar in extreme temperatures (ranging from -60°C to 200°C) to prevent material degradation (loss in elasticity, ductility, etc.).

- Avoid exposing the collar to harsh chemicals, including bleach or strong acids that can compromise the integrity of the collar.
- Store the collar in a dry place when not in use.
- Avoid contact with sharp or abrasive surfaces that could puncture or tear the silicone structure or cloth sleeve.

5.3 Maintenance

Regular maintenance includes washing the cloth sleeve after the user has sweat or has gotten it wet. As well, the collar can be rinsed in warm water if desired. After swimming, it is best to rinse in fresh water to remove any remaining residue of chlorine.

5.4 Support

To get support you can contact the creators via the following emails:

Table 4: Contacts

Cyrus Choi	cchoi064@uottawa.ca
Nicole Ao	lao077@uottawa.ca
Noah Aynalem	nayna096@uottawa.ca
Evan Sterjovski	ester034@uottawa.ca
Matthew Buentiempo	mbuen042@uottawa.ca

6 Product Documentation

6.1 Waterproof Soft Cervical Collar

6.1.1 BOM (Bill of Materials)

Table 5: Bill of Materials

Quantity	Item	Price	Item Description	
1	Silicone Mold Making Kit	$17.85	To cast supportive layer	link
1	Cervical neck collar skeleton	$36.41	To modify and improve based on client suggestions	link
1	PETG Sheet	$10.00	To use with vacuum forming machine	link
1	Foam sheet	$0.05	To insert inside the skeleton (if needed)	N/A
Total		**$64.26**		

6.1.2 Equipment list

- 3D laser scanner
- 3D printer
- PLA filament
- PETG sheet
- Vacuum former
- Silicone mold making kit
- Cervical neck collar
- Cloth
- Sewing machine
- SolidWorks

6.1.3 Instructions

1. Acquire cervical neck collar
2. 3D scan the neck collar
3. Create pad to fit over top the collar in SolidWorks
4. Export .stl file of the pad and print
5. Vacuum form over the PLA print
6. Cast silicone into the PETG mold
7. Adhere the silicone pad to the top of the cervical neck collar

8. Use a sewing machine and create a sleeve to go over top of the collar

6.2 Testing & Validation

The soft cervical collar has undergone a range of focused testing to ensure it meets its ideal specifications. Each test was designed to simulate real-world conditions to evaluate the structural integrity, functionality, and safety of the product. The following are tests conducted, and results found in the design process.

- Compression Testing (Stress, Strain, Displacement)
    - Assess the collar's load distribution and it's ability to maintain original shape under pressure.
    - A controlled force of 45 Newtons was exerted on the top of the collar to simulate the weight of a resting human head.
    - The silicone base maintained structural integrity without significant deformation, confirming that the collar can provide reliable support without compromising its shape.

Table 6: Stress Testing

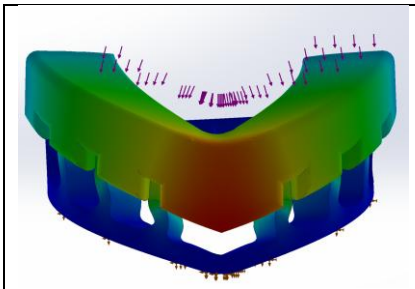


Figure 14: Stress Test (Front View)

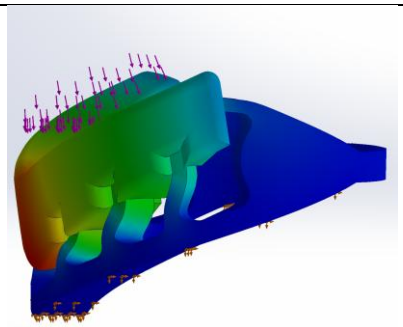


Figure 15: Stress Test (Side View)

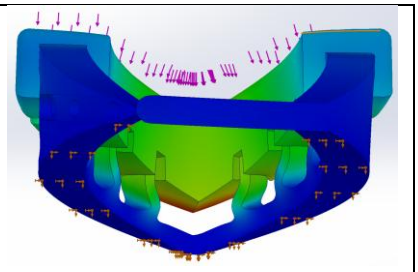


Figure 16: Stress Test (Back View)

- Water Resistance Testing
    - Confirm that the collar maintains its cohesion and functionality after prolonged exposure to chlorinated water.
    - The collar was submerged in water for 4 hours and promptly inspected for any material damage.
    - The silicone core retained its integrity and toughness after being soaked in the water.
- Silicone Strength Testing
    - Validate the strength between the fused silicone base and padding.

- Stress tests via manual pulling were conducted to determine the strength of the adhesive silicone.
- All bonding points did not break apart under brute force, ensuring that the collar is reliable for long-term use.

7 Conclusions and Recommendations for Future Work

The soft cervical collar successfully addresses the need for neck support during physical activity above and below water. It has additionally demonstrated its effectiveness through various testing (stress, submersion, etc.) and user feedback. However, there is always room for improvement and innovation, and the following are recommendations for future work.

- Work more precisely designing the silicone pad to optimize comfort and support.
- Revaluate and improve the manufacturing process of the mold to ensure continuity between the design and the final product.
- Explore various casting techniques for mold creation to discover any innovative approaches.
- Develop additional sleeves for the collar to suit different occasions or aesthetic preferences.
- Create a more secure seal between the silicone padding and the base of the collar for enhanced durability and stability.
- Explore ways to coat the silicone padding to reduce sticking for easier installation and removal of the sleeve.

8 Bibliography

What is PETG? (everything you need to know). TWI. (n.d.). https://www.twi-global.com/technical-knowledge/faqs/what-is-petg

Team, B. (2024, June 25). What is PLA plastic?. What Is PLA Plastic | BioPak Australia. https://www.biopak.com/au/resources/what-is-pla#:~:text=Polylactic%20acid%20or%20polylactide%20(PLA,sugarcane%20or%20sugar%20beet%20pulp.

APPENDICES

9 APPENDIX I: Design Files

Table 7. Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
MakerRepo	https://makerepo.com/sterj/2183.aquabrace-gng2101-group-b22-soft-cervical-collar	Nov 5, 2024
YouTube Demo	https://youtu.be/BcAF1pqM0MM	Dec 3, 2024

10 APPENDIX II: Other Appendices

You can include other critical and important work here. Maybe they are not important in the structure of this document but need to be included.