3D Printed Cervical Collar

Cervical Collar Design by Theodore Brandon, Anna-Kate Schiebel, Tony Yost, and by Kennedy Harris
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Problem Statement

This research is focused on the development of flexible head support for individuals who experience pain and fatigue in their neck. These symptoms might be caused by an injury, a disease, or aging. Previous research suggests that there is a need for inexpensive, flexible head support that can be worn for hours at a time as the wearer performs daily tasks such as driving, low-force work activities, and using a computer. Standard cervical collars such as those used to support the head and immobilize the neck after surgery are too stiff to be used while performing daily tasks. Other collar designs such as foam collars allow some head motion but are bulky and uncomfortable to wear.

Design Parameters

The following design parameters were determined by interviewing individuals living with neck mobility issues.

- Must support the weight of the head.
- Must be breathable.
- Must be easy to clean.
- Must avoid common pain areas.
- Can be worn while doing daily tasks like driving.

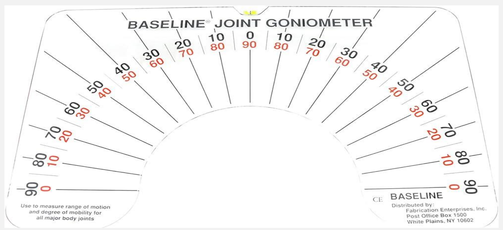
Design Objectives

1. Create an open-source 3D model that allows anyone with a 3D printer to print a support collar.
2. Design a collar that can be removed with reasonable effort.
3. Post-processing should be minimized.
4. Easy to source fasteners.
5. Adjustable rigidity to fit the needs of the wearer.
6. Use a 3D printable material that is functional, durable, and easy to clean.

Experimental Methods and Materials

Materials/Design Process:

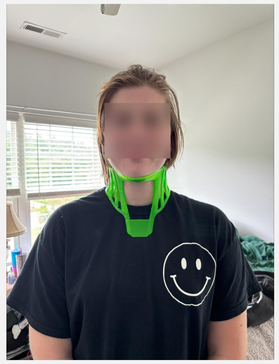
The design was created as a parametric, 3D solid model constructed from freeform surfaces. The initial design work was performed by fitting surfaces to a human-analog model. The support is fabricated on a 3D printer using thermoplastic polyurethane (TPU).



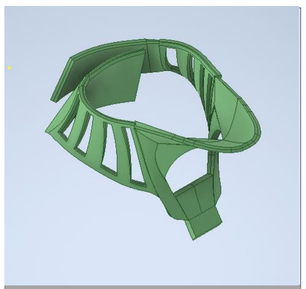
Experimental Methods:

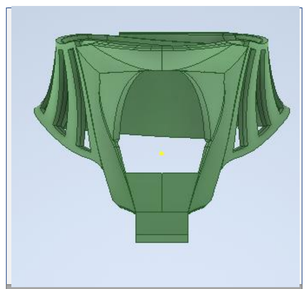
To evaluate the design, a set of six collars (three different collar sizes, each produced in a more flexible and a stiffer version) was fabricated. Volunteers were asked to select a collar size, and then try on both flexibility levels of that size.

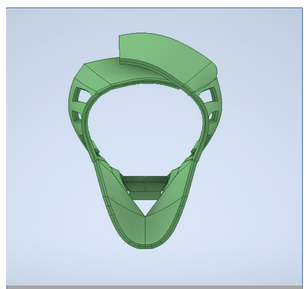
The volunteers' range of head motion with and without the collars was measured with a goniometer, and each volunteer was asked a series of questions regarding the comfort and usability of the collar. A Likert scale was used to quantify the volunteers' responses. At the end of the session, the volunteers were asked for their input regarding improvements that could be made to the design.

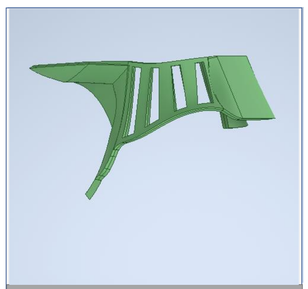


Current Design


Corner View


Front View


Top View


Side View

The first design was made in Fusion 360. The model shown has an overall thickness of about 3mm. The complex geometry was made using a combination of surface modeling and solid modeling. The front has a large cutout to allow the wearer to breathe normally. The sides feature slotted sections that allow airflow to the wearer. The flaps in the back will feature hook and loop fasteners as the method of connectivity.

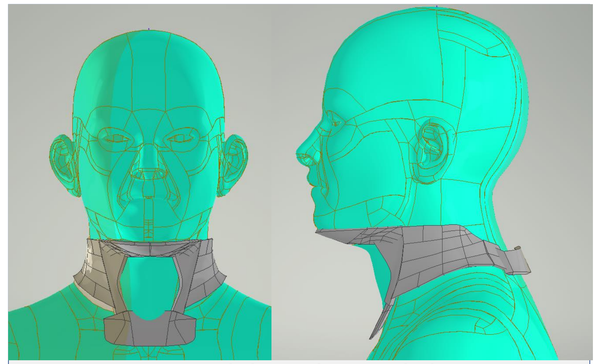
Results

Key Points From Our Feedback:	
Suggestions to Adjust the Supports	Issuses with the Supports
Have a way to personally adjust the back section	Back side is too rough and it hurts to move
Round the tops and bottoms to get a smoother feel	Was uncomfortable on top of the spine
Increase strap sidze around the neck	Chin piece is rough
Back region is too rough, need lots of moleskin or foam	Part that rest on the collar bones were uncomfortable
The chest piece needs more padding or a re-design	Chest plate caused some pain when rest on top of the chest
Offer padding for the person to put wherever they want.	Sides were slightly sharp and rough
	Brace was too small
Offer skin tone neck braces	Brace is too bulky
Sides closest to the jaw need to be sanded down	
Decrease bulkiness	
Velcro needs to be changed or fixed for people with different hair textures. This way it prevents hair getting caught in the support	
More flexability	
Back region needs to be chnaged	**Back region needs to be changed**

	No support	More flexible support	Stiffer support	p-value between no support and more flexible support	p-value between more flexible support and stiffer support
Range of Right Rotation (degrees)	30 - 70	10 - 45	2-40	NA	NA
Mean of Right Rotation (degrees)	45	22	19	0.00	0.39
Range of Left Rotation (degrees)	30 - 70	5-50	2-40	NA	NA
Mean of Left Rotation (degrees)	49	22	17	0.00	0.23
Range of Forward Rotation (degrees)	10 - 43	5 - 20	1-30	NA	NA
Mean of Forward Rotation (degrees)	23	11	10	0.00	0.63
Range of Backward Rotation (degrees)	5 - 30	5 - 25	5-30	NA	NA
Mean of Backward Rotation (degrees)	21	12	10	0.00	0.3

Survey Question - All questions used a Likert scale with 1 = poorest possible performance and 5 = best possible performance	More Flexible Support Mean Response	Stiffer Support Mean Response	p-value between more flexible and stiffer
Do you think that you could comfortably drive while wearing this support?"	3.8	3.3	0.14
Do you think that the support would help to prevent fatigue of your neck muscles if you wore it during a long drive?	4.1	4.2	0.82
Do you think that you could perform daily tasks such as cooking, cleaning or house repair while wearing this support?	3.9	3.7	0.57
How well does the device support the weight of your head when you relax your neck muscles?	4.1	4.5	0.12
Do you think that you could comfortably work at a computer while wearing the device?	4.6	4.3	0.24
Do you think that the support would help to prevent fatigue of your neck muscles if you wore it while working on a computer for a long period of time?"	4.5	4.3	0.59

Future Plans



We are remodeling the neck brace in Inventor to add additional features and make the model easier to edit. Once the model has been refined, we will begin testing the new version.