Novel Negative Pressure Wound Therapy Device for Microtia Surgery Recovery in Children

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Dhruv Nadkarni (BWIG)
Serena Evers (BSAC)
Harshad Gunasekar (BPAG)
Muhaison Ibrahim

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Problem Statement

Newly reconstructed auricles after microtia surgery are fragile, prone to destructive fluid build up, and difficult to dress securely. Clinicians need a conformal negative-pressure wound therapy device that holds a foam dressing over the ear, maintains consistent negative pressure over complex 3D geometry, and safely collects drainage from existing drains to reduce complications and support consistent healing.

Brief Status Update

The team held their third client meeting with Ms. Botros and Dr. Cho on Thursday afternoon at UW hospital. The team had a lot of questions regarding the logistics of the post-rhytidectomy device, to which Dr. Cho suggested a pivot in the project focus. The team's discussion with Dr. Cho led to a microtia surgery recovery focused device in which many of the complications from previous project focus were eliminated. Following the meeting, the team met to discuss new designs and analyze options via a design matrix. Next steps for the team are to conduct research on microtia and begin to brainstorm fabrication techniques of the decided preliminary design.

Summary of Weekly Team Member Design Accomplishments

- Team:
    - Continued research
    - Completed Design Matrix
    - Attended client meeting at the hospital
    - Shifted project focus to a microtia-surgery recovery focus
- Bryan Heaton
    - Worked on safety and cost sections of the design matrix
    - Assisted in brainstorming design ideas for design matrix
    - Led client meeting
- Meghan Kaminski
    - Worked on durability definition of the design matrix
    - Brainstormed design ideas for the design matrix
    - Researched restrictions in NPWT devices
    - Researched hematoma formation in rhytidectomies
    - Set up team meeting with both clients at the hospital
- Serena Evers
    - Worked on design matrix
    - Met with our client
    - Continued research of Negative pressure wound therapy
- Harshad Gunasekar
    - Worked on Ease of use definition of the design matrix
    - Brainstormed possible ideas for design matrix
    - Researched more about NPWT and is multitude of applications
    - Attended team meeting, advisor meeting, and client meeting
    - Researched about the Incision-Vacs already on the market
- Dhruv Nadkarni
    - Worked on justification of designs in the design matrix and easy of application.
    - Brainstormed design idea for the design matrix
    - Attended team meeting and advisor meeting
    - Continued research on WoundVac designs and procedures.
    - Began research on microplasia and current solutions.

Weekly/Ongoing Difficulties

The team was having a difficult time brainstorming ideas to make the post-rhytidectomy device functional with the presence of hair in desired adhesive locations. The project direction and objective seemed vague, hence the shift to the microtia-based application.

Upcoming Team and Individual Goals

- Team:
    - Work on materials for preliminary presentations

    - Finalize design choice
    - Begin research on microtia in children
    - Attend advisor meeting
- Bryan Heaton
    - Research microtia to better understand auricle deformation possibilities
    - Update the PDS to better match new project objectives
    - Draft stock NDA for meeting with industry rep on surgical vacuums
    - Work on preliminary presentation
    - Research y-connectors for drain tube and NPWT vacuum tube
- Meghan Kaminski
    - Work on section for preliminary presentation
    - Schedule continuous client meetings
    - Reach out to rep. from Dr. Cho
    - Create a SolidWorks version of the design
- Serena Evers
    - Research Microtia
    - Prepare for preliminary presentations
    - Give our medical student some work to help with our project
    - Begin researching fabrication techniques and possible testing methods
- Harshad Gunasekar
    - Work on preliminary presentation
    - Changed focus of project
        - Research Microtia and the applications of NWPT specifically
    - Finalize winning design and make revisions if needed
- Dhruv Nadkarni
    - Work on preliminary presentation
    - Work on preliminary deliverables
    - Research microtia to better understand the defect
    - Research adjustable straps for headphone design.

Project Timeline

Project Goal	Deadline	Team Assigned	Progress	Completed
Product Design Specification (PDS)	September 19, 2025	All	100%	X*
Design Matrix	September 26, 2025	All	100%	X
Preliminary Presentations	October 3, 2025	All	0%	
Preliminary Deliverables	October 8, 2025	All	0%	
Show and Tell	October 31, 2025	All	0%	
Poster Presentations	December 5, 2025	All	0%	
Final Deliverables	December 10, 2025	All	0%	

*PDS will require heavy revision following project focus shift

Expenses

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link
Component 1								
Component 2								
Component 3								
TOTAL:								**$0.00**

Design Matrix

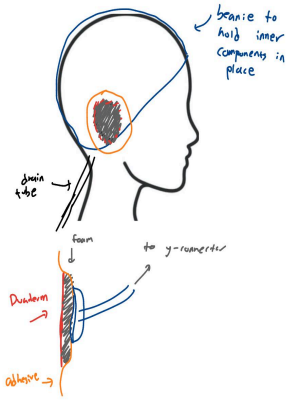
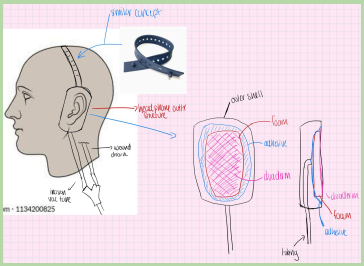
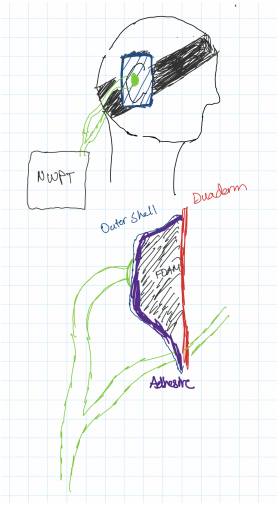
	Design 1: Hat	Design 2: Headphone	Design 3: Headband+Headphone
			
Safety (30)	18	27	20
Comfort (25)	25	25	15
Ease of Use (15)	15	15	15
Ease of Application (15)	9	12	9
Durability (10)	6	4	9
Cost (5)	5	4	5
Total (100)	80	87	73

Table 1. Design Matrix including the Hat design, the Headphone design, and the Headband+Headphone design

Criteria Description

Safety (30):

Device safety refers to the ability of the device to be applied without causing physical harm to either the patient or the operator. The system must localize negative pressure only to the intended treatment sites, ensure that the applied pressure remains within non-harmful limits, and comply with operating room standards to avoid introducing external risks to the procedure. Safety was ranked the highest of all criteria because of the product's intended patients, children. As children are still developing, high pressure systems may become fatal should the pressure become too powerful.

Comfort (25):

Comfort refers to how tolerable and unobtrusive the device is for a microtia patient during a 5-day recovery while wearing a foam-bolster vacuum dressing over the ear with a subcutaneous drain in place. The system should minimize pressure points, itching, and heat buildup, allowing normal activities like sleeping, gentle jaw motion, and wearing glasses or masks without disturbing the seal or ear contour. Comfort was ranked the second highest of all criteria due to the device's intended patient, children. The device must be comfortable for younger children in order for them to use the device to treat microtia.

Ease of Use (15):

Ease of use refers to the usability of the design for the patient who will wear it on their own for up to 5 days. It should be intuitive to turn on and off and should not require too much effort from the patient. Designs must be easy to operate for the patient. Ease of use was tied for the third highest of all criteria because the device must be easy for patients to use.

Ease of Application (15):

Ease of application refers to the initial feasibility of applying the device on the patient. Designs must be easily placeable for surgeons on the treatment site and without the need of extensive and complex instructions. Additionally, devices must be easily removable for surgeons should an error occur during initial placement. Ease of application was tied for the third highest of all criteria as the device must be easily usable for surgeons.

Durability (10):

The durability of the design refers to its ability to maintain functional integrity without material degradation or mechanical failure. Designs must withstand adjustments without breakage to materials. Adhesive attachments must remain sealed to ensure NPWT can be utilized. Designs must be able to withstand normal patient function during a five day period. Durability was ranked the second lowest because aspects of all devices are replaceable, hence weakening the rating.

Cost (5):

Cost of the device weighed the lowest of our constraints due to the availability and cheap cost of the materials used in all 3 designs. The NPWT component will be given to the team from the clients, reducing the cost significantly.

Score Justification

Safety: The headphone design was rated the safest option of the three. The team rated it 27/30 because of its ability to localize the protective covering over the ear, maximizing protection from external conditions. The hat and headband designs were both rated 20/30 due to the lack of localization of protective covering.

Comfort: The headphone and hat designs were rated the most comfortable of the designs, receiving a score of 25/25. Both headphones and caps are used on a daily basis for long periods of time, hence receiving a perfect score. The headband received a score of 15/25 due to the strap across the forehead. This unusual covering may cause discomfort for the patient, hence receiving the lowest score.

Ease of Use: All three designs were given a perfect score as all three designs are already used on a daily basis. Additionally, all replaceable components can be accessed by patients without using complex tools.

Ease of Application: The headphone design was rated the highest at a 12/15 due its adjustable nature upon application. The bridge of the headphone can be easily lengthened or shortened, providing tight fit around the patient's head to optimize fit. The hat and headband designs were both rated 9/15 due to the extra steps required to provide a tight fit. The hat must first be seated on the head of the patient properly prior to placing the device around the treatment site. Similarly, the headband must be tightly strapped around the patient's forehead prior to accessing the treatment site. The wider coverage of the hat and headband may also cause movement of the dressing away from its optimal position, making initial placement more difficult.

Durability: The headband design was rated the highest for durability, reviving a score of 9/10. Once the headband is situated in place, the device will not move and is less subject to displacement via external forces. Additionally, traditional headband materials are soft and not brittle, and therefore not subject to breakage via sudden applied force. The hat design was rated the second highest with a score of 6/10. The cap design also uses minimal brittle and hard components, allowing for a high mechanical strength. The headphone design was rated the lowest with a score of 4/10 due to the components' tendency to snap, tear, or shatter under sudden applied force.

Cost: The cap and headband designs received a perfect score due to the cheap materials required to create the device. The headphone design received a score of 4/5 because of additional materials required to protect the treatment site, such as the outer casing, which may cost more than traditional elastic materials.

Final Design

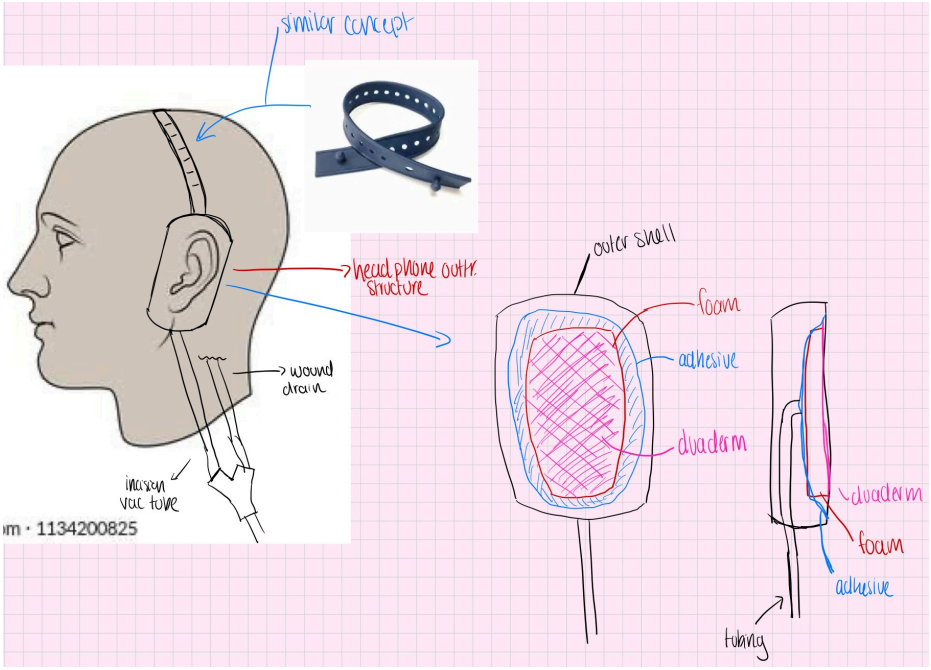


Figure 1. Headphone design concept with views from the side and bottom of the design

Based on analysis via the design matrix, the team's design moving forward was determined to be the headphone design. The design ranked highest of all three designs in the top four ranked criteria. The headphone design's mimicry of a commonly used accessory ensures comfort and familiarity for the patient.

Additionally, the device is more easily adjustable and removable for patients and surgeons than the other 2 designs, allowing for last minute adjustments more readily. Despite scoring the least of the three designs on durability, the team realizes that the device is not intended to be used in rough environments, hence mitigating the risk of destroying the device during use. Finally, with regards to cost, the client has given the team a budget of $1000, giving the team a comfortable sum to develop and iterate the headphone's hard cover; the client has also provided the team access to the components of a negative pressure wound therapy dressings and application, reducing costs for the team.