Pressure Sensor for Mayfield Head Clamp

Saagar Arya, Anna Brusoe, Lindsay Chetkof, Amanda Li
Duke University, Duke Neurosurgery

Duke Neurosurgery
Duke University School of Medicine

DUKE ENGINEERING PODD DESIGN

Background

- The **Mayfield Head Clamp** (Figure 1) is a medical device that utilizes **3 pins** (Figure 2) to **hold the head rigid** during neurosurgery.
- A **pressure pin** is currently used to **communicate the pressure** exerted on the skull by the prongs.

Figure 1: Mayfield Head Clamp

Figure 2: Mayfield Head Clamp pin

Problem

The **current method** of communicating pressure is **inaccurate, inefficient, and difficult to read.** This can lead to **complications** during surgery, including skull fractures, impaling of the brain, lacerations from the head slipping and superficial abrasions.

Objectives

To **increase patient safety** during neurosurgery, the device should be designed to quickly **report the PSI exerted on the skull by the Mayfield Head Clamp** to neurosurgeons.

The device must be:

- **Sterilizable** and compatible with hospital cleaning standards to protect patient safety
- **Integrable** with the current clamp and not obstruct standard practices
- Capable of **withstanding** the safe **pressure threshold** applied during neurosurgery

Results

Figure 3: Final prototype

Final Prototype
(Figure 3) **Includes:**

- **Aluminum** pins with **elongated divot** to accommodate a strain gauge (Figure 4)
- Epoxy-attached **strain gauge** to measure deformation
- **Calibration curve** to convert from deformation to PSI readings (Figure 5)
- **Screen & LED** to display pressure (in PSI) (Figure 6)

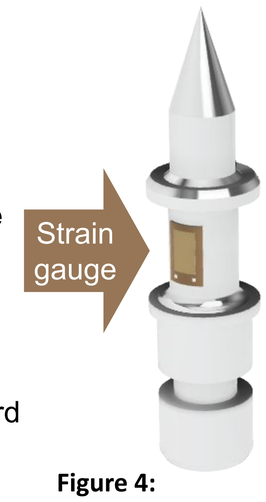


Figure 4: Aluminum pins with elongated divot

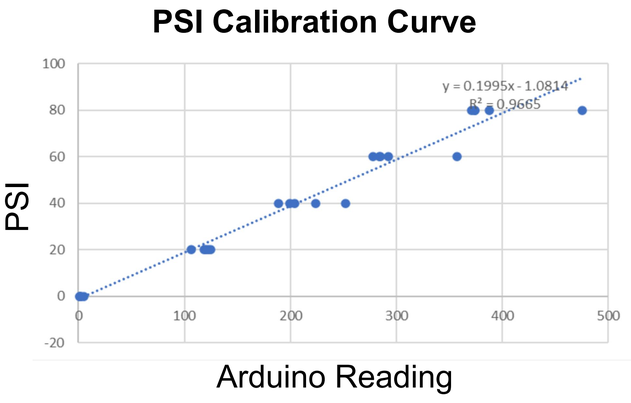


Figure 5: Calibration Curve

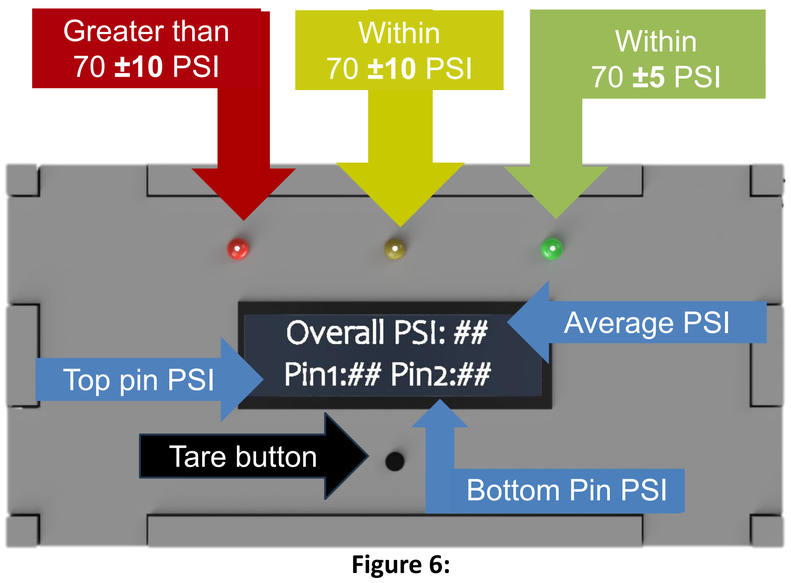


Figure 6: Screen/LED integration

Design Criteria and Testing

Design Criteria	Target Value	Test	Results	
Accuracy	Pressure readings **within ±5 PSI**, **95%** of the time	Comparing reported PSI to PSI indicated by torque screw on clamp	Passed **5/5** calibration curve tests	✓
Intuitive to Use	Pressure readings take **<1 minute**	User given pre-tightened clamp and asked to return PSI	Readings took **~10 seconds**	✓
Pressure Threshold	Strain gauge can **withstand up to 120 PSI**, 80 PSI minimum	Recording voltage readings at 60, 80, 100 and 120 PSI	Dynamic range of strain gauge is **150 PSI**	✓
Durability	**5 year** lifespan	Research and lifespan calculation	Pins are **replaceable** and electronics last **10+ years**	✓
Sterilizability	**Withstand 15 sterilization cycles** at 134°C	N/A due to available resources	TBD	

Conclusion

Our team modified the Mayfield Head Clamp pins to allow for the ability to **efficiently** and **accurately inform** neurosurgeons of the **pressure** exerted **on the skull** by the clamp during surgery.

Future enhancements/plans may include:

- Increasing prototype fidelity by moving from aluminum to stainless steel
- Further calibration and accuracy testing
- Sterilizability testing

Acknowledgements

Our team would like to thank the following for their continued support throughout this project.

Dr. Sonia Bansal, Professor
Dr. Micheal Rizk, Professor
Dr. Eli Johnson, Client
Kevin Shores, Technical Mentor
Alyssa Ramirez, Teaching Assistant
Erin O'Rourke, Writing Consultant

Pressure Sensor for Mayfield Head Clamp

Saagar Arya, Anna Brusoe, Lindsay Chetkof, Amanda Li
Duke University, Duke Neurosurgery

Duke Neurosurgery
Duke University School of Medicine

DUKE ENGINEERING PODD DESIGN

Background

- The **Mayfield Head Clamp** (MHC) (Figure 1) is a medical device that utilizes **3 pins** (Figure 2) to **hold the head rigid** during neurosurgery.
- An **inefficient pressure pin** is currently used to **communicate the pressure** exerted on the skull by the prongs.

Figure 1:
Mayfield Head Clamp

Figure 2:
Mayfield Head Clamp pin

Problem

The **current method** of communicating pressure is **inaccurate, inefficient, and difficult to read.** This can lead to **complications** during surgery, including skull fractures, impaling of the brain, lacerations from the head slipping and superficial abrasions.

Objective

To **increase patient safety** during neurosurgery, the device should be designed to quickly **report the PSI exerted on the skull by the Mayfield Head Clamp** to neurosurgeons.

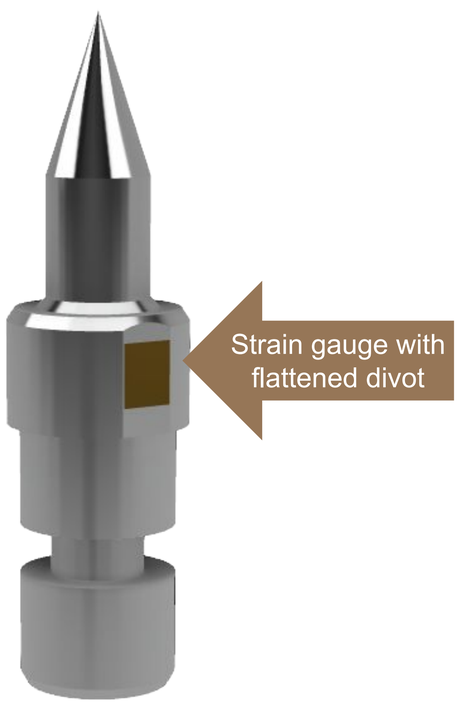
Design Criteria and Testing Plan

Design Criteria	Target Value	Test
Accuracy / Sensitivity	Pressure readings **within ±5 PSI**, **95%** of the time	Comparing reported PSI to PSI indicated by torque screw on clamp. Additional verification using material properties.
Integratable	Pins can fit into a **variety of devices**	Testing usability across multiple brands of the Mayfield Head Clamp.
Intuitive to Use	**Digital** pressure readings take **<1 minute**	User given pre-tightened clamp and asked to return PSI
Pressure Threshold	Strain gauge can **withstand up to 120 PSI**, 80 PSI minimum	Recording voltage readings at 60, 80, 100 and 120 PSI
Sterilizability	**Single use** pins	N/A

Results

Figure 3:
Modified MHC pin iteration 1

Figure 4:
Modified MHC pin iteration 2



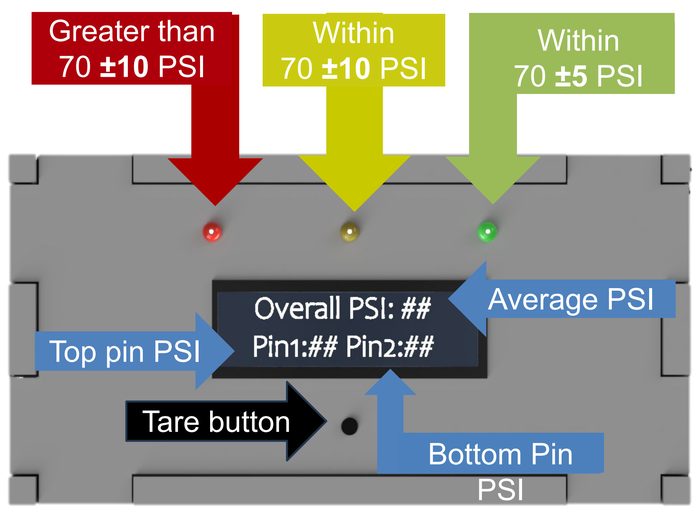


Figure 5:
Screen/LED display integration

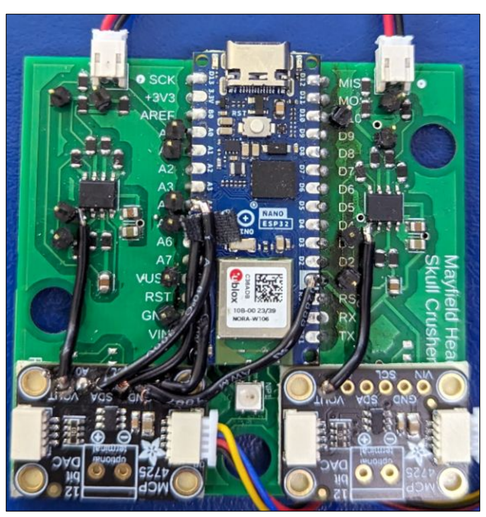


Figure 6:
60mm x 60mm PCB to digital display integration

Feature Comparison

Feature	Iteration 1	Iteration 2
Aluminum pin	✓	✓
Elongated divot	✓	✓
Flattened divot		✓
Epoxy-attached **Strain Gauge**	✓	✓
Flush fit		✓
Screen and **LED** display	✓	
60x60 mm PCB to **digital** display		✓

Pin Modification:

- **Flattened** divot **increases durability** of the pin to strain gauge connection
- **Flush** fit allows for **increased accuracy** of the strain gauge
- More precise measurements allow for a **smoother fit** into the clamp

Display Modification:

- **Personalized PCB** allows for easier modification to accommodate different strain gauges
- **PCB** can **connect** to **various devices**
- **Decreased size** reduces visual disorder and makes display **more intuitive**

Conclusion

Our team modified the Mayfield Head Clamp pins to allow for the ability to **efficiently** and **accurately inform** neurosurgeons of the **pressure** exerted **on the skull** by the clamp during surgery.

Future enhancements/plans may include:

- Increasing prototype fidelity by moving from aluminum to stainless steel
- Further calibration and accuracy testing
- Sterilizability testing

Acknowledgements

Our team would like to thank the following for their continued support throughout this project.

Dr. Ibrahim Mohedas , Professor
Dr. Ann Saterbak, Professor
Dr. Eli Johnson, Client