LSU College of Engineering Department of Mechanical & Industrial Engineering
College of Engineering School of Electrical Engineering & Computer Science
To Predict ▶ To Design ▶ To Perform
ME, ECE Capstone Design Programs

# Team#5: Improving Outcomes in Cervical Spine Trauma – Building a Better Cervical Collar

LSU Health NEW ORLEANS

Ayesha Badat, Don Ho, Cade Lonibos, Alack Patel, Annie Rickman, Joshua Showers, Kyle Wilson

## Objective Statement

Design an adjustable cervical collar for adults that immobilizes the cervical spine, while also monitoring compliance.

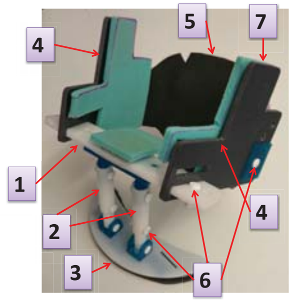
## Background

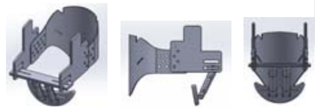
Cervical Collar Purpose:
- Immobilize the neck
- Properly heal and fuse the cervical spine for postoperative patients

## Engineering Specifications

| | |
|---|---|
| Tracheostomy Opening | • 13.8mm diameter opening in front of the neck |
| Monitor Compliance | • Battery life of 6 weeks without recharging or replacing between doctor visits<br>• Record and store the time the collar is worn with 98% accuracy |
| Immobility | • Flexion/Extension: 20% decrease in ROM compared to Aspen<br>• Lateral Flexion/Rotation: 25% decrease in ROM compared to Aspen |
| Adjustability | • Fits the 5th percentile of female head & necks to the 95th percentile of male head & necks in the US |
| Comfort, Fit, Aesthetics | • 15% greater than the average rating for Miami-J and Aspen Vista (competitor's collars) |
| Weight | • Less than 3 lbs. |

## Cervical Collar Design

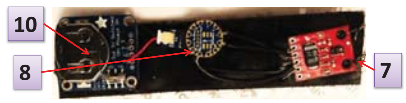


| | |
|---|---|
| 1 | Chin Attachment |
| 2 | Adjustable Columns |
| 3 | Chest Plate |
| 4 | Side Piece |
| 5 | Back Piece |
| 6 | Pins |
| 7 | Monitoring Device (under padding) |

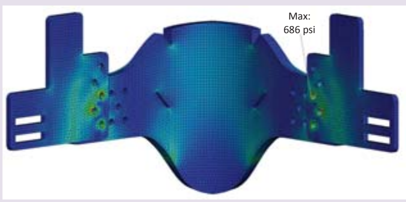
## Compliance Device

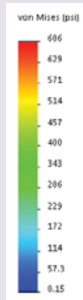
| | |
|---|---|
| 8 | **Microcontroller:**<br>• TinyLily Mini (ATmega328P)<br>• Operating Voltage: 2.7-5.5V<br>• 1KB EEPROM |
| 9 | **Sensor:**<br>• APDS-9960 Proximity Sensor<br>• Operating Voltage: 3.3V<br>• Operating Range: 4-8in |
| 10 | **Battery:**<br>• CR2032 Coin Cell Battery<br>• 3V |




## Analysis

**FEA: Back Piece and Side Piece:**




* Convergence was checked and verified

**Boundary Conditions:**

**Back Piece (pictured center-right):**
- Applied Force of 278N normal to the surface (red arrows)
- Hinged fixture applied to the back piece
- Safety Factor of 4

**Side Piece (pictured left):**
- Applied force of 75.5N normal to the surface (blue arrow)

**Columns (pictured bottom-right):**
- FMEA determined that the most catastrophic failure would be with the columns.
- Bending and Buckling calculations were performed.

## Testing

**Where:**
- LSU Kinesiology Motor Control Lab

**Method:**
- IRB approval (21 subjects tested)
- Subjects were randomly fitted with the prototype collar, Aspen, and Miami-J
- Kinematic data was collected to compare degrees of ROM for each collar

←With the subjects informed consent, the prototype collar is being properly fitted for testing. Three reflective markers can be seen which are depicted by the grey dots on the subjects head.

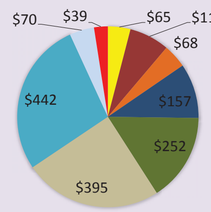
## Results

| Criteria | Data |
|---|---|
| Immobility | Preliminary data shows that the prototype limits motion better than the competition in about 80% of participants |
| Compliance | Not obstructive to users, recorded time accurately, and displayed data to monitor |
| Comfort | Aspen Vista: -16%, Miami-J: -8% |
| Fit | Aspen Vista: +33%, Miami-J: +29% |
| Aesthetics | Aspen Vista: -27%, Miami: -36% |
| Weight | 0.8 lbs. |
| Compression Test-Columns | Held target load of 50 lbs. |

## Budget

Available: $5,000

Utilized: $1,603




**September:** Project kickoff and IRB training → **October:** Kinesiology Department meeting and IRB application submission → **November:** Engineering analysis and design revision → **December:** Supplies ordered → **January:** Kinesiology Department training and collar manufacturing → **February:** Continued manufacturing and volunteers recruited → **March:** Prototype complete and initial testing → **April:** Prototype testing and analysis of results → **May:** Present final prototype and publish results for further development

Sponsor: Dr. Abhishek Kumar

Advisers: Dr. Hunter Gilbert & Linda Cross