# The Knotorious Five

October 10th - October 16th

Client: Dr. Margene Anderson, Dr. Sara Colopy. Dr. Paul Merkatoris
Advisor: Professor Wally Block

Team Members:
Madison Michels (mmichels2@wisc.edu), Leader
Lucy Hockerman (lhockerman@wisc.edu), Communicator
Presley Hansen (pmhansen3@wisc.edu), BWIG
Sadie Rowe (skrowe2@wisc.edu), BPAG
Kate Hiller (khiller@wisc.edu), BSAC

**Problem Statement:**

In veterinary training, mastering the skill of applying appropriate suture tension is essential for successful wound closure and patient recovery, However, novice practitioners often struggle to judge the correct amount of force needed, leading to either insufficient tension or excessive tension, which can cause plastic deformation of the suture material or tissue damage. Currently, the evaluation of suture technique relies heavily upon subjective instructor feedback, lacking objective, real-time metrics to guide learners. This gap hinders consistent skill development and increases the risk of procedural errors. There is a critical need for a real-time suture tension measurement and feedback system to help students learn to apply optimal tension, prevent material or tissue compromise, and improve surgical outcomes through data-driven training.

**Brief Status Update:**

This week, the team moved forward with prototyping of the force sensor circuit and AI model training. Lucy continued the MTS suture testing and began analyzing the plastic deformation and ultimate strengths of the different suture sizes. Maddie and Sadie both explored different model platforms to create a knot identification model. Lastly, Kate and Presley completed replicating a force sensor circuit and began researching resistor values to utilize.

**Team Goals:**

- In the upcoming week, the team plans to continue to develop our solutions and explore potential models and digitalization of the FSR circuit.

**Individual Accomplishments:**

- Lucy: I completed MTS tensile testing and analyzed the raw data using MATLAB. (SEE RESULTS BELOW PROJECT TIMELINE)
- Presley: This week I worked with Kate on calibrating the force sensor resistor circuit. I completed research and calculations to determine the most effective resistor value.
- Maddie: This week I completed the creation of the image analysis model. I trained it against the knot images from the rope dataset and let the model do a few classifications to see its accuracy. I used both ResNet and VGG models for comparison.
- Sadie: This week, I explored Roboflow as a potential tool for creating a machine learning model. Using the same images as Maddie, I built an annotated dataset and trained a model capable of recognizing a knot within an image and cropping to the specific frame of the knot. I've also begun training a model to classify these cropped images as tight or loose, but have encountered some challenges with the Roboflow platform. As a result, I've started exploring a Python-based approach to align more closely with Maddie's technique.
- Kate: This week I worked towards calibrating the force sensor resistor circuit so the output is a force value. I completed research on the force sensor, wrote code, and found the correct resistor value.

**Individual Struggles:**

- Lucy: I had difficulties identifying plastic deformation ranges in the stress/strain plots because most sutures fractured abruptly around tension grips rather than near the knot. Additional testing at a slower testing rate may be necessary to reduce sudden suture fractures.
- Presley: I am having difficulties with outputting the force from voltage values in the circuit.
- Maddie: One module of the code is working on creating a website to display the results, and I am having a hard time understanding how to complete this and deciding if it is necessary or not.
- Sadie: I am having difficulty using Roboflow to create a model capable of classifying images. The platform is well-suited for object detection but does not appear to provide the level of specificity needed for our image characterizations.
- Kate: I am having difficulty figuring out how the FSR will display the output to the user.

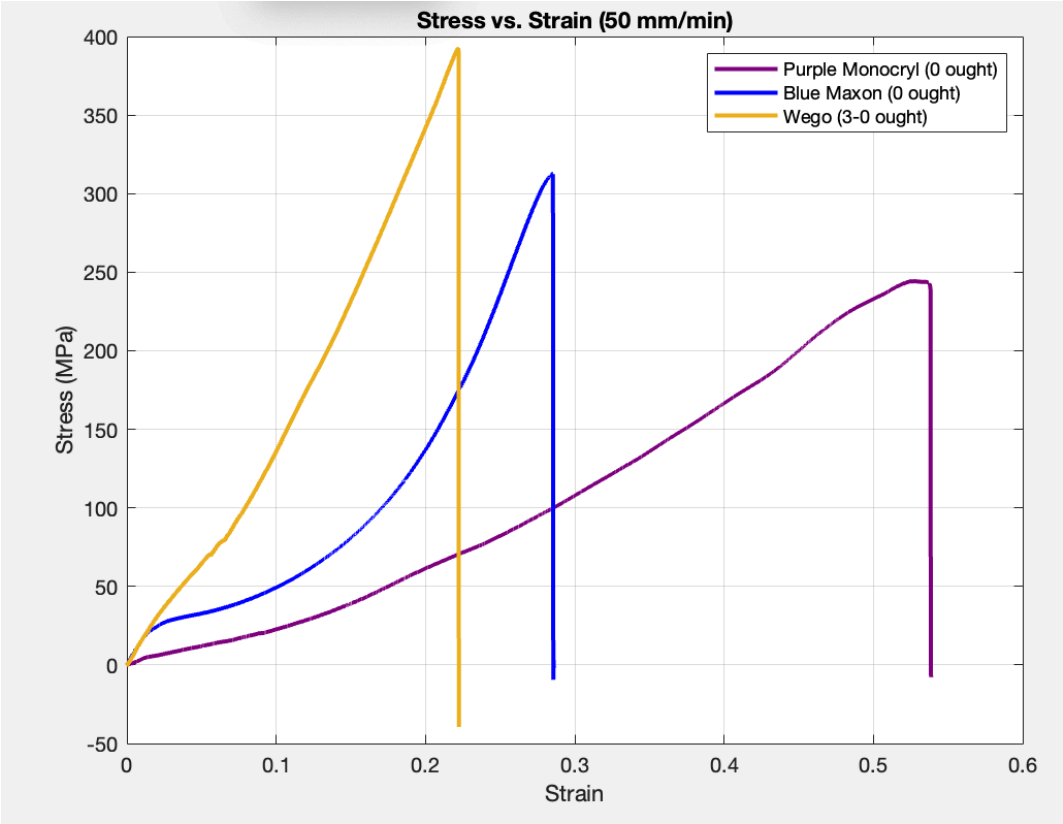
**Individual Goals:**

- Lucy: Next week, I would like to assist Maddie and Sadie with the AI knot characteristics prototype by either researching possible camera options or exploring a new AI prompting platform to create a new knot identification model.
- Presley: Next week, I would like to work with Kate to complete the force circuit display.

- Maddie: Next week I hope to start taking our own pictures to train the model against. I also want to figure out how to compare the training set to the validation and testing sets I have.
- Sadie: Next week, I plan to dive deeper into a Python-based approach and create a dataset to validate our models on.
- Kate:  Next week, I want to have a displayed output of the input force for the user.

**MTS Tensile Strength Results:**

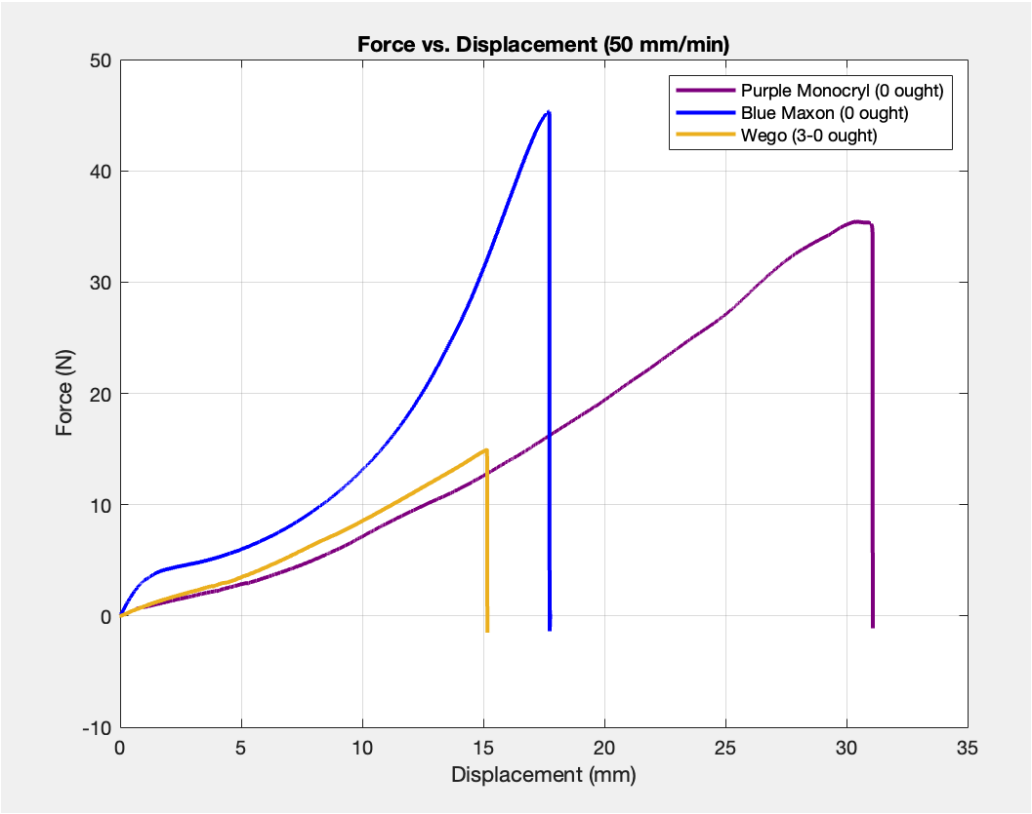
**Stress vs Strain plot**




| Suture Material | Youngs Modulus (Mpa) | Max Strain | Fracture Stress (Mpa) | Yield Stress (Mpa) |
|---|---|---|---|---|
| Purple Monocryl (0 ought) | 568.04 | 0.54 | 244.21 | 189.89 |
| Blue Maxon (0 ought) | 2184.17 | 0.29 | 310.07 | N/A* |
| Wego (3-0 ought) | 2019.32 | 0.22 | 390.41 | N/A* |

* No visible plastic deformation on Maxon and Wego suture material

**Force vs Displacement plot**




| Suture Material | Max Displacement (mm) | Max Force (N) |
|---|---|---|
| Purple Monocryl (0 ought) | 30.98 | 35.30 |
| Blue Maxon (0 ought) | 17.73 | 44.96 |
| Wego (3-0 ought) | 15.16 | 14.85 |

**Project Timeline:**

| Week | Description | Status |
|---|---|---|
| 9/5 - 9/11<br>Week 1 | Initial research | Complete |
| | Client Meeting 1 | Complete |
| | Team Meeting 1 | Complete 9/12 |
| | Advisor Meeting 1 | Advisor did not attend |
| 9/12 - 9/18<br>Week 2 | Product Design Specifications | Due 9/16 |
| | Team Meeting 2 | Complete 9/18 |
| 9/19 - 9/25<br>Week 3 | Design Matrix | Due 9/25 |
| | Team Meeting 3 | Complete 9/22<br>Complete 9/24 |
| | Advisor Meeting 2 | Complete 9/19 |
| | Meeting with Dr. Numinkar | Complete 9/24 |
| 9/26 - 10/2<br>Week 4 | Client Meeting 3 | Complete 9/26 |
| | Team Meeting 4 | Complete 9/29 and 10/1 |
| | Preliminary Presentation Review | Complete 10/1 |
| 10/3 - 10/9<br>Week 5 | Preliminary Presentation | Complete 10/3 at 12:35 PM |
| | **Preliminary Report** | **Due 10/8** |
| 10/10 - 10/16<br>Week 6 | Advisor Meeting 3 | Scheduled for 10/10 |
| | Team Meeting 5 | Scheduled for 10/10 |
| 10/17 - 10/23<br>Week 7 | Advisor Meeting 3 | Scheduled for 10/17 |
| | Team Meeting 5 | Scheduled for 10/17 |
| | Force Sensor Resistor Value Testing and Research | Goal by 10/17 |
| | Calibrate Sensor | Goal by 10/17 |
| | Determine Output Force Equation | Goal by 10/17 |

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|---|---|---|
| | MTS Testing | Goal by 10/17 |
| 10/24 - 10/30<br>Week 8 | Advisor Meeting 4 | Scheduled for 10/24 |
| | Team Meeting 6 | Scheduled for 10/24 |
| | Digitalize Circuit | Goal by 10/24 |
| | RoboFlow Model | Goal by 10/24 |
| | MTS Data Analysis | Goal by 10/24 |
| | Python Model | Goal by 10/24 |
| 10/31 - 11/7<br>Week 9 | **Show and Tell** | **Due 10/31** |
| | Team Meeting 7 | Scheduled for 10/29 |
| 11/8 - 11/14<br>Week 10 | Advisor Meeting 5 | Scheduled for 11/08 |
| | Team Meeting 8 | Scheduled for 11/08 |
| 11/15 - 11/21<br>Week 11 | Advisor Meeting 6 | Scheduled for 11/15 |
| | Team Meeting 9 | Scheduled for 11/15 |
| Thanksgiving Break<br>11/22 - 11/28 | | |
| 11/29 - 12/5<br>Week 13 | **Final Presentation** | **Due 12/05** |
| 12/6 - 12/12<br>Week 14 | **Final Report** | **Due 12/10** |
| | Advisor Meeting 7 | Scheduled for 12/6 |
| | Team Meeting 10 | Scheduled for 12/6 |
| 12/13 - 12/18<br>Week 15 | Advisor Meeting 8 | Scheduled for 12/13 |
| | Team Meeting 11 | Scheduled for 12/13 |
| Winter Break | | |

## Expenses

| Item | Description | Manufacturer | Mft | Vendor | Vend | Date | QTY | Cos | Total | Link |
|---|---|---|---|---|---|---|---|---|---|---|

| | | | **Pt#** | | **or Cat#** | | | **t Each** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Force Sensor Resistor | Force sensor that outputs resistance in a voltage divider circuit (2 in pack) | Haosie? | N/A | Amazon Prime | N/A | 10/1 | 1 | $7.59 | $7.59 | Link |