<u>The Knotorious Five</u>

September 19th - September 25th

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:

The team has met twice to research and evaluate the possible ways of measuring force and tension in the suture. We came up with three viable options and conducted research to examine example products and measurement techniques for each option. DESIGN MATRIX AND PRODUCT EXAMPLES ARE LISTED AT THE BOTTOM OF THE REPORT.

Team Goals:

- In the upcoming week, the team wants to connect with professionals in each discipline to determine the best path forward and open up doors to new options if possible. After that, we will begin preliminary prototyping and finalizing the preliminary presentation and reports. We also will be attending a suture practice lab Friday, September 26th to explore the suturing technique for later testing.

Individual Accomplishments:

- Lucy: I researched information about tensiometers including strain gauges and tension meters. I drew a sketch of a movable stand to incorporate a basic tensiometer at the end of the suture, shown in LabArchives. With the group, I participated in two team meetings, an advisor meeting, a TECH mentor introduction session, and a meeting with Dr. Numinkar to discuss electronic methods for measuring force.
- Presley: I researched information about possible sensor ideas for our design to discuss with the team during our Monday meeting. I attended two team meetings, an advisor meeting, and a TECH mentor introduction session. I worked with the team to create our design matrix of three viable design options.
- Maddie: I researched example products for each measurement approach the team considered. I also drew up a few design options for the different measurement capabilities, shown in LabArchives. I attended two team meetings, an advisor meeting, and a meeting with Dr. Numinkar about electronic methods of obtaining force. I also attended a meeting to introduce our team to the medical student that we will be working with.
- Sadie: I researched existing suture training devices, focusing specifically on camera-based designs. My review looked at the types of cameras previously used, the technologies behind them, and the platforms for conducting image analysis. I found promising information on a MATLAB-based program that could potentially be adapted for real-time feedback. Throughout the week, I met with the team to divide up methods of tension measurement for further investigation, then reconvened to share findings and evaluate each method against criteria in the design matrix. I also attended an advisor meeting and a session with Dr. Numinkar to gain insight into electronic methods of measuring force.
- Kate: This week, I was tasked with finding values of knot strength that we can use as a reference when designing our device. I researched suture materials that the client told the team they most often use and found their strength (including ultimate tensile strength) and elongation values. For one material, I was able to find a value for the force to tie the last throw and gathered information on how they were determined. Additionally, I helped with brainstorming for the design matrix. I also attended an advisor meeting, TECH meeting, a meeting with Dr. Numinkar, and set up meetings with my mentees as I am the BSAC.

Individual Struggles:

- Lucy: I am struggling on how to incorporate tensiometers in a way that does not interfere with the suture process and measures the full tension in the string.
- Presley: I am struggling with visualizing how the camera design idea can accurately identify and display force in real time at an affordable price.

- Maddie: I am struggling to identify camera/visual options to identify force via diameter change in the suture that are within a reasonable price range.
- Sadie: I am struggling to find a method of tension measurement that is feasible given our team's skill set and will not interfere with the natural suturing technique.
- Kate: I am struggling with finding the force in Newton it takes to tie the last throw in literature.

Individual Goals:

- Lucy: My goal next week is to reach out to experts on visual options to learn more about the feasibility to incorporate a camera in this project. Also, complete/present preliminary presentations.
- Presley: My goal for next week is to work on my portion of the preliminary presentation and play around with electronic sensors using information from the meeting with Dr. Numinkar.
- Maddie: My goal for the upcoming week is to do some small prototyping with electronic circuits that will track the pressure sensor resistor.
- Sadie: My goal for next week is to begin building rough prototypes to help determine which ideas are most suitable for further development. I will also prepare materials for the preliminary presentation.
- Kate: My goal is to learn how to suture and use this knowledge to come up with a way to measure the last throw of the suture, which can be used to measure our client's last throw.

Design Accomplishments:

The team is organizing a meeting with the client to discuss project requirements.

Weekly/Ongoing Difficulties:

No difficulties have been identified at this early stage of the project.

Project Timeline:

Week	Description	Status
9/5 - 9/11 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 Week 2	Product Design Specifications	Due 9/16
	Team Meeting 2	Complete 9/18

9/19 - 9/25 Week 3	Design Matrix	Due 9/25
	Team Meeting 3	Complete 9/22 Complete 9/24
	Advisor Meeting 2	Complete 9/19
	Meeting with Dr. Numinkar	Complete 9/24
9/26 - 10/2 Week 4	Client Meeting 3	Planned for 9/26
10/3 - 10/9 Week 5		
10/10 - 10/16 Week 6		
10/17 - 10/23 Week 7		
10/24 - 10/30 Week 8		
10/31 - 11/7 Week 9		
11/8 - 11/14 Week 10		
11/15 - 11/21 Week 11		
11/22 - 11/28 Week 12		
11/29 - 12/5 Week 13		
12/6 - 12/12 Week 14		
12/13 - 12/18 Week 15		
Winter Break		

Design Matrix

	Camera		Pressure/Resistance Sensor		Force Tensiometer (Tension Meter)	
	Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Cost (20)	1	4	4	16	3	12
Interference with suturing technique (25)	5	25	3	15	1	5
Durability (10)	5	10	1	2	4	8
Usability (25) (Ease of use)	5	25	4	20	3	15
Safety (5)	5	5	5	5	5	5
Feasibility (15)	2	6	5	15	5	15
Total (100)		75		73		60

Descriptions:

- **Cost:** Cost was ranked high at 20 because the client has provided a low budget for the project and cost will be a limiting factor in pursuing select options.
- **Interference:** The goal of this project is to simulate a natural suture technique while providing live feedback to the students. If the design interferes with their procedure, it can cause improper suturing techniques post training.
- **Durability:** Durability was ranked low because it is not a primary concern or focus of our device. All of the options are relatively durable.
- **Safety:** Safety is a required category that does not affect our project significantly. All three measurement techniques will be safe for the user and will not create risks within the suturing process.
- **Feasibility:** Feasibility was ranked in the middle of the categories at 15. While all the designs are complicated, it is essential to consider how easily the idea can be brought to life to ensure a working product at the end of the project.

Camera

- **Cost**: The camera-based design scored 1/5 due to its high cost (≥ $250) for a high-definition camera and a single-board computer such as a Raspberry Pi to handle

image processing. Proof of concept can be validated using a standard computer before investing in the Raspberry Pi.
- **Interference**: The camera-based design received a 5/5 since it introduces no physical obstacles and will not interfere with natural suturing technique.
- **Durability**: Because the camera-based design ranked 5/5 since it will not be exposed to any mechanical load like other designs.
- **Safety**: No safety concerns with the camera-based tool because it will only be used on a suturing model for training purposes.
- **Feasibility**: The camera-based design requires advanced image analysis, coding, and electronic knowledge beyond the team's current skills. While these could be learned, the approach does not leverage existing experience and would require significantly more time.

Pressure/Resistance Sensor
- **Cost**: The pressure/resistance sensor received a high score because circuitry parts like a Force Sensing Resistor (FSR) are relatively cheap to buy.
- **Interference**: The sensor received a medium score for this category because the sensor would be placed somewhere on the hand which could cause suturing hand placements to be slightly altered.
- **Durability**: The sensor is not as durable as the other designs because of its small size, low cost, and openness to the environment which could cause it to be damaged more easily.
- **Safety**: No safety concerns with this sensor tool because it will only be used for training purposes.
- **Feasibility**: The sensor was ranked high for this category because it will be easier to make than the camera-based design. The sensor can be hooked up with a sleeve and microcontroller display that can output force readings.

Force Tensiometer
- **Cost:** The force tensiometer was ranked 3/5 in cost because, depending on the tensiometer chosen, the typical price range for a tensiometer is $100 - $500. The team could also create a device modeled after a tensiometer to explore cheaper options.
- **Interference:** The tensiometer was ranked low in the interference category because it will likely involve a component that requires an additional step in the suturing process or forces the student to pull the knot tight from a different angle or distance.
- **Durability:** The durability of the tensiometer was ranked high because there is some exposure to mechanical load in the suturing environment.
- **Safety:** There are no safety concerns with the tensiometer design.
- **Feasibility:** The tensiometer design is very feasible and can be constructed quickly. The tensiometer purchased will require a stand or operating environment to be constructed.

Examples of Each Option					
Category	Name	Picture	Key Details	Price	Link
Camera	Dino-Lite Digital Microscope AM4112NT		• Viewing • Capture • Measurement • Geotags • Calibration • Edge detection	$249.00	Link
Force Sensor	FSR UX 400 Short		• Solder tabs 34-00137 • 0.5 N - 150 N • 7.2 mm in diameter • 20 mm length	$3.99	Link
	FSR UX 402 Short		• Solder tabs 34-00143 • 12.7 mm diameter • 30.3 mm length • 0.5 N - 150 N	$3.99	Link
	FSR X 400 Short		• Solder tabs 34-00136 • 0.3 N - 50 N • 7.2 mm diameter • 20 mm length	$3.49	Link
	FSR X 402 Short		• Solder tabs 34-00142 • 7.6 mm diameter • 20 mm length • 0.3 N - 50 N	$3.49	Link
Tensiometer	Tajima Thread Tension Gauge		• Tension reading provided in grams	$29.99	Link

	Handheld Digital Tension Meter		• 196 N max • Many size, pricing variations	$440	Link

Expenses

Item	**Description**	**Manufacturer**	**Mft Pt#**	**Vendor**	**Vendor Cat#**	**Date**	**QTY**	**Cost Each**	**Total**	**Link**