

Knee Arthroscopy Manikin

Client: Corinne Henak

Consultants: Corinne Henak, Russ Johnson

Team: Shrey Ramesh (leader) Delaney Reindl (leader)
Jack Thurk (accountant) Connor Dokken (communicator)
Sierra Reschke (admin) Rachel Dallet (admin)

Status

Report Date: 03/21/2024

Next Milestone: Working Prototype

Deadline: 03/22/2024

Status: on schedule (green), deadline at risk (yellow), deadline unachievable (red)

Technical Summary

Important aspects of this past week include meeting with Dr. Johnson and Dr. Henak to discuss updates on the enclosure assembly and to receive feedback on the progress of each project division, as well as giving the Show and Tell Presentation 3/20. For the bone team, the stress analysis on the enclosure with the bones is being done and a valve for the probe port was found which will function to prevent leakages when the probe enters the assembly. For the enclosure team, the enclosure assembly was updated and the femur and tibia enclosures were redesigned to minimize the amount of light accessing the interior of the model. For the pump team, a flow loop was created using the entire model and testing was conducted. Going forward, updates to each subsystem will be done in order to improve testing results.

New Tasks

Bone Team

Task Name	Description and Concrete Outcome	Owner	Est. Time
Update BME and ME websites	Add the progress reports to both the ME and BME websites. Update the project status as well.	RD	0.5 hr
Set up a time to do testing with the tissues on the new bones	Discuss with the team and Dr. Henak a plan for our next round of testing. Should this be on a working prototype? Or should we do one	RD	2 hr

	more round of just the tissues and the wire? Find a time to do the testing.		
Finish outreach deliverables	For outreach, we need a report, activity guide, and presentation to submit to Dr. Puccinelli. Work with the BME side of the team on those items	RD	2 hr
Conduct wire testing	Use random objects/scraps from the makespace to test the strength of our new wire	RD	1.5 hr
Conduct wire testing	Wire testing was performed without the bone models and we have been waiting for the bones to be reprinted. Now we will perform wire attachment testing on the bone models. Record and analyze results.	SGR	2 hrs
Continue stress analysis in ANSYS	Work with Peter Noonan to learn the ANSYS and SpaceClaim software and how to import our model and re-mesh. Goal is to successfully import the re-meshed model into FEBio.	SGR	2 hr
Finish outreach deliverables	Work over spring break to complete all outreach deliverables.	SGR	2 hr

Enclosure Team

Task Name	Description and Concrete Outcome	Owner	Est. Time
Work on outreach deliverables	Utilize spring break to complete all outreach variables.	DR	2 hr
Test with updated enclosure and reservoir	Once the CAD is updated and the leakages are mediated, we will work on attaching the enclosure to the reservoir and testing the fluid system.	DR	2 hr
Determine new duct clamp attachment mechanism	The clamps are currently causing small tears within the plastic bag of the enclosure causing leakages. We are currently considering using the polyurethane foam to cover the area that's ripping and then applying the clamps over that.	DR	2 hr

Leak prevention development	There are numerous modes of leaks which need to be addressed with the enclosure. I will work with Connor and Delaney to determine any potential solutions and implement them before the next meeting	SKR	4 hr
Tibia enclosure reprint	Once we receive the port valves, reprint the tibia enclosure with two insertion points of the correct dimensions.	SKR	2 hr

Pump Team

Task Name	Description and Concrete Outcome	Owner	Est. Time
Test flow loop with two pumps	Second pump has been set aside but it needs to be brought home from Shrey's lab. Once it is available set up a test that uses both pumps to continue trying to make the current pressure gauge work. If more pressure is required perhaps the outlet pump could be at a slower speed, in reverse to provide back pressure, etc. testing will be completed to try and answer some of these questions.	CD	2.5 hr
Flow rate sensor inquiry	We received a flow rate sensor from Renesas, but they did not provide wiring to power and read data from the sensor. Need to check if they will provide it as they did with the last sample.	CD	0.5 hr
Continue testing with enclosure team	Continue testing enclosure with fluid flowing through it with Shrey. Need to determine if foam will provide enough extra padding to protect the bags from leaks. Also would be ideal to test second port with second pump.	CD	3 hr
Reevaluate the leaks at the connection ports between the sensor	Once the flow loop is constructed, the ports will need to be sealed to eliminate leakages from the port connections. This could be done	JT	3 hr

	using the extra sealant that was used for the reservoir construction.		
Test enclosure with water and nitrogen setup	At some point in the near future, when the enclosure and pump team connect their projects together, it would be valuable to test the oxygen concentration test again with a more accurate volume of liquid. To do this, we would have to bring both the enclosure and the full setup for the pump team to Dr. Henak's lab and fill the whole thing with liquid and begin deoxygenating. Most likely, the process will take longer to deoxygenate to the desired oxygen concentration, but hopefully will still be under 10 minutes which is the maximum time cartilage can live without a media.	JT	3 hr

Old Tasks

Bone Team

Task Name	Description and Concrete Outcome	Owner	Est. Time
Update BME and ME websites	Add the progress reports to both the ME and BME websites. Update the project status as well.	RD	0.5 hr
Continue working through stress analysis	Talk to Dr. Henak at this week's meeting about what our next steps should be for the stress analysis.	RD	2 hr
Prepare for and give presentation	Meet with the group to assemble or prototype for our presentation on the 20th. Sierra and I need to find something to act in place of the live tissues. Practice going through our demonstration.	RD	2 hr
Finish outreach deliverables	For outreach, we need a report, activity guide, and presentation to submit to Dr. Puccinelli.	RD	1.5 hr

	Work with the BME side of the team on those items		
Conduct wire testing	Wire testing was performed without the bone models last week. Now, perform wire attachment testing on the bone models. Record and analyze results	SGR	2 hr
Continue stress analysis	Ask Dr. Henak about our current struggles with stress analysis. Continue to implement next steps and possible solutions.	SGR	1 hr
Find a valve for the probe port	Conduct research to find a one-way valve that will allow the probe to be inserted into the assembly and not allow water to leak.	SGR	1 hr
Prepare and practice presentation	Work with the team to create our demonstration presentation. Finish assembling the initial prototype and prepare a demonstration for peers.	SGR	2 hr

Enclosure Team

Task Name	Description and Concrete Outcome	Owner	Est. Time
Meet with FC	Meet with Dr. Henak 03/13 to discuss enclosure assembly and design specifications relating to it.	DR	0.5 hr
Work on Outreach Deliverables	Attended Georgia O'Keeffe Middle School and gave a presentation/complete biomechanics jumping activity with kids. Now must work to complete the associated deliverables.	DR	2 hr
Update enclosure assembly	Determine what <i>new</i> enclosure bags we want to use for the testing aspect of this project.	DR	0.5 hr
Prepare for Show and Tell Presentation	This presentation will take place on 03/20 and it will function to demonstrate our working prototype to our peers.	DR	3 hr
Connect the enclosure to the reservoir	Coordinate with the pump team to determine how the enclosure handles fluid flow.	SKR	3 hr

Redesign Femur and Tibia Enclosure	Redesign and reprint the femur and tibia enclosures to prevent light from entering at any point and include dedicated ports for scope insertion.	SKR	4 hr
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Pump Team

Task Name	Description and Concrete Outcome	Owner	Est. Time
Create flow loop using entire model	Help with changes to the enclosure based on feedback from last week's meetings. Once necessary improvements are made, create the first flow loop using the entire system, including pumps, reservoir, and actual enclosure model.	CD	4 hr
Prepare for presentation	Determine how we plan to represent our model, what level of functionality we plan to show (just the components, all the components together, components together with water flowing, etc.). Practice the demo with the whole team. Presentation is wednesday at 4pm.	CD	2 hr
After testing adjustments	The reservoir will be tested on friday before the meeting with Jingyi. Once tested, there will be things that need to be adjusted and fixed to based on the testing results. Hopefully only minor fixes will be needed. If larger things need to be fixed, next week tasks will incorporate those tasks. Otherwise this next week will be dedicated to smaller fixes that will increase the reliability of the reservoir.	JT	4 hr
Prepare for presentation	With the upcoming presentation this next week. I will help to prepare the pump system for showing our progress throughout the capstone project. I will also attend a peer review to ask questions and give advice for another group.	JT	2 hr

Technical Section

Author: Rachel Dallet

Continue working through stress analysis	Talk to Dr. Henak at this week's meeting about what our next steps should be for the stress analysis.	RD	2 hr
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Dr. Henak got us in touch with a graduate assistant, Peter, who gave us his meshing workflow. Sierra and I tried to run through that in ANSYS but encountered some issues uploading our .stl. We are currently working through it with Peter.

Prepare for and give presentation	Meet with the group to assemble or prototype for our presentation on the 20th. Sierra and I need to find something to act in place of the live tissues. Practice going through our demonstration.	RD	2 hr
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Here are the slides to our demonstration:

https://docs.google.com/presentation/d/13dhJBz4IALLxxOgPIK4NGr4Q0gP_UYJgngPs4RbyKuM/edit#slide=id.g2c49cbf28c9_0_11

To prepare, Sierra and I talked about what points we needed to make for the bone team:

I will first show an actual visual from when we did the testing with live cartilage samples. Then explain as a member of the bone team, a major task we were responsible for was attaching the live cartilage to our 3D printed bones. A design requirement for the time of attachment is under 5 minutes as the cartilage will be out of the PBS and we need to make sure they stay viable. We chose the staple mechanism to limit cell death by wrapping over the tissue rather than puncturing through. I will explain that the tissues vary in sizes and therefore our new model has a grate underneath the lip to make sure no pieces fall through as opposed to the hollow old design here. We also increased the number of attachment holes to increase stability and options. The wire was not bendable on the spot so we will try out a new wire that we have here. New testing needs to be done on our new model that has the grate and more holes and new wire which is more bendable. Sierra and I also found scrap wood pieces to act in place of the tissues.

Prepare for presentation	Determine how we plan to represent our model, what level of functionality we plan to show (just the components, all the components together, components together with water flowing, etc.). Practice the demo with the whole team. Presentation is Wednesday at 4pm.	CD	2 hr
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Team met virtually on Monday and Tuesday night to prepare for the presentation. Prepared slides, prototype, and script for presentation.

Create flow loop using entire model	Help with changes to the enclosure based on feedback from last week's meetings. Once necessary improvements are made, create the first flow loop using the entire system, including pumps, reservoir, and actual enclosure model.	CD	4 hr
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Worked with Shrey to put together first tests with new enclosure design and pumps / reservoir. Had issues in first few tests with the sharp edges of the clamps puncturing the plastic bags and causing leaks, even with the clamp placed on top of the silicon. One test was ran with one bag pulled over the enclosure, the ports inserted, and then a second bag placed over the first bag for extra protection. This produced better results, but there was an issue with the port on this test. Removing the backing on the silicon and sticking it to the bag could provide more secure protection for the bag, the foam ordered earlier in the year could also be of use for extra padding where the clamps are applied. Only one pump and one port were used in this test, as well as no bones as we do not have samples to put on them and the objective of the tests was to find points of leakage. More testing will be completed the week after spring break.

Author: Sierra Reschke

Continue stress analysis	Ask Dr. Henak about our current struggles with stress analysis. Continue to implement next steps and possible solutions.	SGR	1 hr
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Rachel and I worked to import the solidworks model of the enclosure into ANSYS. We were successfully able to open it (after a long waiting period) in SpaceClaim through ANSYS but this model was still not able to be opened in ANSYS. We are in communication with Peter Noonan to figure out how best to use ANSYS to mesh and export prior to importing into FEBio to perform the stress analysis.

Find a valve for the probe port	Conduct research to find a one-way valve that will allow the probe to be inserted into the assembly and not allow water to leak.	SGR	1 hr
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I conducted research into different valves that could potentially be used for our probe insertion port ([link](#)). I found a few different possibilities and asked Jack to order dressing bottles from [Amazon](#). I was also in contact with [YEJIA Silicone](#) and Hopewell to discuss purchasing their valves. They offered to send me a free sample, but the cost of shipping was \$50, so I decided to order the Amazon ones.

Prepare and practice presentation	Work with the team to create our demonstration presentation. Finish assembling the initial prototype and prepare a demonstration for peers.	SGR	2 hrs
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The team met to determine how we are going to approach the demonstration presentation. I prepared my individual slides on the background of our project. We will give this presentation on Wednesday to our peers and demonstrate our prototype and its functionality. I attended a peer presentation on Tuesday afternoon and gave my feedback.

After testing adjustments	The reservoir will be tested on friday before the meeting with Jingyi. Once tested, there will be things that need to be adjusted and fixed to based on the testing results. Hopefully only minor fixes will be needed. If larger things need to be fixed, next week tasks will incorporate those tasks. Otherwise this next week will be dedicated to smaller fixes that will increase the reliability of the reservoir.	JT	4 hr
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The testing went much better than expected. The reservoir did not leak and the water that was used for testing was able to be deoxygenated to the acceptable range in about a minute and a half. Although this is not a perfect test (water was used instead of PBS and more liquid will be required in the full working prototype), this testing provided valuable data and information for the reservoir and the pump team.

Prepare for presentation	With the upcoming presentation this next week. I will help to prepare the pump system for showing our progress throughout the capstone project. I will also attend a peer review to ask questions and give advice for another group.	JT	2 hr
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The presentation went well and the pump team described the progress made in detail since the beginning. There is still a lot to do and more iterations to our current prototype will need to be made before the final prototype design.

Figure 1 shows the test results from the reservoir and bubbler testing completed last week. The dissolved oxygen sensor was not calibrated so the dissolved oxygen content shown on the Y-axis is not accurate. However, the drop in DO2 over time was still reported accurately.

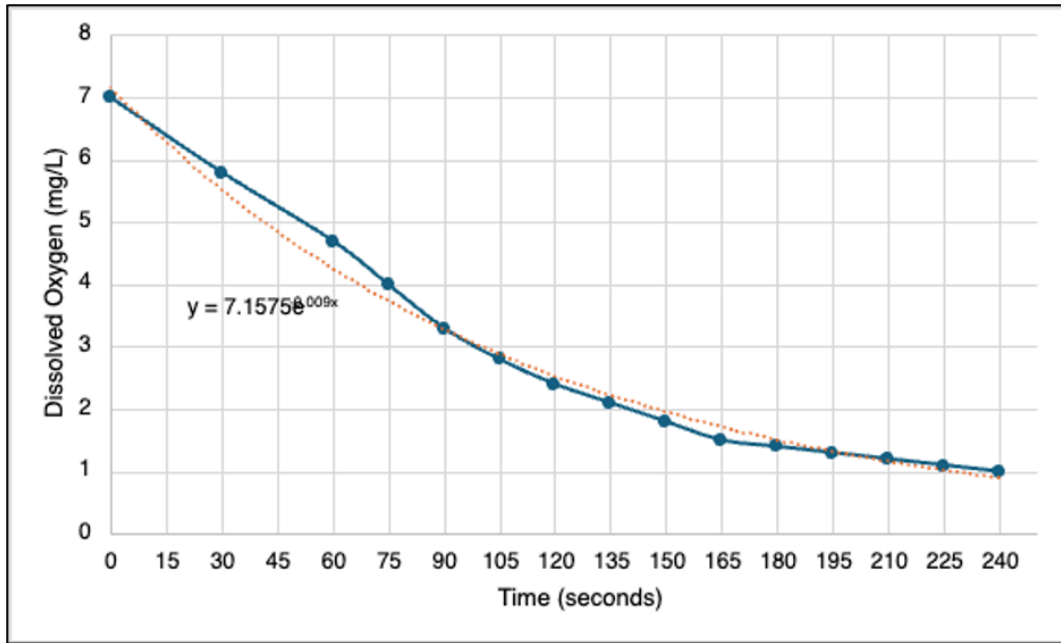


Figure 1

Author: Delaney Reindl

Meet with FC	Meet with Dr. Henak 03/13 to discuss enclosure assembly and design specifications relating to it.	DR	0.5 hr
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Met with Dr. Henak 3/13 to discuss the updated enclosure assembly, and asked for feedback on how we can fix the design without using too much of our budget. A large problem for that specific assembly was that the bags we had ordered from McMaster-Carr were way too short to cover the appropriate amount of the assembly frame. Dr. Henak was able to supply us with longer bags and further gave us feedback on how we can attempt to shield much of the interior frame from light while maintaining the mobility of the structure and probe that will be entering during testing.

Update enclosure assembly	Determine what <i>new</i> enclosure bags we want to use for the testing aspect of this project.	DR	0.5 hr
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After meeting with Dr. Henak, we were able to get different enclosure bags to fill in where the last bags didn't work. Now we will continue to test with the bags.

Prepare for Show and Tell Presentation	This presentation will take place on 03/20 and it will function to demonstrate our working prototype to our peers.	DR	3 hr
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Created a conclusion and future directions slide for the show and tell presentation. While giving the presentation, I mainly talked about how beneficial the client meetings have been to applying feedback to the updated design and that we will continue with the meetings.

Connect the enclosure to the reservoir	Coordinate with the pump team to determine how the enclosure handles fluid flow.	SKR	3 hr
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I worked with Connor to connect the pump system and reservoir to the enclosure to determine if the fluid flows through the system as intended. We found that fluid does flow correctly, but there are significant issues with leaking. We initially found leakage when filling the enclosure after tightening the two bottom clamps using just a single bag to surround the enclosure. There were small tears in the bag at the points at which the clamps were tightened around the bag and the silicone. I had tightened the clamps until they could be tightened no further, so for the second attempt, we tried again with a single bag and slightly loosened the clamps. This still resulted in small tears once the enclosure was filled. For our third and final attempt, we double bagged the enclosure and still had leaks at the clamp points as well as the barbed tube ports. We still wanted to ensure these ports were functioning properly, so we connected the pump and plugged the holes with our hands as best we could. We found that the ports work properly and the desired flow was achieved. In the upcoming weeks, we plan to use the polyurethane foam ordered last semester to protect the bag at the clamp points and prevent any more leaks. We will also need to develop a more robust method to prevent fluid from leaking into the bottom of the bag below the enclosure.

Redesign Femur and Tibia Enclosure	Redesign and reprint the femur and tibia enclosures to prevent light from entering at any point and include dedicated ports for scope insertion.	SKR	4 hr
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The femur side was redesigned and reprinted along with a new femur bone. The previous tibia is still in use. The tibia enclosure was not printed because we do not know the dimensions of the port valves as this information is not available on the data sheet.

Gantt Chart

	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Week 8		Week 9		Week 10		Week 11		Week 12		Week 13		Week 14		Week 15	
	Feb				Mar				Apr				May																	
Task	2	9	16	23	1	8	15	22	29	5	12	19	26	3	10															
Individual Presentations				O																										
Testing	X																													
Redesign and Fabrication	X	X	X	X																										
Presentations				X																										
Working Prototype Demonstration									O																					
Redesign						X	X	X	X																					
Fabrication						X	X	X	X																					
Presentation and Demonstration									X																					
Final Presentation																														
Testing																														
Report																														
Presentation																														

X = Completed Tasks, O = Milestone Deadlines