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: 02/08/2024

Next Milestone: Individual Presentation

Deadline: 02/09/2024

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

Technical Summary

Important aspects of this past week include meeting with Dr. Johnson to discuss weekly updates as well as to receive feedback on the progress of each project division. Within this past week, the bone team conducted research on both the total joint arthroplasty (TJA) protocol that is conducted post-removal, as well as on magnets that will be used for the enclosure system. Additionally, testing times with the TJA samples were scheduled, a sample acquisition and testing plan was developed. For the enclosure team, research into a more flexible material to be used for the joint mechanism as well as a sealant (such as superglue or biocompatible caulk) was conducted. The silicone we got last semester has been determined to be too stiff to be used in the flexion of the joint without leakage, so research into a polyethylene (PE) film was conducted as it is both flexible and liquid resistant. Additionally, updates were made to the enclosure CAD as well as the bone CAD to add more structural support. For the pump team, reservoir materials were found and assembly of the reservoir began. Research was conducted on flow rate sensors as well as pump tubing clamps for the connection between tubing and the enclosure. The second half of the tubing system was developed, a design matrix was developed to determine a more permanent solution for fabricating the bubbler attachments.

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
Create testing protocol	Finalize the protocol to test the attachment mechanism before Sierra and I go in to test. Discuss this with the team	RD	2 hr
Test attachment mechanism	Meet with Dr. Henak and Sierra and test the attachment mechanism based on the protocol the team came up with	RD	2 hr
Get the magnets ordered	Confirm on the magnets that we decided on and make sure Jack gets them ordered.	RD	1.5 hr
Finalize testing protocol	Finalize the attachment mechanism implementation and strength of attachment testing protocol. Ensure data collection method is organized and sufficient to draw accurate conclusions.	SGR	2 hr
Test attachment mechanism	Meet with Rachel and Dr. Henak to perform testing on the attachment mechanism in terms of both time to implement and strength. Record data and observations in testing protocols document.	SGR	2 hr
Assist with finalizing the ordering of magnets	Assist Rachel and Jack with the ordering of the magnets. Begin to implement them into the bone model design if/when they arrive	SGR	2 hr

Enclosure Team

Task Name	**Description and Concrete Outcome**	**Owner**	**Est. Time**
Order PE film, Order biocompatible caulk	Talk with Shrey to confirm the exact PE film and biocompatible caulk that should be ordered. Then submit the order form to Josh.	DR	2.5 hr
Find what enclosure clamps we want to use	Need to research various types of “hose”clamps that will function to help adhere the PE film onto the frame.		1.5 hr
Reach out to Dr. Puccinelli about outreach	Reach out to Dr. Puccinelli regarding our outreach plan. Ideally we want to take part in	DR	0.5 hr

	Engineering EXPO, happening April 19-20th where we would volunteer multiple times for different activities.		
Develop enclosure material attachment plan	Develop an exact enclosure material attachment plan. This will involve determining which region of the enclosure frame will need which specific material. It may be helpful to devise back up plans as well.	DR	1.5 hr
Update Bone CAD	Update the bone CAD based on feedback from Rachel and Sierra's testing. Some of the changes to be made include adding more points of attachment and adding a "lip" below the mounting edges of the model.	SKR	4 hr
Print Enclosure CAD	Make final changes to the enclosure CAD based on magnet dimensions and print at the makerspace	SKR	1.5 hr
Order flow rate sensor for Pump team	Request a free sample of the fluid flow rate sensor from Renesas	SKR	.5 hr

Pump Team

Task Name	**Description and Concrete Outcome**	**Owner**	**Est. Time**
Optimize the plastic sheet to find the dimensions needed for cutting and trace it out.	Now that the plastic sheet has been found for fabricating the reservoir, now the box itself has to be put together. The current dimensions are around 15.5 inches by 40.5 inches. Since the box only has to have 5 sides (no plastic cover needed), the box dimensions will be optimized to produce the best size box possible that will accommodate the liquid.	JT	1 hr
Reserve a time slot in the Team Lab	Reserve a time slot at the Team Lab at ECBto fabricate the box. The band saw will need to be reserved in order to cut the plastic to the dimensions needed.	JT	30 min

Fabricate the reservoir box	Go to the Team Lab and cut the plastic. Use the recently ordered glue to create a bonding agent between the edges to ensure there will be no leaking. This reservoir will be used to hold PBS liquid and will be crucial in ensuring the PBS is at the correct oxygen concentration.	JT	4.5 hr
Begin assembling reservoir	Fabricate the walls of the reservoir with a band saw at the team lab. Use an ordered bonding agent and caulk to seal the walls.	CD	4 hr
Research flow rate sensors	Research whether or not the acquired flow rate sensor is compatible with liquids, or if the company offers a similar product that is designed for use with liquids.	CD	1 hr
Finish designing reservoir	Finalize the dimensions for each of the walls and if any other acrylic pieces are needed	CD	1 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
Look into TJA tissue protocol	Research into the protocol of how the total joint arthroplasty tissue is dealt with after removal	RD	2 hr
Research magnets for enclosure system	Find possible magnets to use for the enclosure system that don't break off during assembly	RD	2 hr
Schedule testing times for the TJA samples	Talk with Dr. Henak and Sierra and find times to begin testing on the TJA samples. Also collaborate with the rest of the group on when a working model will be ready.	RD	1.5 hr
Research magnets for bone and enclosure attachment.	Conduct research into possible magnets that can be used in place of the currently implemented magnets. The current magnets are brittle and pieces often fall off during use.	SGR	2 hr

	Ensure the dimensions are compatible with the current design.		
Schedule TJA discarding testing times.	Work with Dr. Henak to schedule testing times and availability with the total joint arthroscopy discarded samples.	SGR	1 hr
Develop sample acquisition and testing plan	Work with Rachel and the rest of the team to begin to develop the plan for acquiring the TJA discard samples as well as the testing protocols.	SGR	2 hr
Assist other sub-teams	Assist the other sub-teams with any tasks or ideas that arise.	SGR	1 hr

Enclosure Team

Task Name	**Description and Concrete Outcome**	**Owner**	**Est. Time**
Biocompatible Caulk	I will need to research and order biocompatible caulk as a method of sealing the enclosure material to the frame. Another option would be superglue, however we want this to be biocompatible/medical grade so it does not conflict with viability testing. As of now, we may use super glue as a cheaper seal method.	DR	1 hr
Flexion of Joint Material	I will need to research materials that allow for flexion of the joint, while not impeding mechanical movement of the model or conflicting with viability testing. Last semester we ordered a silicone sheet, but it turns out to be too stiff to allow for the desired movement of the knee model.	DR	3 hr
Flexion of Joint Material (cont.)	As an aside to the aforementioned material for joint flexion, I will research a different enclosure material altogether that may meet the flexibility demands of the knee model. Considering the use of a polyethylene material with hose clamps.	DR	2 hr

Update enclosure CAD	Update the enclosure CAD based on the preliminary feedback from Dr. Henak as well as visual inspection	SR	3 hr
Make preliminary changes to bone CAD	Add more crossbars to the top of the bone and wait for feedback from Sierra and Rachel for what other changes should be made	SR	3 hr

Pump Team

Task Name	**Description and Concrete Outcome**	**Owner**	**Est. Time**
Find reservoir materials	Look through available resources, specifically scrap acrylic or plastic, to find suitable materials for the reservoir. If needed consult advisors and Dr. Cheedle.	CD	1 hr
Begin assembling reservoir	Pick up materials and begin designing enclosures based on what is available. The fabrication methods used will depend on the material picked for the walls of the reservoir.	CD	3 hr
Research flow rate sensors	Research whether or not the acquired flow rate sensor is compatible with liquids, or if the company offers a similar product that is designed for use with liquids.	CD	2 hr
Create the second half of the tubing system	To complete the closed loop for fluid flow, the tubing from the enclosure to the reservoir needs to be made. The system will look very similar and will require another pump system which Shrey is able to find and provide.	JT	2 hr
Create a design matrix for the bubbler attachments.	From last semester, there were two different bubbler attachments being considered. These bubblers will be responsible for distributing Nitrogen gas through the PBS liquid. Once a design matrix is created, a clear winner between the two designs will be seen and therefore chosen for the final prototype.	JT	2 hr
Based on the design matrix, find a more permanent solution for	Once a bubbler design is chosen, find better ways for the bubbler to be made so that there	JT	1 hr

fabricating the bubbler attachments.	is less chance of equipment failure and need for replacement.		
Look into pump tubing clamps for connection between tubing and enclosure	Research into pump clamps and find clamp options for eliminating potential leaks from the connection ports between the enclosure and the pump tubing. These clamps could possibly be used to replace caulk that was previously being considered.	JT	1 hr

Technical Section

Look into TJA tissue protocol	Research into the protocol of how the total joint arthroplasty tissue is dealt with after removal	RD	2 hr

Author: Rachel Dallet

Editor: Sierra Reschke

Source citation:

[1] "Silicones for Medical Devices | MasterBond.com." Accessed: Feb. 08, 2024. [Online]. Available: https://www.masterbond.com/products/silicones-medical-devices

Summary:

As I was researching TJA discard tissues, I came across multiple journal articles that discussed their testing for pathogens. Many institutions mandate routine pathologic analysis of bone removed during primary THA and TKA. This study aimed to discover if that is a necessary step or merely a waste of money and time. They found that after spending $67,246 on routine analysis of TJA specimens by a pathologist, there were no changes in postoperative patient care plans. This could be an interesting topic to bring up to Dr. Henak to see what her lab's protocol is and why.

Author: Rachel Dallet

Research magnets for enclosure system	Find possible magnets to use for the enclosure system that don't break off during assembly	RD	2 hr

After some research, I discovered that most magnets are from neodymium iron. This type of material is reactive to acids and basic solutions and is therefore not biocompatible in the body. The best solution that we discussed at our advisor meeting was to cover the neodymium iron magnets in the biocompatible caulk that we buy.

Link for magnets:

https://www.amazon.com/Magnets-Neodymium-Refrigerator-Building-Kitchen/dp/B09TQPNGFG/ref=pd_lpo_sccl_3/138-3435935-9439055?pd_rd_w=2O91q&content-id=amzn1.sym.c35e6feb-beeb-48b8-ba98-06ab34ca37b4&pf_rd_p=c35e6feb-beeb-48b8-ba98-06ab34ca37b4&pf_rd_r=CAC4B44NSBS0WA8Q5CTY&pd_rd_wg=Egdpe&pd_rd_r=ba287670-45e0-4ad8-bb5d-722cdc726498&pd_rd_i=B09TQQHQLP&th=1

Author: Rachel Dallet

Schedule testing times for the TJA samples	Talk with Dr. Henak and Sierra and find times to begin testing on the TJA samples. Also collaborate with the rest of the group on when a working model will be ready.	RD	1.5 hr

Sierra, Dr. Henak, and I all found a time that works and set a testing date on the calendar for: Wednesday, February 7 at 8:00am. We decided in our team meeting that this test will simply be for attachment mechanism purposes and we do not need a working model of the entire system.

Author: Sierra Reschke

Research magnets for bone and enclosure attachment.	Conduct research into possible magnets that can be used in place of the currently implemented magnets. The current magnets are brittle and pieces often fall off during use. Ensure the dimensions are compatible with the current design.	SGR	2 hr

Source citation: Magnetech, HangSeng. “How Strong Is 1000 Gauss Magnet?” Magnets By HSMAG,20 June 2022, www.hsmagnets.com/blog/how-strong-is-1000-gauss-magnet/#:~:text=Magnets%20of%20about%201000%20gauss,induction%20speed%20measuring%20devices%2C%20etc. Accessed 06 Feb. 2024.

I conducted research into different types of magnets that we could potentially implement in our design as well as the different strengths of magnets. I found that a refrigerator magnet is typically around 100 gauss and the dimensions of the magnet will change to increase or decrease the strength. I found possible magnets that we could utilize on Amazon.com, but the final decision was to purchase some of the magnets that Rachel found. It was also discovered that most magnets are typically made out of neodymium iron which is toxic to live cells. As a result, the magnets purchased will be covered in biocompatible caulk both to allow for biocompatibility and potentially decrease the strength of the magnets if needed.

Schedule TJA discarding testing times.	Work with Dr. Henak to schedule testing times and availability with the total joint arthroscopy discarded samples.	SGR	1 hr

Rachel and I worked by email with Dr. Henak and find a time that worked for all of us to go into Dr. Henak's lab and test the attachment mechanism. We were able to successfully find a time and will be testing the attachment mechanism implementation time and strength of attachment.

Develop sample acquisition and testing plan	Work with Rachel and the rest of the team to begin to develop the plan for acquiring the TJA discard samples as well as the testing protocols.	SGR	2 hr

I wrote an initial rough draft of the testing protocol, but will need to finalize the steps and data collection format prior to going in to test the attachment mechanism. The samples will be acquired and utilized during the testing period in Dr. Henak's lab.

Assist other sub-teams	Assist the other sub-teams with any tasks or ideas that arise.	SGR	1 hr

As the semester is still picking up speed, there were no pressing issues or challenges that the other sub-teams needed assistance with. However, I will continue to offer assistance with anything that may arise.

Find reservoir materials	Look through available resources, specifically scrap acrylic or plastic, to find suitable materials for the reservoir. If needed consult advisors and Dr. Cheedle.	CD	1 hr

We were able to find a sheet of thin acrylic scrap in the team lab that was available for free.

Create a design matrix for the bubbler attachments.	From last semester, there were two different bubbler attachments being considered. These bubblers will be responsible for distributing Nitrogen gas through the PBS liquid. Once a	JT	2 hr

	design matrix is created, a clear winner between the two designs will be seen and therefore chosen for the final prototype.		

Bubbler Design Matrix	Tube (1-5)		Bottlecaps (1-5)	
Ease to fabricate (25)	3/5	15	4/5	20
Ability to disperse Nitrogen (35)	4/5	28	2/5	14
Ease of anchoring (25)	3/5	12	4/5	16
Longevity (15)	2/5	6	3/5	9
Total (100)	61		59	

I created a design matrix and assigned categories I thought to be essential in deciding what design would be best. The bottlecap proved to excel in more categories than the tub solution but the tube really excelled in the ability to disperse nitrogen. This was because the tube was longer and could be wrapped around to disperse more bubbles across a greater range of space. Therefore, as our mission with the bubble disperse design is to deoxygenate the PBS first and foremost, the ability to disperse nitrogen category carried the most weight and was the reason for deciding that the tube was the better design choice.

Based on the design matrix, find a more permanent solution for fabricating the bubbler attachments.	Once a bubbler design is chosen, find better ways for the bubbler to be made so that there is less chance of equipment failure and need for replacement.	JT	1 hr

For the tube design prototype, the design was fabricated using punched holes and a stuffed end with extra plastic. While the punched holes worked well and will be used in the end design, the “plug” at the end of the plastic tube is not reliable and not a good solution for long term testing. Therefore a medical tube end cap will need to be purchased for a more reliable and long lasting testing equipment.

Look into pump tubing clamps for connection between tubing and enclosure	Research into pump clamps and find clamp options for eliminating potential leaks from the connection ports between the enclosure and the pump tubing. These clamps could	JT	1 hr

	possibly be used to replace caulk that was previously being considered.		

Pump tubing clamps will be used for eliminating potential leaks between the enclosure and the pump tubing. This was a new idea brought up recently. After investigating possible options, there seems to be many possible options on Amazon that can be ordered for around 10 dollars or less. After talking with the team in the near future, these clamps will be ordered and implemented.

Author: Delaney Reindl

Biocompatible Caulk	I will need to research and order biocompatible caulk as a method of sealing the enclosure material to the frame. Another option would be superglue, however we want this to be biocompatible/medical grade so it does not conflict with viability testing. As of now, we may use super glue as a cheaper seal method.	DR	1 hr

[1] "Silicones for Medical Devices | MasterBond.com," *www.masterbond.com.* https://www.masterbond.com/products/silicones-medical-devices

I found a website for biocompatible caulk. I found three different options that not only meet the ISO 10993 standard, USP Class VI standard, but are also liquid resistant, which will help us prevent fluid leakage. The caulk use is intended to keep the silicone/PE film attached to the frame, as well as to seal any holes around the flexion mechanism that could possibly leak fluid. Shrey and I have to decide between which of the three we want to purchase for our project.

Links to caulks of interest:
https://www.masterbond.com/tds/mastersil-151med
https://www.masterbond.com/tds/mastersil-153med
https://www.masterbond.com/tds/mastersil-910med

Flexion of Joint Material	I will need to research materials that allow for flexion of the joint, while not impeding mechanical movement of the model or conflicting with viability testing. Last semester we ordered a silicone sheet, but it	DR	3 hr

	turns out to be too stiff to allow for the desired movement of the knee model.		
Flexion of Joint Material (cont.)	As an aside to the aforementioned material for joint flexion, I will research a different enclosure material altogether that may meet the flexibility demands of the knee model. Considering the use of a polyethylene material with hose clamps.	DR	2 hr

[1]"McMaster-Carr," *www.mcmaster.com.* https://www.mcmaster.com/products/polyethylene/performance~food-safe/slippery-uhmw-polyethylene-film/ (accessed Feb. 08, 2024).

Both of these pertain to finding a polyethylene film that will function to enclose the frame while allowing for flexion at the knee joint. We want a material that is flexible enough that it won't crinkle or impede the motion of the knee when in use, thus PE film, lined with silicone at the top and the bottom of the frame should allow for that while also preventing fluid leakage. Shrey and I need to determine which we want to purchase and submit an order form. It is likely we are going with McMaster-Carr's *Slippery UHMWPE Film* as it is both food safe and flexible.

Link to film:
https://www.mcmaster.com/products/polyethylene/performance~food-safe/slippery-uhmw-polyethylene-film/

Update enclosure CAD	Update the enclosure CAD based on the preliminary feedback from Dr. Henak as well as visual inspection	SR	3 hr

The CAD of the enclosure has been updated with a new ring around the model to increase the amount of support provided to the struts.

Gantt Chart

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	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															
Redesign and Fabrication															
Presentations															
Working Prototype Demonstration									O						
Redesign															
Fabrication															
Presentation and Demonstration															
Final Presentation															
Testing															
Report															
Presentation															

X = Completed Tasks, O = Milestone Deadlines