BME Design-Fall 2022 - Zach Spears
Complete Notebook

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Table of Contents

Project Information ... 2
- Team contact Information ... 2
- Project description ... 3

Team activities ... 4
- Client Meetings ... 4
  - 2022/09/13: Client Meeting 1 ... 4
  - 2022/10/26: Client Meeting 2 ... 6
  - 2022/10/26: 3D Printing Meeting ... 8
  - 2022/11/18: Prototype Update ... 10
  - 2022/11/22: WARF Meeting ... 11
- Advisor Meetings ... 12
  - 2022/09/16: Advisor Meeting 1 ... 12
  - 2022/09/30: Advisor Meeting 2 ... 13
  - 2022/10/14: Advisor Meeting 3 ... 14
  - 2022/10/28: Advisor Meeting 4 ... 16
  - 2022/11/11: Advisor Meeting 5 ... 17
  - 2022/11/18: Advisor Meeting 6 ... 19
  - 2022/12/02: Advisor Meeting 7 ... 20
- Design Process ... 21
  - 2022/09/27: Design Options Meeting ... 21
  - 2022/09/30: Team & Makerspace Meeting ... 23
  - 2022/10/09: Preliminary Report Meeting ... 24
  - 2022/10/18: Materials Meeting ... 25
  - 2022/10/23: Prototyping Meeting 1 ... 27
  - 2022/10/28: Meeting with Dr. Roldan Alzate ... 29
  - 2022/10/30: Show & Tell Week Prep ... 31
  - 2022/11/05: Show & Tell Responses ... 33
  - 2022/11/27: Post-Thanksgiving Team Meeting ... 35
- Materials and Expenses ... 36
  - Expenses Spreadsheet 9/30/2022 ... 36
  - Expenses 12/12/2022 ... 37
- Fabrication ... 38
  - 2022/10/05: 3D Scanning 1 ... 38
  - 2022/10/26: Muscle Fabrication 1 ... 39
  - 2022/11/06: Muscle Fabrication 2 ... 43
  - 2022/11/08: 3D Print Test 1 ... 45
  - 2022/11/17: Week 11 Fabrication & Meetings ... 49
  - 2022/11/21: Week 12 Fabrication (Silicone) ... 52
  - 2022/11/30: Week 13 Fabrication ... 56
  - 2022/12/04: Week 14 Fabrication ... 58
- Testing and Results ... 59
  - Protocols ... 59
    - 2022/10/26: Magnet/Fabric Strength Testing ... 59
    - 2022/12/2: Life in Service Durability Testing Protocol ... 62
    - 2022/12/04: Vet Student Survey ... 63
  - Experimentation ... 65

2022/11/29: Bone MTS Testing Session 1 66
2022/12/2: Life in Service Durability Testing Results 69
2022/12/14: MTS Testing Session 2 71
2022/12/14- MTS Testing Session 3 73
2022/12/14- Vet Student Demo Photos 76
Project Files 79
2022/09/23: PDS 79
2022/09/29: Design Matrix 80
2022/10/12: Preliminary Report 81
2022/12/09: Final Poster 82
2022/12/14: Final Report 83
Zach Spears 84
Research Notes 84
Biology and Physiology 84
The role of 3D printed models 84
Final Design Muscles 85
Competing Designs 88
3D Printed Bone Models 88
Commercially available 3d printed bone model 90
Axis Scientific Bone Model 92
Design Ideas 94
Spandex Synthetic Muscle Research 94
Silicone Muscle Research 95
Elastic Band Muscle Research 97
Future Work 99
Training Documentation 102
Biosafety and chemical Safety Training 102
Green pass 103
Lauren Fitzsimmons 104
Research Notes 104
Competing Designs 104
2022/09/19- "3D scanning and printing of skeletal tissues for anatomy education" Notes 104
20122/09/22- "Veterinary Students and Faculty Partner in Developing a Virtual Three-Dimensional (3D) Interactive Touch Screen Canine Anatomy Table" Notes 106
2022/11/12- Patent Research -- Competing Designs 107
Background 111
2022/09/11- "Adult Learning in Veterinary Education -- Theory to Practice" Notes 111
2022/09/11 - "The Production of Anatomical Teaching Resources Using 3D Technology" Notes 112
2022/09/11 - "3D Printing Comes to Veterinary Medicine" Notes 113
2022/09/22- "Teaching anatomy without cadavers" Notes 115
2022/12/13 -- MTS Research 116
2022/12/13- Computer diagram of modeled muscles 118
Design Ideas 120
2022/09/26- Muscle Attachments Materials Brainstorming 120
2022/09/26- Muscle Fiber Materials Brainstorming 121
2022/10/04- Muscle Attachment Design Figures 122
2022/10/04- Muscle Material Design Figures 124
2022/10/04-Final Design Figure 127
2022/10/26- Fabrication Meeting Diagrams 128
2022/11/12- Silicone Rubber Muscle Material Research 131
Molly Paras 133
Research Notes 133
Background 133
2022/09/10: "Dual-extrusion 3D printing of anatomical models for education" 133
2022/09/10: "What Is the Role of 3D Printing in Undergraduate Anatomy Education? A Scoping Review of Current Literature and Recommendations" 134
2022/09/17: Relevant Standards 135
2022/11/11: Silicone Research 136
Biology and Physiology 137
2022/10/04: "Bones of the Pelvic Limb" in Miller's Anatomy of the Dog 137
2022/10/04: "Muscles of the Pelvic Limb" in Miller's Anatomy of the Dog 139

Competing Designs ... 143
2022/09/12: "Production of accurate skeletal models of domestic animals using three-dimensional scanning and printing technology" ... 143
2022/09/10: "Three-dimensional printing educational anatomical model of the patellar luxation in dogs" ... 144
2022/09/17: "A three-dimensional musculoskeletal model of the dog" ... 145
2022/09/19: Anatomy Warehouse Model ... 148
2022/09/26: "Nylon fibers made to flex like muscles" ... 149
2022/11/20: WARF Presentation Research ... 150
Design Ideas ... 151
2022/09/26: Netting Design ... 151
2022/11/14: Silicone Mold CAD ... 153
Training Documentation ... 155
2022/01/29: Green Permit ... 155
2022/01/26: Biosafety & Chemistry Certification ... 156
Cora Williams ... 157
Research Notes ... 157
Biology and Physiology ... 157
2022/09/13-Miller's Anatomy of the Dog Textbook PDF ... 157
2022/09/16-Canine Muscles in Forelimb ... 158
2022/09/16-Canine Muscles in Hindlimb ... 161
2022/10/12-Canine Muscle Attachment Points in Hindlimb ... 166
Competing Designs ... 169
2022/09/25-Anatomy Lab Domestic Canine (Canis lupus familiaris) Anatomy Model ... 169
Materials ... 173
2022/10/26-Modifying Neodymium Magnets ... 173
2022/10/26-Hot Glue Gun Temperatures ... 174
Design Ideas ... 175
2022/09/26-Muscle Attachment Mechanism Design Individual Brainstorming ... 175
2022/09/26-Muscle Material Design Individual Brainstorming ... 176
Maggie LaRose ... 177
Research Notes ... 177
Biology and Physiology ... 177
2022/09/17: "Dog Leg Anatomy in Human Terms" ... 177
2022/09/23: "Miller's Anatomy of the Dog" ... 178
2022/10/14 - Comparison of Muscle Sizes Across Dog Breeds ... 185
Design Ideas ... 186
2022/09/26 Using Dragon Skin Liquid Rubber to Mimic Muscle ... 186
2022/09/28 Mold making techniques ... 187
Training Documentation ... 188
2022/09/26-09/30 Green Permit Training ... 188
Emily Hutsell ... 189
Research Notes ... 189
Biology and Physiology ... 189
Medium Dog ... 189
Purpose of Gluteal Muscles ... 190
Purpose of Gastrocnemius ... 193
Purpose of the Adductor ... 194
Competing Designs ... 196
Axis Scientific ... 196
Anatomy Lab ... 198
4D Master ... 199
Client's Design ... 200
Materials ... 201
Spandex ... 201
Silicone ... 202
Definitions of Material Science Terms ... 203
Design Ideas ... 204
Magnet Lock for Cabinets ... 204
Pin ... 205
2014/11/03-Entry guidelines ... 206
2014/11/03-Template ... 207

Team contact Information

Zach Spears - Nov 13, 2022, 11:45 AM CST

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Project description

Molly Paras - Sep 17, 2022, 10:17 AM CDT

Course Number: BME 200/300

Project Name: Structural and Mechanical Functions of Bones, Muscles and Joints by use of 3D Models in Veterinary Medical Education

Short Name: 3-D Printed Veterinary Models

Project description/problem statement:

Veterinary students learn the anatomy of animals in great detail, and benefit greatly from actually seeing and working with the bones and muscles that they learn about in class. In the past, this has often been taught through the use of cadavers, but such methods pose many ethical, safety, and cultural concerns, along with the monetary cost required to obtain them. With the rise of 3D printing technology, teachers have been moving towards using 3D printed animal models since they are cheaper, longer lasting, and safer. The client has requested that 3D printed models of a dog limb be constructed, creating both accurate 3D printed bones and muscles that can be connected to the bones in the proper locations and simulate what the muscles do in a real dog.

About the client:

Dr. Gunderson is a lecturer for first-year students at UW Madison's veterinary school. She teaches anatomy, but her students have had troubles with the structure and function of muscles within cats and dogs, so she decided to make models that can show this information for the students to better learn the content. She started a prototype of a model, using rubber-bands and J-hooks to represent the muscles, but would like more precise models of the bone (3D printed) and have the item representing the muscle span the whole surface area of where it actually attaches to bone. She has bone boxes, textbooks, and her prototype for us to use to create our design.

2022/09/13: Client Meeting 1

Molly Paras - Sep 14, 2022, 3:51 PM CDT

Title: Client Meeting 1

Date: September 13, 2022

Content by: Team

Present: Team

Goals: Ask the client questions to get a better understanding of the project.

Content:

Questions & Answers:

- What specifications are you looking for (like size, texture and rigidity/flexibility of materials, weight, detail)?
  - Same as real life dog
- What is the budget for this project?
  - Will we need to purchase items or will we be using what they already have?
  - At least $500
- Has this project been attempted in previous semesters? If so, what did you like/dislike about the previous group's project?
  - No, only by client within the last month.
- Are we creating a dog or horse model, or both?
  - Focus on dog this semester, and specifically, one limb of the dog
  - Which bones/muscles should be modeled?
  - In the animal model, do you have a specific breed in mind? Ex. Poodle vs Golden Retriever, Arabian vs thoroughbred
    - No specific breed
- What kind of 3D printer is available to us?
  - 3D printer on the 3rd floor is complex
  - There are rooms where we can book to work. (like MD1 - multidisciplinary 1)
  - Potentially could get a closet or storage space
- Do you want us to create models for the bones or are there already 3d cad designs created that we can use to start with
  - Have CT scans available to us, however a few of them are unusual (maybe the bone is broken or it has cancer or is only a segment.
- How do you envision the bones connecting together; Do you want the model to be entirely rigid or should the skeletal structure be able to move, and if it can move, do you want us to try to limit the range of motion to mimic real life?
  - Mimic real life
- How many students will be using the model at once? How many models should we make?
  - Group of students, we should work to produce one model at the end of this semester
  - 96 students in each class, three sections (31-32 people); work in groups not individuals…. Groups of 2-3 is ideal

- What is the anticipated outcome of this project, two bones attached together, multiple models
  - An area of the body (hip and hind leg) or shoulder area. Use a pre-existing model and add muscles that flex.

Client Meeting Notes:

- Looking to connect different muscles and show their type of movement
- Possibly a cat
- One specific limb that students struggle with the most?
  - Front limb attached by muscles only -- Hip
  - Back limb -- flexion vs. extension -- Shoulder
  - Focus on one of the other
- Cannot give us a bone model, but can give us a prototype of real dog bone
- Bone boxes
- Anatomy books
- Make it slightly easier to hook up and visualize.
- Represent the whole muscle and works accurately
- May need two separate mechanisms for flexion and extension.
- Connection points: magnets, velcro,
- Have attachment points distinguishable for each muscle
- Muscle should attach to entire surface area according to model
- One muscle and its movement at a time -- first year students would like to see one movement per muscle
- Potentially find free STL files of dog bones online that we could print using machines in the Makerspace
- Don't have to do the paw, because it can get complicated.
- Color coding would be nice, but we will have to see how it works. Colors can distract students and make them focus on memorizing the color rather than learning the muscle.

Task 1 : Print the Bones

Conclusions/action items: Now that we know more about the project, we can start doing more research and coming up with ideas of how to meet the specifications of the client.

2022/10/26: Client Meeting 2

LAUREN FITZSIMMONS - Oct 26, 2022, 1:36 PM CDT

Title: Client Meeting 2

Date: 10/26/22

Content by: Team

Present: Team

Goals: To document information and questions that were answered during the team's second client meeting.

Content:

Dr. Gunderson (questions related to quantifying muscle attachments)

- How exact do muscle attachment areas have to be? Estimation or exact surface area?
    - She has a model with all of the muscles painted on
    - Not incredibly specific
- Is it ok if we base our model off of border collie measurements?
    - It is okay
- Do you already know the locations and size of the shapes of muscle attachments and could provide us with this information, or should we figure this out more based on the book and more research?
    - Has a model; will give it to us (it is large)
    - As long as the muscle action doesn't change; it's okay to modify it
- Would you like us to focus on all muscles, or just the most important, largest ones for now?
    - Hard to answer; the hip is really important because most muscles start at the top and connect down
    - Quadriceps (important, but difficult)
    - Biceps femoris
    - Hamstring (semimembranosus and semitendinosus)
- Muscle attachments are more important than 3D printing bones
- Ideally have the two agonist muscles to show how one muscle's movement opposes the other
- Patella ?
    - Quadricep attaches to the patella; can just glue it
    - She wants the students to know what it is

Other Notes:

- Very excited about the possibility of seeing any of our possible designs
- Fascia prevents muscle from sliding all over the place; holds the muscles in place
- She really wants veterinary students to do more hands-on work rather than sitting in lecture.

- She has no expectations

Citation & Link: N/A

Conclusions/action items: Now that the team has more quantifiable information from the client, they can begin fabrication.

2022/10/26: 3D Printing Meeting

LAUREN FITZSIMMONS - Oct 26, 2022, 1:42 PM CDT

Title: 3D Printing Meeting

Date: 10/26/22

Content by: Team

Present: Team

Goals: To present information from the team's meeting with Dr. Peter Muir's postdoc regarding 3D printing of dog bones.

Content:

Peter Muir (questions related to CT scans and 3D printing)

- How do you currently connect your 3D printed bones? What is the best way to connect bones/create joints?
- Modifying STL files
  - Do we need to cut holes in bones for joints?
  - Placing indentation in bones for magnets?
- Do they 3D print specific dog breeds or a generalization of breeds?

Notes from meeting:

Meeting with postdoc :

- 3 - matic
- Talk to TEAM Labs about using ultimaker and drilling a hole
  - Jeff or jay

3-matic - need to get access to a computer with this software

Intuitive if you are familiar with CAD

STL file only includes info about surface of the object. How do you print the object with a hole that has a depth?

Increase the infill to make it less brittle

Get connections from him

Not sure how to print a hole.

In that case, print without editing files and talk to teamlab about best material to use

Printing with a hole in it would be much easier. Do research to figure out if it is possible.

3-matic -

Work with design tab

Make a cylinder -- add 2 surfaces in the STL file (has similar tools to solidworks like extrude and revolve)

Not a great mesh, go to remesh tab, click surface mesh, uniform 0.5-0.75 mm keep surface contours

Analytical > cylinder > method : fit cylinder or 2 points

Check out “pins and holes” on design tab

Cylinder -- axis

Ask dr. murphy how we can get access to a computer with 3-matic software (rest of the semester)

Need a couple of days to learn the software - someone needs to show us the computer and how to get on it. Need a list of dates and times where the computer is available.

Ppl that software is shared with:

Oliver wieben - Medical Physics

***Alejandro roldan alzate** -BME and ME -- ask if he has a grad student that can help us with technical questions. 2 or 3 grad students

*Hantang qin - ME - most time out of all of these professors.

Ask dr. muir if he can give us DICOM folder (DICOM -- file extension of a CT scan)

Import folder into mimics - same liscense of 3-matic

Not the best idea -- lots of work to convert DICOM to STL and render that -- and would still need to use the restricted software

Formlabs printer is better because has a smaller layer thickness which gives increased 3d printing accuracy

Citation & Link: N/A

Conclusions/action items: The team asked Dr. Murphy to email Dr. Alejandro Roldan-Alzate for the team's permission to access the restricted software. He has yet to respond. The team will follow up if he does not respond soon.

2022/11/18: Prototype Update

Molly Paras - Nov 19, 2022, 1:15 PM CST

Title: Prototype Update

Date: November 18th, 2022

Content by: Lauren Fitzsimmons & Molly Paras

Present: Team

Goals: Discuss our current prototype, WARF patent meeting, and when we can come in to survey their class.

Content:

- Either bone (nylon or PLA) one is fine … consider: cost? Time of removing supports?
  - Bones having weight is nice, but not super critical
- More durable the better … they are leaning more towards PLA for the purpose of this project
- Drawer liner (give it a texture similar to muscles)
- Materials given to us at the meeting
  - Silicone thickener
    - Make it more rigid
  - Dye silicone red
    - gave us some brown silicone dye, don't need to use it but could be fun
  - Swimsuit material
    - Add to mold with silicone, keeps it from ripping as easily
- Lab every day all day on Thursdays + active learning Monday and Wednesday 8:50-10:45, so may be best if we come in on a Monday or Wednesday to survey students since it can be an activity added in to the rotation.
- They have applied for patents before but WARF always said no. Consider the market and how we can make it more applicable to other markets like presenting the idea as something that could be used in veterinary or medical schools. Dr. Gunderson can be present at the meeting if we would like.

Citation & Link: N/A

Conclusions/action items: This was a very helpful meeting. Dr. Gunderson was very happy with the bones and really excited about the progress we made. They gave us some guidance in that they want the model to be durable rather than as accurate as possible, so we will move forward printing in PLA. They were also able to give us some supplies to enhance our product, along with giving us a little better understanding of what our meeting with WARF will likely look like. We are hoping to go into Dr. Gunderson's class in December to have students test out our model and get survey results. They also have a machine that we could possibly use to make molds for pouring silicone. Now we need to test out silicone a little more and finish our prototype.

2022/11/22: WARF Meeting

Molly Paras - Nov 22, 2022, 11:03 PM CST

Title: WARF Disclosure Meeting

Date: November 22nd, 2022

Content by: Molly

Present: Lauren Fitzsimmons, Zach Spears, Maggie LaRose, Emily Hutsell, Molly Paras, and Dr. McLean Gunderson

Goals: Discuss our product with Mr. Frushour at WARF and learn about the patent process.

Content:

- Met at the WARF Office Building with Brian Frushour, went through our presentation, showed different models we had, and answered any questions he had
    - mentioned how this could be a bigger market than just vet schools, could apply similar ideas to human anatomy as well
    - could also be useful for PTs and similar jobs to explain to patients what is wrong
    - discussed the market and what companies are currently out there that may be interested in our product
- He will meet with others on December 15th to discuss all disclosures from the past month and will let us know the next day if they will move forward with it or not
    - More likely that a company will want to produce it but not really patent, since it is more of a combination of different ideas already found in the market

Citation & Link: N/A

Conclusions/action items: While we may not end up with a patent out of this, it was a good experience to get to have an informal disclosure meeting and learn about the process. Zach and Lauren mainly presented our product, with the rest of us filling in here and there and Dr. Gunderson helping out with explaining the purpose of the product. We will hear back in December.

2022/09/16: Advisor Meeting 1

Molly Paras - Sep 17, 2022, 10:09 AM CDT

Title: Advisor Meeting 1

Date: September 16, 2022

Content by: Team

Present: Team + Dr. Murphy

Goals: Discuss the overall objectives/milestones for the semester and the details of our project with Dr. Murphy.

Content:

- 3D print bones of the shoulder or hip joint of a dog
  - Can use a 3D scanner in the makerspace or find stl file online
  - Can print paw as one thing instead of multiple bones, should print wrist bones, forearm, and one leading to shoulder
- Find a way to attach “muscles” to the bone the whole length of how connected it is in real life, detachable, mimic function of real dog muscles
  - Velcro or magnet?
- Use 3D printer at the Makerspace since the one at the vet school is broken
- $500, more if necessary
- Very durable- has to last a long time (how many years?), for groups of 5 students
- Try to figure out what client level of involvement will be
- Ask as specific as questions as you can
  - Logistics: Budget, testing (do they have equipment or students that we can test it with)
  - How long should model last?
- 3D print a mesh and fill it in with something?
- What is the focal point of the project -- accurate bones or muscle attachments?
  - Do we really need to 3D print the bones?
- Make sure our specifications are very specific
- Do the bone boxes include bones from the same dog?
- Schedule follow up with Dr. Gunderson
  - How often do we want to meet with her?
- Determine if we want to reschedule advisor meeting

Conclusions/action items:

Talking with Dr. Murphy we determined that we have a really cool project, but it might be hard to complete the 3D printing of multiple bones and designing/prototyping durable, realistic, removable muscles all in one semester. Thus, in our next meeting with Dr. Gunderson we should determine if the 3D printing of bones is entirely necessary at this point or if we should focus our time and energy on the muscle prototypes and utilize the bones that she currently has for this process. Based on the specifications determined with our advisor, client, and from research, we will complete the PDS this week and use that to start coming up with possible designs for our product.

2022/09/30: Advisor Meeting 2

Molly Paras - Oct 06, 2022, 2:04 PM CDT

Title: Advisor Meeting 2

Date: September 30, 2022

Content by: Team

Present: Team + Dr. Murphy

Goals: Discuss PDS, Design Matrix, upcoming presentations, and how the design process is going.

Content:

- PDS looks pretty good, comments released on canvas
  - make sure all requirements are testable (at the end of the semester, can you say if your design met the standards?)
- Dr. Murphy has a few contacts in the vet school/may know some people that do research using dogs who may have CT scans or a method for creating 3D printed bone models that he could possibly put us in contact with
- Start working on presentation, which is roughly 10 min plus questions
  - suggestion: split up so that each person is in charge of answering different types of questions so that it's not nobody or everybody trying to answer a question at the same time
- Might want to use model bones to start while waiting to 3D print bones so we can work on muscles and attachments more
  - split into two to three groups to start working on each of the different tasks (making muscle, making attachment point, printing bones)
- Last year the presentations got pushed off a week, but that will not be happening this year
  - allows for more time to work on project instead of spending more time preparing presentation and multiple possible designs
- This class is a lot of work (especially since only 1 credit), but in the end it is great experience and is a great resume builder, like no other programs in the country -- we've got this!

Citation & Link: N/A

Conclusions/action items: Now that we have decided on a final design, we should look into how to scan bones and 3D print at the Makerspace. In addition to this, we could talk to Dr. Murphy's contacts about how they go about printing bone models. We also need to determine the size and location of muscle attachments so that we can start designing those. Beyond prototyping things, we need to complete our presentation and preliminary report soon after that.

2022/10/14: Advisor Meeting 3

Molly Paras - Oct 14, 2022, 2:11 PM CDT

Title: Advisor Meeting 3

Date: October 14th, 2022

Content by: Team

Present: Maggie, Emily, Cora, and Molly

Goals: Meet with Dr. Murphy about our current progress in terms of starting fabrication.

Content:

Lauren and Zach were not able to make the meeting, but added some notes beforehand to make sure we discussed these topics during the team and advisor meetings. Following Lauren's notes are the notes from the meeting with Cora, Molly, Maggie, Emily, and Dr. Murphy.

Notes from Lauren:

- Great job everyone on the preliminary presentation!
- Next steps:
    - Over the weekend: Research background information for fabrication next steps (fabric pattern creation, best way to 3D model attachment points, etc)?
    - Early next week: Meet with Lennon from Makerspace for help with post 3D scan processing
- Goal for next week: Get 3D scanned files ready for printing, 3D print, begin to model 3D attachment mechanisms
- Looking ahead: Next major thing coming up is Show and Tell on Nov. 4th. (Bring in a prototype and receive feedback on it from other groups, pretty lowkey)

Meeting Notes

- Magnets and stuffing are coming next week
    - ***Update, they actually arrived this afternoon!
- How to get muscle attachment placement and shape
    - Should we focus on main muscles or be sure to include all of them?
        - For now, maybe just a few of the main ones and can consider adding more later
    - May need to 3D scan the hip, patella, and determine what to make paw out of
    - Surgical tubing for tendons?
- Meeting w/ Lennon at the Makerspace
    - Friday during class?
        - First determine size of bones
        - Then need to determine where we are placing magnets and which size magnets, along with muscle attachment size/shape
        - Determine muscle length/shape (but wait to determine this, for now keep focus on muscle attachments and bones)
- Maggie found a source with muscle sizes for different dog breeds

    - Maybe decide a dog breed to focus on? (boxer, doberman, belgian shepherd)

- Maybe communicate with Peter about 3D printing dog models (Dr. Murphy connection)
- Schedule a meeting with client to discuss quantifying muscle attachment areas
- Never stop thinking about testing

Citation & Link: N/A

Conclusions/action items: This week we need to email Peter (vet school contact), Dr. Gunderson (client), and Lennon (Makerspace) to ask questions and figure out times to meet. They may have some resources for us so that we do not have to create all these things (like figuring out how to attach bones to one another or size/placement of muscle attachments) from scratch. We will also be splitting up into two teams soon to be more efficient.

2022/10/28: Advisor Meeting 4

Molly Paras - Oct 30, 2022, 11:13 PM CDT

Title: Advisor Meeting 4

Date: October 28, 2022

Content by: Team

Present: Team

Goals: Meet with our team and then with Dr. Murphy, discussing our mini team meetings this week and future goals.

Content:

Key takeaways:

- Magnetism affected by hot glue
- Not sure if magnets is a viable options
  - Velcro - not great for small insertions
- Bones
  - 3D printing and drilling - talk to team lab
  - File rendering - meeting with alejandro later today
- Ask Dr. Murphy what would be feasible for our team to have fabricated at show and tell
  - Contact strips (maybe not the strongest, but you can control the area)
  - Liquid adhesive (control surface area)
  - Using hooks for smaller surface areas and another option for larger SA

What if the outer area was the current muscles we have created and then the inside was what the client has already created? This could then mean we could use her model and magnets to cover the full surface area. Sort of like a sheath around the outside of the core which is the rubber band.

Magnets attached to something more rigid, which is then attached to the fabric.

Talking with Dr. Murphy

- Could we use an adhesive? Maybe something like command strips? What about velcro?

Citation & Link: N/A

Conclusions/action items: We are a little stuck, as we are not sure if our magnets will be strong enough. We are meeting with Dr. Roldan Alzate this afternoon about using his 3-matic software to edit our scanned files. Hopefully we can do some more tests and get back to moving forward with our project.

2022/11/11: Advisor Meeting 5

Molly Paras - Nov 19, 2022, 1:16 PM CST

Title: Advisor Meeting

Date: November 11th, 2022

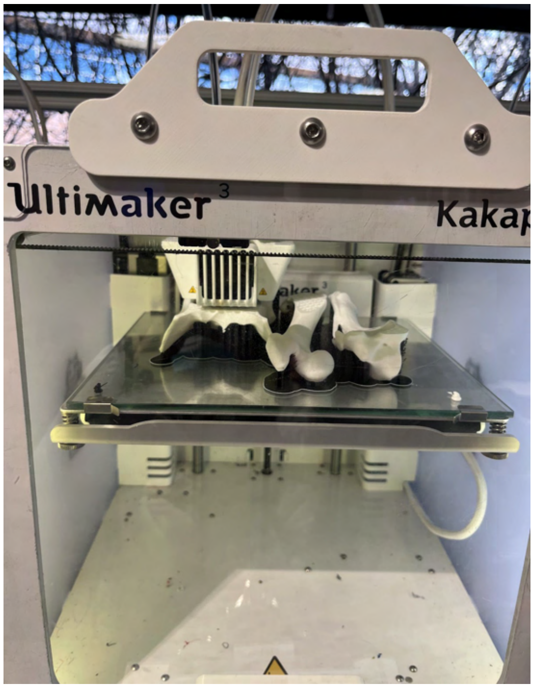
Content by: Molly Paras

Present: Team

Goals: Discuss where we are currently with our prototype, problems, and future plans.

Content:

- Print nylon tibia/fibula and resized bones in tough pla without holes
- Muscle ideas from Dr. Murphy
    - Theraband
    - Balloon
        - Fill with something like cornstarch or a viscous liquid
    - Silicone
        - Look into if there is any heat generated when pouring the silicone
- Patent
    - File disclosure with WARF (online, easy form)
    - Publicly disclosed on final presentation date
- Testing
    - Include durability testing (force when attached and detached a bunch of times)
- Get most of fabricating done by thanksgiving, then do testing
- Next week:
    - Meet with Dr. Gunderson next Friday hopefully
        - Discuss paying for things at Makerspace/getting reimbursed
        - Figure out how to do testing with their students
        - Discuss patenting
    - Order silicone kit for muscles
    - Get prototype and USB back from James
    - Pick up 3D printed parts, get rid of supports on PLA model and test out drilling holes in nylon model
    - Test strength of magnetic strips
    - Meet on Tuesday (12-1pm) and Thursday (12-???) to fabricate/test



Citation & Link: N/A

Conclusions/action items: This meeting was pretty productive in that we got a couple new ideas for how to better fabricate the muscles. We need to meet with our client soon to check in on some things, but overall it is going well, we just need to spend more time fabricating and testing the materials and methods. We also should begin planning our testing processes and doing what we can now.

2022/11/18: Advisor Meeting 6

Molly Paras - Nov 19, 2022, 1:23 PM CST

Title: Advisor Meeting 6

Date: November 18th, 2022

Content by: Lauren Fitzsimmons & Molly Paras

Present: Team + Dr. Murphy

Goals: Discuss how to best create silicone molds and our testing plans.

Content:

After sharing our current testing ideas, here are some of the suggestions that Dr. Murphy gave:

- Build in a safety factor for individual stress events
- Test force able to be withstood
- Flex/extend the product 100 times and then retest force

WARF Presentation Consideration Suggestions:

- Market -- who would license this and use it for prototypes
- Competition?
- Market size?
- Companies that would be interested?
- If WARF passes... Still not the end of the road … provisional patent application possible, but costs a couple thousand dollars
- Bring physical prototype

Silicone Suggestions:

- Could we use an actual dog muscle to make a 3d mold?
- Can make the muscle out of playdough, pour a silicone mold and put the muscle in, and then take it out so you have a mold for the silicone muscle made out of silicone (maybe costs more than 3D printing?)
- Attaching two halves of silicone should be easy, when materials is not cured but is generally solid, flip one half onto the other half and they will stick together when they dry

Citation & Link: N/A

Conclusions/action items: Dr. Murphy was able to give us some guidance with our silicone, suggest questions to be prepared for with our meeting with WARF, and gave ideas in how we could improve our testing methods.

2022/12/02: Advisor Meeting 7

Molly Paras - Dec 04, 2022, 4:35 PM CST

Title: Advisor Meeting 7

Date: December 2nd, 2022

Content by: Molly Paras

Present: Team

Goals: Get advice on what to include on our poster, figure out what all needs to be done by the end of this weekend.

Content:

- Poster due by 12/9 (submit to website by 10 am), print by 12/7, email Dr. Murphy by Tuesday
- Free pizza before the presentation
- Final report due 12/14 - don't worry about this too much right now
- Testing on Monday (11:50am - 1:20pm
- Put testing on poster even if it doesn't look like what we want it to
- Send poster draft by Wednesday at the latest
- Speak really loud since LOTS of people at presentations
- If bring in other props, make sure to relate that to the final design
- No progress report next week
- Schedule final meeting after final report is due
- Overall explain if the product meets the specs
- Take pictures, maybe videos (can put on laptop in front of poster) when testing

Citation & Link: N/A

Conclusions/action items: We got some good advice for what to include in our final poster and prototype. Mostly this is just proof of concept so it's ok if things don't look super nice or perfect, but we should make sure to get lots of testing done and compare that to specs. We are meeting with vet students on Monday to survey them on our product.

- Stress test bones and muscles
- Pick up bones
- Dremel and sand
- Divide sections of poster and work on getting it done by Tuesday
- Make another muscle/smooth them out
- Meet on Saturday & Sunday

2022/09/27: Design Options Meeting

Title: Design Matrix/Options Meeting

Date: September 27, 2022

Content by: Team

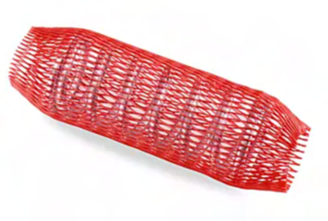
Present: Team

Goals: Determine what our top design options will be for our design matrices.

Content:

Muscle

- Polyethylene netting tube with plastic(?) portions capping off the ends containing magnet/muscle attachment method



https://www.uline.com/Product/Detail/S-6581R/Netting/Protective-Netting-2-4-x-164-Red

- Spandex/knit fabrics
- Elastic band/fabric
- Resistance band (might be the same thing as elastic band?)
- Nylon: https://news.mit.edu/2016/nylon-muscle-fibers-1123
- Dielastic polymer: https://www.nature.com/articles/539333c
- Silicone rubber: https://www.wcu.edu/WebFiles/PDFs/KS_Sparks_Tanaka.pdf
- Dragon Skin or Ecoflex

    Pros: very durable, smooth finish

    Cons: would need a mold to pour in, requires a vacuum for air bubbles

    https://www.smooth-on.com/product-line/dragon-skin/?pk_campaign=dynamicsilicone&pk_kwd=&gclid=CjwKCAjwm8WZBhBUEiwA178UnEDEHwZ9cHNOyHQVy

    https://www.smooth-on.com/products/dragon-skin-20/

Muscle attachment

- Magnets
    - Tiny magnets on amazon
        - https://www.amazon.com/FINDMAG-Refrigerator-Magnets-Premium-Whiteboard/dp/B08M3GHMWN/ref=sr_1_3_sspa?gclid=CjwKCAjwm8WZBhBUEiwA178UnOxvfCw3cwDqoPKaPUMdpsGJptVP269tT0TvQ2QV153y3PPw5QYtUBoCM0MQAvD_BwE&hvadid=174219166229&hvdev=c&h 66620330630&hydadcr=24656_9648981&keywords=mini%2Bstrong%2Bmagnets&qid=1664248426&qu=eyJxc2MiOiI0LjY3IiwicXNhIjoiNC4zMSIsInFzcCI6IjMuNzcifQ%3
    - Magnetic Strips
        - https://amfmagnets.com/products/magnetic-strip-neodymium-1m-x-12-5mm-x-1-5mm-non-adhesive?variant=40370935333014&currency=USD&utm_medium=product_sync&utm_source=google&utm_content=sag_organic&utm_campaign=sag_organic&utm_source=goog 4BqrpggtTBIJbFXMKZyQW3dyKHgnQCbrnb_MuFBoCkKwQAvD_BwE&gclid=CjwKCAjwm8WZBhBUEiwA178UnIJ1gL2zh4rAaJ-4BqrpggtTBIJbFXMKZyQW3dyKHgnQC
        - PROS: Very thin (1.5mm), can cut to customize surface area, flexible
        - CONS: How magnetic will they actually be?
    - Thin disk magnets
        - https://www.amazon.com/Universal-Magnetic-Sticker-Fastener-Multi-Use/dp/B07B3X5ZC4
        - PROS: Probably a more magnetic magnet than strips.
        - CONS: Not flexible, cannot customize surface area, bulky, heavy
- Velcro (Simplistic, but could work well)

  - https://www.amazon.com/VELCRO-Brand-PS51-PS52-5cmx1m/dp/B01M7P18HP/ref=asc_df_B01M7P18HP/?tag=hyprod-20&linkCode=df0&hvadid=416690262181&hvpos=&hv 350197122143&psc=1&tag=&ref=&adgrpid=93604214773&hvpone=&hvptwo=&hvadid=416690262181&hvpos=&hvnetw=g&hvrand=16929207095745312848&hvqmt=&hvdev=c
  - PROS: thin, easy to work with, flexible
  - CONS: not as cool as magnets, harder to attach/detach
- Hooks, then have an elastic stretch around them

Conclusions/action items: We talked through the pros and cons of each of the different options that we all researched for both muscle and muscle attachment materials. We de attachment portion and elastic band, silicone rubber, and spandex/fabric for our three options.

2022/09/30: Team & Makerspace Meeting

Molly Paras - Oct 04, 2022, 8:38 AM CDT

Title: Team and Makerspace Meeting

Date: September 30, 2022

Content by: Team

Present: Team

Goals: Order materials (send out email over the weekend, goal to order on Monday), plan for preliminary presentation and deliverables.

Content:

Meeting Notes

- Copied presentation template from last year, split up slides
- Materials needed to order:
  - Magnets
  - Stuffing
  - Multi-colored spandex
  - Surgical tubing for joints?
  - Future: Stand for model?
  - 3D Printing of Bones
- Meeting Thursday night for practice presentation at 8pm at ECB
- Weekly meeting Sunday nights 7:15pm
  - Materials summary of order

Makerspace Notes

- STL files could be found online and used, but it is better to find individual files of each of the bones rather than put together
  - this may make it hard to find all the bones from the same dog that are accessible/downloadable
- Scanning is really easy and specific, just may take a bit of time to upload
  - changing size of object will make the resolution worse
- Come in and talk to a 3D printer/scanner technical staff specialist in the Makerspace (availability is online on the website)

Citation & Link: N/A

Conclusions/action items: In our team meeting, we decided to order magnets, different colored spandex fabric so muscles could be more easily told apart, a small amount of stuffing to fill the spandex after it is sewn to shape, and the rest will be 3D printed. Surgical tubing (for connecting joints) and a stand may be provided by the client, we just need to confirm this. After our meeting we talked to a shop manager at the Makerspace and determined that it may be better to 3D scan all of the bones that we have in the bone box since individual STL files of a lot of bones from the same dog may be hard to find online. Next, we have to actually order our materials and prepare for our preliminary presentation.

2022/10/09: Preliminary Report Meeting

Molly Paras - Oct 09, 2022, 7:41 PM CDT

Title: Preliminary Report Meeting

Date: October 9th, 2022

Content by: Team

Present: Team

Goals: Edit, review, and ask questions about report, along with other goals for this week.

Content:

- Try to put more dimensions on things if possible
    - Hard to do with some of our drawings because we are using an example bone in the drawing but in real life we are making multiple different bones with different dimensions along with different dimensioned muscle attachment points
- Abstract will be written last, once the rest of the report is done
- Make sure to include drawings and lots of specifics, but some parts (like PDS and materials table) can be added as an appendix at the end of the report and just referenced earlier
- Splitting up research/background section into multiple parts, so can be better organized and flow better
- This week we should email the makerspace to get help with post-processing of our STL files so that we can start printing those

Citation & Link: N/A

Conclusions/action items: It is pretty clear what we each need to do for our sections and so far it's looking good. We decided we will have it all finished on Tuesday so that we have a day or so to edit and look over our report. Molly is going to email Lenin at the Makerspace to get some help with the post-processing of our scans from last week.

2022/10/18: Materials Meeting

Molly Paras - Oct 18, 2022, 1:12 PM CDT

Title: Materials Meeting

Date: October 18th, 2022

Content by: Maggie and Molly

Present: Maggie, Zach, Lauren, Cora, Molly

Goals: Take a look at all our materials and plan.

Content:

- Next time either go to makerspace or bring fabric scissors
- Choosing to use border collie as model breed
- Bone model options
    - Axis scientific
    - 3D printing
        - Scanned bones, processed
        - Files from Peter
- Muscle attachments
    - Magnet into bone or muscle attachment on bone first? — muscle attachment plastic piece connects to fabric, single magnet on bone
        - Hard to process 3D printed bones precisely
        - Maybe only work on bigger muscles for now
- Design Decisions
    - Magnet ON TOP of bone, not in
    - Plastic attachment piece has slot to fit over magnet, other magnet on following side
    - Fabric glues around edge of plastic piece

Questions:

Dr. Gunderson (questions related to quantifying muscle attachments)

- How exact do muscle attachment areas have to be? Estimation or exact surface area?
- Is it ok if we base our model off of border collie measurements?
- Do you already know the locations and size of the shapes of muscle attachments and could provide us with this information, or should we figure this out more based on the book and more research?
- Would you like us to focus on all muscles, or just the most important, largest ones for now?

Peter Muir (questions related to CT scans and 3D printing)

- How do you currently connect your 3D printed bones? What is the best way to connect bones/create joints?
- Modifying STL files
  - Do we need to cut holes in bones for joints?
  - Placing indentation in bones for magnets?
- Do they 3D print specific dog breeds or a generalization of breeds?

Citation & Link: N/A

Conclusions/action items: We will be meeting with Dr. Gunderson and hopefully Peter this week. We are also trying to make a mock model to understand if our idea is going to work. Our team is concerned about magnet size, but we will see when we go pick them up.

2022/10/23: Prototyping Meeting 1

Molly Paras - Oct 23, 2022, 9:50 PM CI

Title: Prototyping Meeting

Date: October 23, 2022

Content by: Team

Present: Team

Goals: Look at all the materials we have and figure out how to make our muscle attachments.

Content:

- Muscle attachment options
    - Should we pour silicone strips and cut them to the shape of the attachment points?
        - How would we attach fabric to silicone? Sew it into silicone? Glue it?
        - https://www.amazon.com/Silicone-Turquoise-Platinum-Casting-Molds-1/dp/B08ZJF2D22/ref=sr_1_1_sspa?keywords=silicone%2Bmold%2Bmaking&qid=1666574166&qu=eyJxc2MiOiI1LjU1IiwicXNhIjoiNS4xNCIsInFzcCI6IjQuOTcifQ%3D%3D&sr=8-1-spons&th=1
    - Silicone on bone directly (not just magnet attached to bone)
    - Maybe a material firmer than silicone?
        - 2 part epoxy putty
        - Air-dry clay for mock-up
- Looks vs effectiveness
- Method 1: magnet directly on bone, magnet in *silicone
- Method 2: magnets both in *silicone

Steps

1. Muscle attachment: firm or stretchy
    1. How strong is silicone? Leaning towards firm attachment point
        1. Start with firm, look into silicone this week (ORDER)
2. Meet in two small teams (method 1 vs method 2)

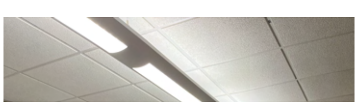
What we need

- Super glue
- Play-doh
- Silicone?

Goals for this next week

- Pick one muscle to model
- Use play-doh to sculpt out an attachment point

While discussing these things, we also tested the strength of the different sized magnets in hot glue, between a few layers of fabric, and tried sewing a little bit of the fabric. An image of one of our practice muscles can be found below.



Citation & Link: N/A

Conclusions/action items: We came up with a lot more questions about our product while meeting today. We have to decide if we will have one of the magnets glued onto the bone or within a piece of material, and we decided that the small muscle attachments will be straight on the bone. As for the other attachments, we are going to try out a few options this week and decide based on that.

2022/10/28: Meeting with Dr. Roldan Alzate

Molly Paras - Oct 30, 2022, 11:30 PM CDT

Title: Meeting with Dr. Roldan Alzate

Date: October 28, 2022

Content by: Maggie, Emily, Zach, Lauren, Molly

Present: Maggie, Emily, Zach, Lauren, Molly

Goals: See if we can use 3-matic to make some holes in our STL files.

Content:

- We need some holes so that we can put surgical tubing through the bones to connect them
    - Seems like mimic's 3-matic software is perfect for what we need to do
- In his lab, Alejandro uses this software a lot to make holes of arteries and such in hearts or bladders
    - One of his grad students, James Rice, can help us out with editing the file
- Don't know exact location right now of holes, but will make a plan and meet with James about it next week (Tuesdays and Thursdays work best)
    - Can meet at the ME building or WIMR

Citation & Link: N/A

Conclusions/action items: After having a week full of unanswered questions and uncertainty about our design, it was great to end on a high note with our meeting with Alejandro and James. They seemed curious about our project and were very helpful, showing us how the software works and offering up time in this next week to get our work done. We really appreciate their time and are excited to be able to move forward with the 3D printing of bones.

Molly Paras - Nov 06, 2022, 10:36 PM CST

Title: Meeting with James

Date: November 2nd, 2022

Content by: Molly

Present: Zach, Maggie, Emily, and Lauren

Goals: Use 3-matic software to make some holes in our STL files so that we are able to connect the bones once they are printed.

Content:

James was able to create holes in our scanned files in similar areas as the model that Dr. Gunderson gave us. We really appreciate his time and willingness to help us out. The STL files are attached below.

Citation & Link: N/A

Conclusions/action items: We were able to get the files edited by James and ready for printing. They will be sent to the 3D printer at the Makerspace to be printed in PLA so we can make sure the holes are a good size and in a good spot.

Molly Paras - Nov 06, 2022, 10:37 PM CST

Download

femur_left_Scaled_1.5_with_Holes_V2.stl (2.08 MB)

Molly Paras - Nov 06, 2022, 10:37 PM CST

Download

Pelvis_Scaled_1.5_w_Hole.stl (6.34 MB)

Molly Paras - Nov 06, 2022, 10:37 PM CST

Download

tibia_fibula_left_Scaled_1.5_w_Holes.stl (2.13 MB)

2022/10/30: Show & Tell Week Prep

Molly Paras - Nov 06, 2022, 10:19 PM CST

Title: Show & Tell Week Prep

Date: October 30, 2022

Content by: Team

Present: Team

Goals: Make a plan for the week to be prepared for show and tell on Friday.

Content:

- Bone Box Bones
  - Femur: 106.5 mm
  - Tibia/Fibula: 100 mm
  - Patella: 14.43 mm
- Axis Scientific Model
  - Femur: 17.15 (knob) + 147.21 = 164.36 mm
  - Tibia/Fibula: 27.63 + 139.36 = 166.99 mm
  - Foot (heel-ankle): 134.69 mm
  - Patella: 17.19 mm
- Proportionality:
  - Femur = 164.36/106.5 = 1.54%
  - Tibia/Fibula = 166.99/ 100 = 1.67%
  - Patella = 17.19/14.43 =
- Diameter of holes on Axis Scientific model is 2.95 mm (or maybe 3 mm)

TO DO:

Monday – 2:25-4 … [Emily, Maggie, Molly]

- 3D scan the hip and patella (already have femur and tibia/fibula)
- Ask them about sizing up files?
- Ask about the queue for the nylon printer .. realistic to have something printed by Friday?
- Ask how to submit files for printing
- Bring thumb drive to put files on

Tuesday – either 8-9, 12-1, 3-4

- Meeting with James Rice to add holes to bones
- Make sure whoever goes brings the thumb drive!
- Shoot to make 3mm holes in model

After that – Submit files to Makerspace for printing

For now, thinking of using both magnets and hooks (for small points) to attach muscles.

Citation & Link: N/A

Conclusions/action items: We measured the bones from the bone box to be able to know how much we need to scale up the scanned files. Our team will go to the makerspace to scan the last few bones that we haven't already, meet with James to edit the files, and hopefully get something printed this week. We will have another meeting on Thursday to discuss our goals for Show & Tell and try working with the muscles a little more.

2022/11/05: Show & Tell Responses

Molly Paras - Nov 05, 2022, 12:58 PM CDT

Title: Show & Tell

Date: November 4th, 2022

Content by: Team

Present: Team

Goals: Gather ideas from other students to solve some of our issues.

Content:

We split into two teams to take turns going around the room and hearing other people's projects vs presenting our own, which is why the following information split into two sections.

Part 1:

- Hooks around outside/border of attachments
  - More hooks around entire area
- Velcro - need to test strength and wear
- Foam for muscle material
- Stronger magnets?
- Add loops to fabric on each end for hooks option
- Bungee cord fabric
- Braid bundles of elastic material
- Double sided tape
- Tac for walls
- Ridges with friction that resist against falling off when stretching
- Earring clasps - clips in or earring back
- Circular disk that you put in and twist??
- Still keep hooks but have thicker muscle around elastic band to show true muscles and their surface area
- Extrude a slot before print
- Removable bone parts

Part 2:

- Make model a lot larger than real life so you don't have to worry about thickness of bone
- Magnetic cable ties
- Springs that withstand specific forces
- Change tension by changing force of muscle without attachment or detachment
- 3D print out of magnetic material?
- Magnetic paint?
- Multiple hooks that come together at one point

- Put big magnets inside of the bone?
- Snaps

To do on Sunday:

- Experiment with Velcro (go to makerspace and get velcro)
- Experiment with wire or springs inside of muscles
    - Springs available in makerspace (may be a bit stiff though)
- Order very small hooks or ask dr. gunderson if they have any smaller hooks
- Over the weekend: 3D print the bones

Citation & Link: N/A

Conclusions/action items: This was a fun experience to be able to hear other peoples' projects and think of ideas, but we didn't get a ton of helpful feedback. A lot of people just said something like, "Oh wow, yeah you're project sounds deceptively hard," but we did get some suggestions of using velcro or finding ways to enhance the magnets/make the whole dog magnet. We are going to try to explore a few more options, but need to just move forward with one thing soon since the semester is over halfway over.

2022/11/27: Post-Thanksgiving Team Meeting

Molly Paras - Nov 27, 2022, 8:21 PM CST

Title: Post-Thanksgiving Team Meeting

Date: November 27, 2022

Content by: Cora Williams

Present: Team

Goals: Revisit what we ended up prototyping before break and make plans for the final two weeks.

Content:

- Removed model muscles from silicone and plaster molds
  - Found that it was difficult to remove the clay from the molds, especially from the silicone cup mold and the plaster mold
- Poured silicone in all three molds to create muscles
  - Found out silicone cures really fast when mixed thoroughly
- Goals for the end of this project
- Create three muscles (2 antagonist and 1 other)
  - Deep gluteal m. (Brown muscle)
  - Adductor m. (Red muscle)
  - Gastrocnemius (Light pink)
- Give vet students model and have them fill out survey next Monday

TO DO THIS WEEK

- Email Dr. Gunderson about bringing in the model on next Monday
- Do MTS machine testing of bones - (Monday, November 28 @ 12:15 PM) - Molly, Zach
- Spring force testing of muscles and magnet strength
- Reprint bones with white supports -- LAUREN
- Remove new muscles from mold and attach magnets (Monday, November 28 @ 2:15 PM) - Cora, Emily, Maggie

Citation & Link: N/A

Conclusions/action items: The poster presentation for this class is coming up really soon, so we are hoping to get a lot of work done on a prototype so that we can test and make our deliverables in time. The action items for this week are listed above, in the content section.

Expenses Spreadsheet 9/30/2022

Maggie LaRose - Oct 11, 2022, 4:27 PM CDT

Last updated: 10/11/22

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link
Attachments								
Disk Magnets	Heavy Duty Neodymium Magnets	TRYMAG	MIX 255Pc	10/2/2022	1	$16.99	$16.99	Magnets
							$0.00	
Muscle Materials								
Polyester Stuffing	3.5oz Premium Fiber Fill Stuffing	NOVWANG	Z-37_28	10/2/2022	1	$8.49	$8.49	Stuffing
Nylon Spandex	1/2yd Nylon Spandex Matte Tricot Fabric	FabricLA	Precuts	10/2/2022	5	$9.90	$49.50	1/2yd Fabric
Misc. (optional)								
Surgical Tubing	3/8" OD Latex Surgical Tubing	SUCOHANS	N/A	10/2/2022	0	$8.99	0	Surgical Tubing
Lab Stand	Chemical Resistant Steel Lab Stand Set	Eisco	FBA_LABSTANDSET	10/2/2022	0	$37.89	0	Lab Stand
Hindlimb Model	Axis Scientific Canine Hindlimb with Foot	Axis Scientific	A-109194	10/2/2022	1	$72.00	$72.00	Axis Scientific
						TOTAL:	**$146.98**	

Expenses 12/12/2022

Maggie LaRose - Dec 12, 2022, 4:28 PM CST

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link
Attachments								
Disk Magnets	Heavy Duty Neodymium Magnets	TRYMAG	MIX 255Pc	10/2/2022	1	$16.99	$16.99	Magnets
Neodymium magnet tape	neodymium magnetic tape strips, 2 pack	Strongman Tools	2100GS	11/6/2022	1	$22.99	$22.99	Magnetic Strips
Gorilla Glue	Gorilla Super Glue Gel	Gorilla Glue	N/A	11/6/2022	1	8.88	8.88	
Muscle Materials								
Polyester Stuffing	3.5oz Premium Fiber Fill Stuffing	NOVWANG	Z-37_28	10/2/2022	1	$8.49	$8.49	Stuffing
Nylon Spandex	1/2yd Nylon Spandex Matte Tricot Fabric***	FabricLA	Precuts	10/2/2022	5	$9.90	$49.50	1/2yd_Fabric
Silicone	Smooth-On Ecoflex 00-50 Platnium Silicone 2 lb Kit	River Colony Trading		11/12/2022	1	39.49	39.49	
Plaster	50 lb Diamond Veneer Plaster Finish	USG	1836857	11/15/2022	1	0	0	
Silicone Mold Release	mitreapel silicone mold release spray (14.4 oz) release agent aerosol	Benasse	N/A	11/12/2022	1	16.99	16.99	
3D Printing								
Bone print	Dog hindlimb bones: pelvis, femur, tibia	UW Makerspace	N/A	11/10/2022	1	4.8	4.8	N/A
Silicone Mold	Mold for pouring silicone	UW Makerspace	N/A	11/15/2022	1	10.8	10.8	N/A
Misc.								
Surgical Tubing	3/8" OD Latex Surgical Tubing	SUCOHANS	N/A	10/2/2022	0	$8.99	$0.00	Surgical Tubing
Lab Stand	Chemical Resistant Steel Lab Stand Set	Eisco	FBA_LABSTANDSET	10/2/2022	0	$37.89	$0.00	Lab Stand
Hindlimb Model	Axis Scientific Canine Hindlimb with Foot	Axis Scientific	A-109194	10/2/2022	1	$72.00	$72.00	Axis Scientific
						TOTAL:	**$250.93**	
	***for fabric, get colors white, yellow, green, red, and blue							

2022/10/05: 3D Scanning 1

Molly Paras - Oct 05, 2022, 12:34 PM CDT

Title: 3D Scanning 1

Date: October 10th, 2022

Content by: Molly Paras

Present: Molly Paras, Zach Spears, Maggie LaRose

Goals: Start the 3D scanning process at the Makerspace.

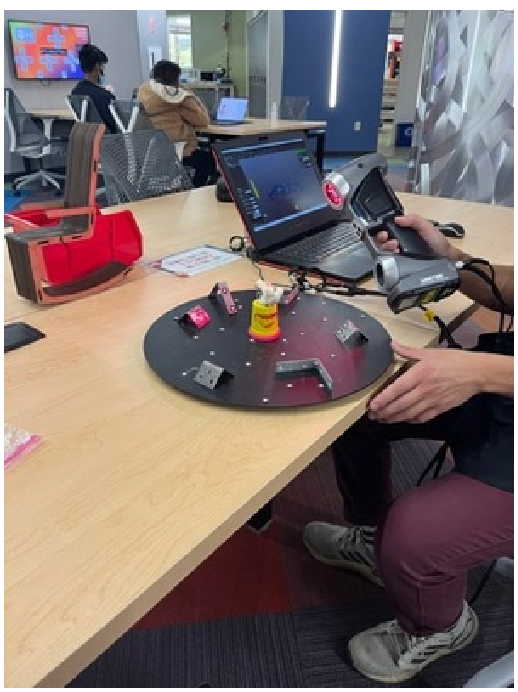
Content:

- Met with Kirk (Makerspace Technical Staff)
- Used Creaform handy scan to scan the left femur and tibia/fibula combo (femur with blue and connected tibia/fibula from canine bone box)
- STL files are on Maggie's USB
    - download meshmixer (free) to edit the design before printing or V2elements (on Makerspace computers)
    - email makerspace and ask for Lenin for post-processing help
- Can use formlabs printer with nylon material
    - may have to wait a bit (up to a week) to print

Citation & Link: N/A

Conclusions/action items: We got two types of bones scanned (femur and then tibia/fibula were combined) into stl files. If we want to edit them (scale them up, cut circles out, etc.) we should email the makerspace and set up a time to do post-processing. Kirk recommends using the formlabs printer that uses nylon powder to print, so next we have to edit and prepare to print.

Molly Paras - Oct 05, 2022, 12:07 PM CDT



Download

Scanning_left_femur.jpg (52.5 kB)

2022/10/26: Muscle Fabrication 1

LAUREN FITZSIMMONS - Oct 26, 2022, 1:33 PM CDT

Title: Muscle Fabrication 1

Date: 10/26/22

Content by: Maggie, Lauren, Emily

Present: Lauren

Goals: To record notes taken during the teams initial muscle fabrication session.

Content:

- The team began looking into Method 2 (Magnets both directly in silicone, one silicone is attached to the bone already, and the other is attached to the muscle)
    - Right away, they found that since the muscle is so small, adding an additional attachment onto the bone causes it to look extremely bulky and greatly hinders aesthetics of model.
- The team created two prototypes -- one with clay and one with hot glue
    - Maggie and Lauren worked on the prototype with the hot glue. The magnets were embedded into the glue but were either extremely close to the surface or placed on top of the glue on the surface. This was done to maximize the magnetic force of the magnets.
        - Even with the magnets at the surface of the attachment mechanism, the magnetism was very weak.
            - The team discovered that this is because when magnets are exposed to heat, their magnetism is permanently weakened.
    - Emily worked on the prototype with the clay. She cut out a circle to stick the magnet into.
        - While the clay was easier to create since it was malleable, it didn't reliably hold the magnet. The team also didn't progress enough with this idea to fully test it out.
- Next, the team attempted to create a muscle out of fabric.
- Early on, the team decided that the muscle model would have to be in permanent flexion in order to have consistent lengths between muscle origins and insertions for measurement purposes.
    - The team taped the dog model in constant flexion for a short term solution.
- It was much harder than expected to create a muscle.
    - The team had to measure each attachment point, find the circumference of areas that were not perfect shapes, and then translate the 3D muscle into a 2D pattern. Since the muscle attachments were such odd shapes, this proved to be extremely difficult.
        - Emily looked into an online software that could do this for us, but could not find anything.
    - Both Lauren and Maggie attempted two different fabric patterns for the muscles, however, could not determine the correct shape for the muscle pattern.
    - Takeaway: We previously thought that fabricating the muscles would be the final step since it would be the easiest. However, this will not be true.

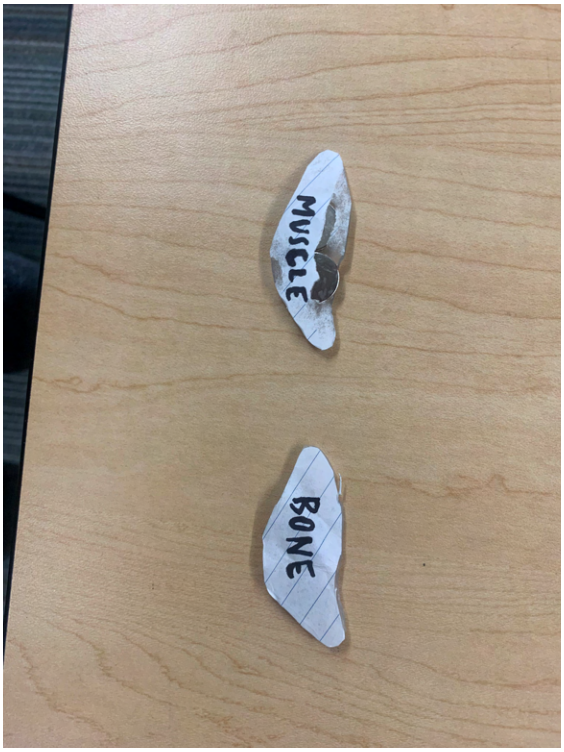


Figure 1 (above): Initial fabrication of muscle attachment mechanisms made out of hot glue. The hot glue was mounted on paper.

Figure 2 (above): Axis scientific muscle with two muscle attachment surface areas labeled.

Figure 3 (above): Measuring the fabric to determine the length of the muscle model.

Figure 4 (above): The model was taped in order to be in constant flexion. This will aid the team in obtaining accurate and consistent measurements during fabrication of the muscle models.

Figure 5 (above): Muscle attachment mechanism made out of clay.

Citation & Link: N/A

Conclusions/action items: The fabrication session was very helpful, but the team came out of it with more questions than answers. Some things were conclusive:

- Hot glue cannot be used to make muscle attachments since it weakens the magnets

- Method 2 (both magnets in silicone) is very bulky and the team should not move forward with this method.

The team came up with more questions:

- What should the muscle attachment mechanism be made out of? Clay? Silicone? Should it be flimsy or hard?

- How will the team make the muscle attachment the least bulky as possible while still being sturdy?

- How will the team ensure that the magnets are strong enough to retain attachment to the model?

- Should the team glue the magnets directly onto the model? Should the team drill holes into the model to put the magnets into?

2022/11/06: Muscle Fabrication 2

Molly Paras - Nov 06, 2022, 10:3

Title: Muscle Fabrication 2

Date: November 6th, 2022

Content by: Lauren

Present: Team (Molly was unable to make it until the last 30 min)

Goals: Create a muscle that can be attached to the proper attachment points.

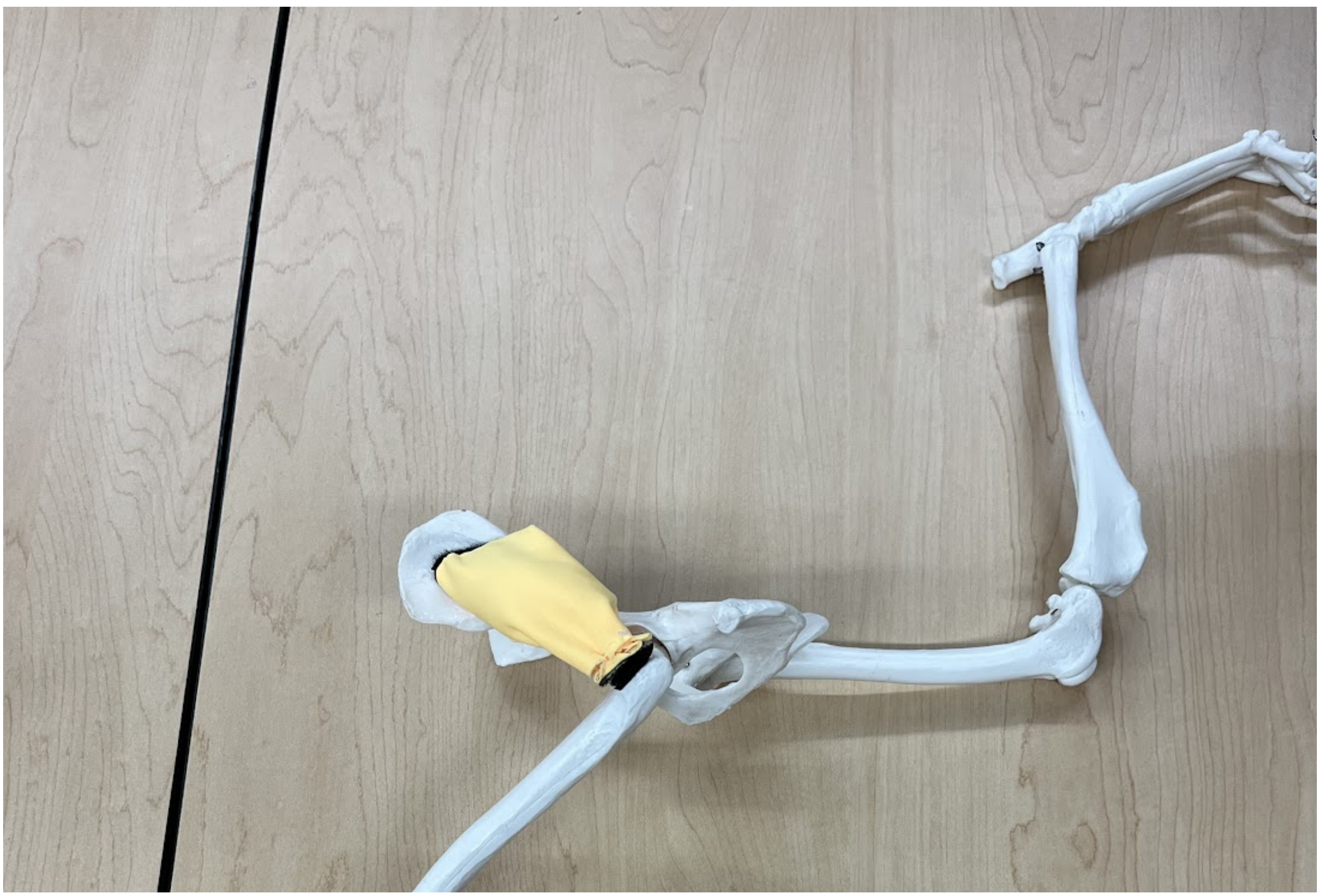
Content:

11/6 Meeting Notes:

Questions we have:

- How will we connect the muscles to the bones?
    - Magnets
    - Magnetic tape: https://www.amazon.com/NeoFlex-Flexible-Neodymium-Magnetic-3M/dp/B01IVJQM80/ref=sr_1_9?keywords=neodymium+magnetic+powder&qid=1667779740&sr=8-9
    - https://www.amazon.com/dp/B09717HXYR?ref=vse_pfo_vwdp
    - Velcro
- How will we make the muscles?
    - Braided - stretches more than when braided and stuffed
    - Braided and stuffed
    - Cut to shape and stuffed - more realistic

Using velcro from the Makerspace, we were able to cut shapes that properly represented the muscle attachment points. We then had one of our team members sew piec fabric into the shape and length of a muscle and stuff it with stuffing. The muscles were then sewed onto one piece of velcro, and the opposing velcro was stuck onto the example of this can be seen in the image below.



Next fabrication meeting on Tuesday 11-1 ish

- Superglue
- Dremmel
- Check out hooks from team lab
- Magnetic Tape

Citation & Link: N/A

Conclusions/action items: This was a very productive meeting, as many techniques were able to be fabricated and tried and decisions/plans were made. We found that velcro is stronger tha thought and could be used since it allows for us to go directly from muscle to bone without having to make an additional attachment piece to make the bone more flat. Overall we are excited to making progress, but are going to try a few more options for muscle attachment mechanisms this week. Also, the 3D printed bones should be ready to be picked up tomorrow.

2022/11/08: 3D Print Test 1

Molly Paras - Nov 08, 2

Title: 3D Print Test 1

Date: November 8th, 2022

Content by: Molly

Present: Team

Goals: Pick up our 3D printed model, see if it is good or if changes need to be made.

Content:

- Sanded down 3D printed bones, drilled the holes a little more
- Using tubing provided by Dr. Gunderson and wire from the makerspace, we were able to connect the bones at the holes we created
- Problems w/ Current Prototype
  - Decided that the holes are not in the best places, will need to meet with James again to move them to better placement (or just drill own holes)
  - Holes too thin
  - Need to size up the pelvis (right now the femur ball joint does not fit into the socket on the hip)
  - Hole on wrong side of pelvis!
- Supports were able to be removed, but took a lot of time
- Got magnetic tape- seems pretty strong, but have to experiment a little more
- Made another muscle but attached it with magnets instead of velcro
- Got some hooks from the makerspace
- Super glue also arrived


Dispose of Waste Properly
Leave What You Find
Minimize Campfire Impacts
Respect Wildlife
Leave No Trace


NO TRACE

Link: N/A

Conclusions/action items: The first iteration of our 3D printed bones turned out good. The holes need to be moved slightly, but it seems sturdy and good in shape. The hip will also need to b the femur and tibia/fibula are bigger comparatively. We ordered some magnetic tape, which also turned out to be really good as it is strong and flexible. We will reprint some new bones and co muscle fabrication methods.

2022/11/17: Week 11 Fabrication & Meetings

Molly Paras - Nov 17, 2022, 1:48 PM CST

Title: Week 11 Fabrication & Team Meetings

Date: November 17, 2022

Content by: Team

Present: Team

Goals: Create silicone mold/muscle, process printed bones, plan meeting with Dr. Gunderson.

Content:

11/15

- Printed silicone mold to ultimaker
- Sanded 3D printed bones
- Drilled holes
- Nylon print seemed to be more brittle and not really any better than PLA

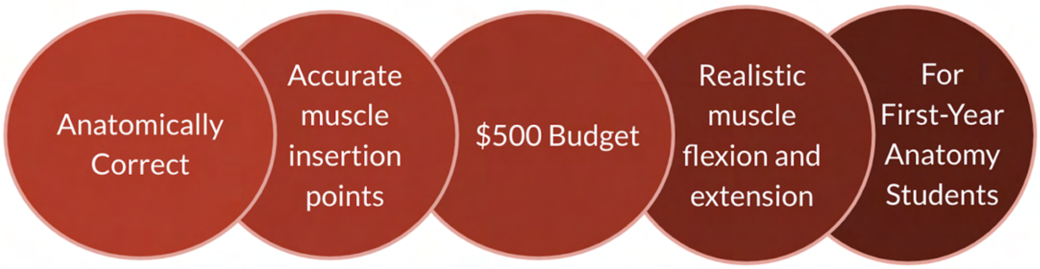
11/17

- Elastic band to join bones? Like on Axis Scientific
    - Found some at Makerspace and purchased
- Poured silicone model
- Drilled holes in bones
- Tried using dremel to make slot for magnet to fit in bone

Points to bring up with Dr. Gunderson:

- Discuss updates on product design
    - Bring bones that we have printed
    - Ask for feedback
    - Discuss design criteria
- Will we be able to survey her students? If so, when would work best?
- Ask if she wants to be included in patent application meeting
- How to pay for Makerspace prints/reimburse for what we've bought ourselves

Client Requirements



Molly Paras

Product Design Specifications

1	Accuracy	Must represent canine hindlimb bones and muscles to 95% degree of accuracy according to survey of veterinary students
2	Durability	Should withstand 180° flexion/extension (100 times) with no measurable decrease in attachment force
3	Reliability	Must attach/detach at the correct surface areas of real canine anatomy, according to *Miller's Anatomy of the Dog*
4	Life in Service	May be used by 96 students up to 12 hours a week for 5 years

Accuracy: Change to 70% degree of accuracy

Durability: Joints should withstand 90 degrees of rotation

Reliability:

Test #1:

Survey of vet students … ask if it is accurate … if 70% of people say yes, then it is a pass

If not, what could be fixed

Test #2:

90 degrees of rotation… manually flex and extend 100 times

Measure force before and after

Test #3: Reliability

Survey of vet students … give them images from the vet book … ask if model matches up with the anatomy textbook … need a percentage of ‘yes’ specified in PDS

Test #4: Life in Service

Crush bones with MTS machine

If bones can withstand X amount of force in X seconds (calculate force/time), they should also be able to withstand X amount of force for 12 hours per week for 5 years (calculate force over time). Compare two force/times. If mts is bigger it can work

Citation & Link: N/A

Conclusions/action items: We were able to make a lot of progress this week with printing a second iteration of the bones along with a nylon one. We were also able to drill holes and connect the bones so that they can properly articulate and start making a silicone muscle.

2022/11/21: Week 12 Fabrication (Silicone)

Molly Paras - Nov 22, 2022, 10:54 PM CST

Title: Week 12 Fabrication

Date: November 21, 2022

Content by: Team

Present: Team

Goals: Try out different ways to make silicone muscles with magnet attached, prepare for WARF meeting.

Content:

Things to figure out for Sunday 11/20

- Warf presentation
- Creation of mold for future muscles
    - How are we going to approach this?
    - Need to learn about what the muscle should look like, would be good to look up what they are like in real life
    - Possible approaches:
        - 3D printed molds that are in two pieces and are put together when silicone is poured in
        - Make a Silicone mold that is then used for further pours
        - Which muscle are we going to try to mimic

Sunday 11/20

Things to bring to fabrication tomorrow:

- Play-doh
- Multiple spoons, gloves, cups for silicone
- Tins
- Needles/toothpicks to keep things in place
- More gloves

Monday 11/21

-Performed multiple tests on silicone

Test #1: First prototype with embedded magnets and polyurethane

Conclusion: Really strong with polyurethane, any distance between magnets very significantly weakens magnetic force

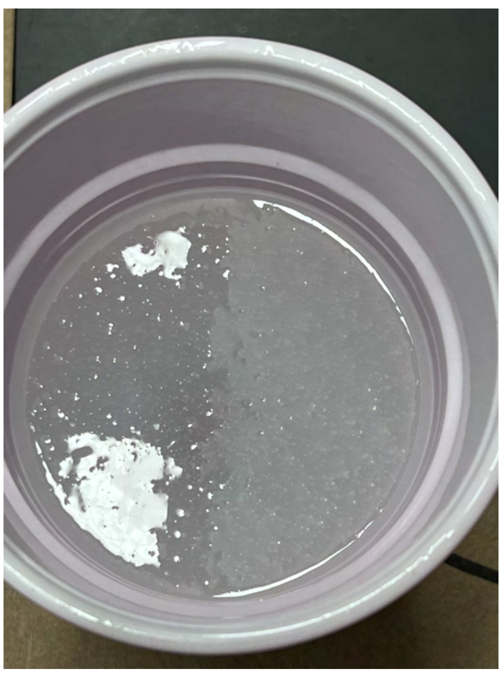
Test #2: square piece of silicone with polyurethane

Conclusion: Zach could not rip, so it must be very strong !!!

Test #3: Realistic muscle mold

Muscle was molded with clay and shaped to fit each attachment point. Mold was created from a red solo cup. Muscle was held up with toothpicks

Conclusion: Muscle was harder than expected to mold out of clay.



Muscle embedded in silicone to create a mold

Muscle created with magnets.

Citation & Link: N/A

Conclusions/action items: In addition to the above things, we also tried out using plaster as a mold. Now, we need to analyze the different things we have created and decide on what to move forward with so that we can finish a prototype. We also prepared a short presentation to present to WARF, which is attached. The meeting will be on 11/22 with Brian Frushour.

Molly Paras - Nov 22, 2022, 10:54 PM CST

Download

WARF_Presentation.pptx (6.53 MB)

2022/11/30: Week 13 Fabrication

Molly Paras - Dec 04, 2022, 4:40 PM CST

Title: Week 13 Fabrication

Date: November 30th, 2022

Content by: Team

Present: Team

Goals: Continue fabrication process.

Content:

- Poured 3 more silicone muscles
- Tested cutting the magnets to shape for one of the muscles
- Plan:
    - 3D print more bones on Thursday, so they will be done on Friday
        - Drill holes, remove supports, and glue magnets onto bones
    - MTS test old bones/muscles on Friday afternoon
    - Respond to Dr. Gunderson's email about testing on Monday

Citation & Link: N/A

Conclusions/action items: More muscles were created that will be used for the final prototype. We made a plan for the last few weeks, and are reprinting bones so that they will look nicer/cleaner. We will also be testing our product with vet students on Monday.

Molly Paras - Dec 04, 2022, 4:46 PM CST

Title: Week 13 Fabrication Part 2

Date: December 2nd-3rd, 2022

Content by: Team

Present: Team

Goals: Continue fabrication and testing process.

Content:

- Cut magnets to shape of muscle attachment
- Painted the bone where it was originally covered in sharpie or dirty since unable to reprint new set of bones before Monday (print failed)
- Super glued some of the magnets to the proper origin/insertion points
    - Having some troubles with the magnets since for some reason they don't align perfectly anymore
- Attached foot to tibia and tibia to femur
- Reshaped muscles a bit
    - covered holes with extra silicone
- Tested out the model holders given to us by our client.

Citation & Link: N/A

Conclusions/action items: We will finish fabricating on December 4th so that we have a functional prototype to use with the students on Monday.

Molly Paras - Dec 04, 2022, 4:47 PM CST

Download

Current_Status_of_Prototype.jpg (94 kB)

2022/12/04: Week 14 Fabrication

Molly Paras - Dec 04, 2022, 5:01 PM CST

Title: Week 14 Fabrication

Date: December 4th, 2022

Content by: Molly Paras

Present: Zach Spear, Lauren Fitzsimmons, Emily Hutsell, Maggie LaRose, and Molly Paras

Goals: Finish fabricating final prototype.

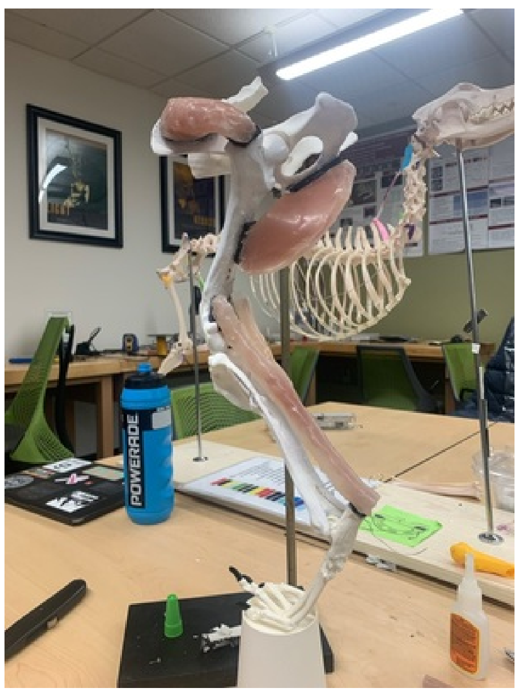
Content:

- Cut muscle attachment magnets for the final 3 attachment points
- Cut muscle to size
- Attached magnets to muscles and bones
- Repainted areas that were marked up

Citation & Link: N/A

Conclusions/action items: Now that the prototype is finished as much as we are able to for this semester, we need to finish up testing next. We will be testing with vet students tomorrow and will also be finishing testing some of our other specifications throughout this week.

Molly Paras - Dec 04, 2022, 5:01 PM CST



Download

Prototype.jpg (149 kB)

2022/10/26: Magnet/Fabric Strength Testing

Molly Paras - Oct 26, 2022, 11:18 PM CDT

Title: Magnet and Fabric Strength Testing

Date: October 26, 2022

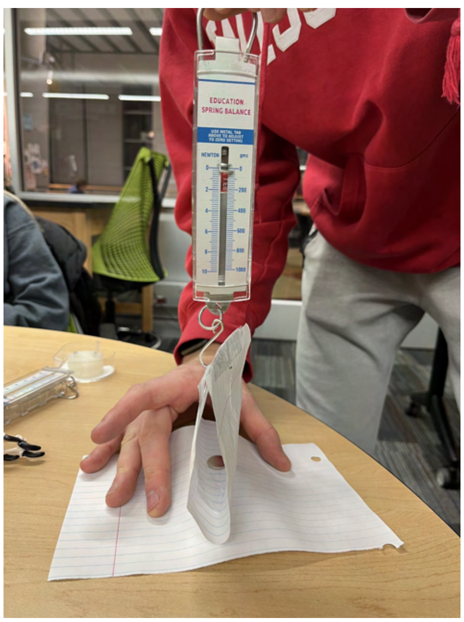
Content by: Molly, Zach, and Cora

Present: Molly, Zach, and Cora

Goals: Test the strength of the fabric and different size magnets that we have.

Content:

- Magnet Testing Methods:
    - Place magnet on table with a sheet of paper on top
    - Place a second piece of paper down and put the second magnet on top
    - Tape the top piece of paper on two parallel ends
    - Make a hole through the two sides of the paper below the tape and attach the spring balance
    - Hold bottom paper down while someone else lifts the spring balance vertically, and make note of the tension right before the magnets separate



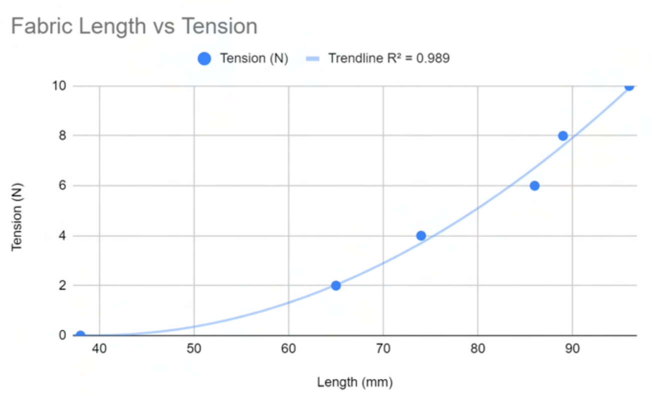
Fabric Testing Methods:

- Measure the side length of a square piece of fabric
- Make a hole on two opposite sides of the fabric
- Attach the spring balance to both ends, extending one to full length
- Measure the distance between the two holes at 2N, 4N, 6N, 8N, and 10N of force

Results

- Second smallest magnet (10mm diameter)
    - Test 1: detached at 1.5 N
    - Test 2: ~1N
    - Test 3: 1.5 N

- Second largest magnet (15 mm diameter)
    - Test 1: 1.5 N (magnet taped inside paper pocket
    - Test 2:1.5 N
    - Test 3: 2.5 N (magnet not taped to paper)
    - Test 4: 2.5 N
    - Test 5: 2.5 N
- Largest magnet (32 mm diameter)
    - Test 1: 10+ N
- Goal: determine if having two magnets is better
    - Two 15 mm diameter magnets
        - Test 1: 6 N
        - Test 2: 6 N
        - Test 3: 5 N
    - Two 10 mm diameter magnets
        - Test 1: 3 N
        - Test 2: 2.5 N
        - Test 3: 4 N
- Results
    - Width: 38 mm
    - Height: 58 mm
    - Distance between holes: 38 mm
    - At 2 N: 65 mm
    - At 4 N: 74 mm
    - At 6 N: 86 mm
    - At 8 N: 89 mm
    - At 10 N: 96 mm



Citation & Link: N/A

Conclusions/action items: We tested the fabric and a couple different size of magnets. The magnets were not as strong as we thought, but doubling up the magnets seemed to be pretty effective. We also found that the fabric and stretch to almost double its length with even just 2 N of force.

2022/12/2: Life in Service Durability Testing Protocol

Cora Williams - Dec 14, 2022, 1:10 PM CST

Title: Life in Service Durability Testing Protocol

Date: December 2, 2022

Content by: Cora

Present: Cora and Maggie

Goals:

- Measure the force needed to remove the muscles from the attachment points before extended use
- Use the model for extended period of time
- Measure the force needed to remove the muscles from the attachment points after extended use

Content:

- Life in Service Durability Testing Protocol
    - 1. Attach all three muscles to model
    - 2. Determine which muscle has the smallest attachment areas
    - 3. Using a meter spring dynamometer, measure the force it takes to remove the muscle from one attachment area. Reattach the muscle and repeat this measurement two additional times for a sample size of 3.
    - 4. Repeat Step 3 with the other attachment areas of the same muscle. These will be the measurements for before extended use
    - 5. Determine how far the model will be extended and flexed on each motion; use a folder to ensure the model moves approximately the same amount each repetition
    - 6. With all of the muscles reattached, flex and extend the model 50 times
    - 7. Repeat Steps 3 and 4 to measure the force needed to remove the muscle from the attachment point after extended use
    - 8. Analyze the data

Citation & Link: N/A

Conclusions/action items: We will be testing the strength of the magnetic attachments both before and after extended use. This will allow us to determine if the magnetic attachments can withstand extended use in a classroom environment and if our Life in Service Design Criteria has been met.

2022/12/04: Vet Student Survey

Molly Paras - Dec 04, 2022, 4:51 PM CST

Title: Vet Student Survey

Date: December 4th, 2022

Content by: Team

Present: Team

Goals: Finish creating and revising questions for the vet students to answer after testing our prototype.

Content:

The file with the questions is attached below.

Citation & Link: N/A

Conclusions/action items: Meet with students so they can test our prototype and fill out the survey.

Molly Paras - Dec 04, 2022, 4:51 PM CST

Dog Hindlimb Model Survey

1. What is your expected graduation year?

Mark only one oval.

- 2023
- 2024
- 2025
- 2026
- Other:

Download

Vet_Student_Survey_-_Google_Forms.pdf (139 kB) Vet Student Survey

Molly Paras - Dec 14, 2022, 10:06 AM CST

Title: Vet Student Survey Testing

Date: December 5th, 2022

Content by: Molly Paras

Present: Lauren Fitzsimmons, Zach Spears, Emily Hutsell, and Molly Paras

Goals: Meet with vet students and have them test our prototype.

Content:

This was a really great experience. The vet students were all very thankful that we were working on a project for them, since most money and advancements tend to go to human medicine rather than vet med. They were very nice and gave a lot of feedback on our project. We explained the project, had them test it out, and then had them fill out the survey we created. The results are linked below, and show that the students rated it roughly 84% accurate and 84% intuitive, meeting our design specifications.

Citation & Link: N/A

Conclusions/action items: Analyze the results and integrate it into our final poster and report.

Molly Paras - Dec 14, 2022, 10:07 AM CST

Download

Vet_Student_Survey.csv (13.9 kB)

2022/11/29: Bone MTS Testing Session 1

Molly Paras - Dec 01, 2022, 8:19 AM CST

Title: Bone MTS Testing

Date: November 29th, 2022

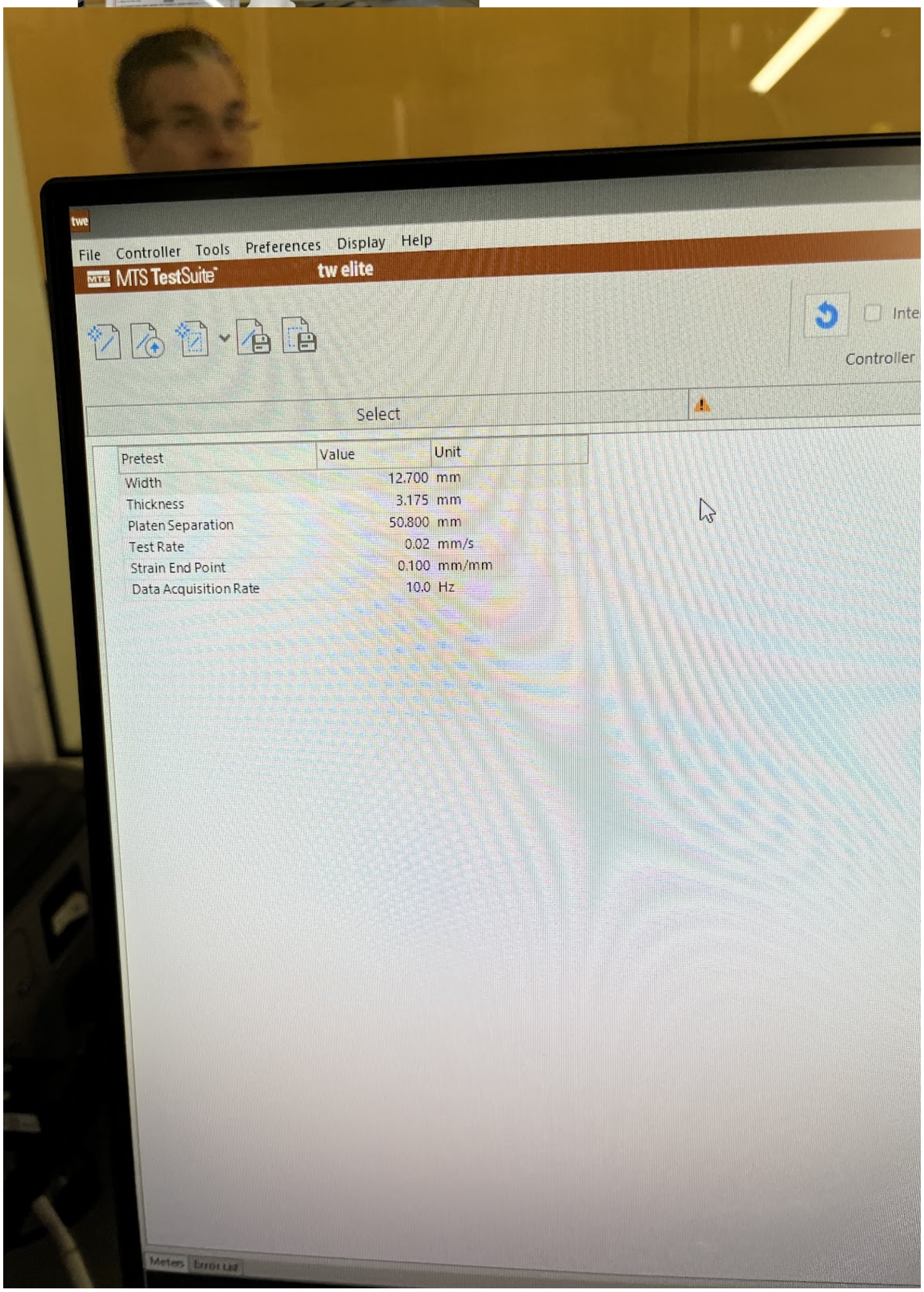
Content by: Molly Paras and Zach Spears

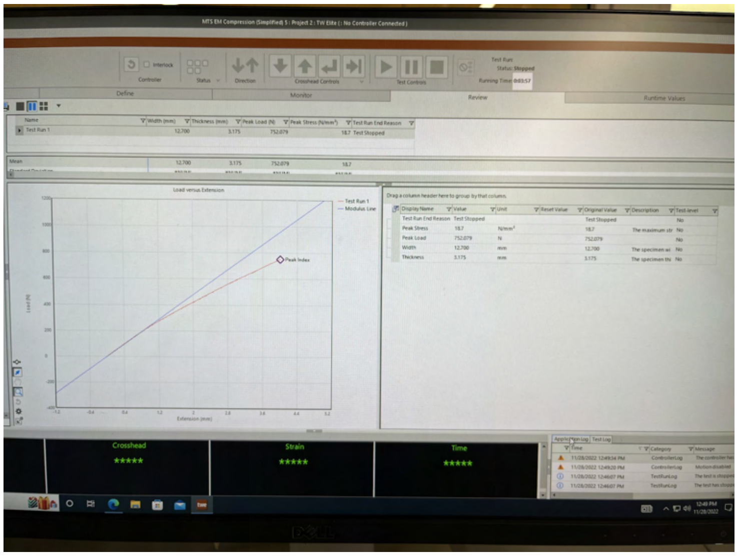
Present: Molly Paras and Zach Spears

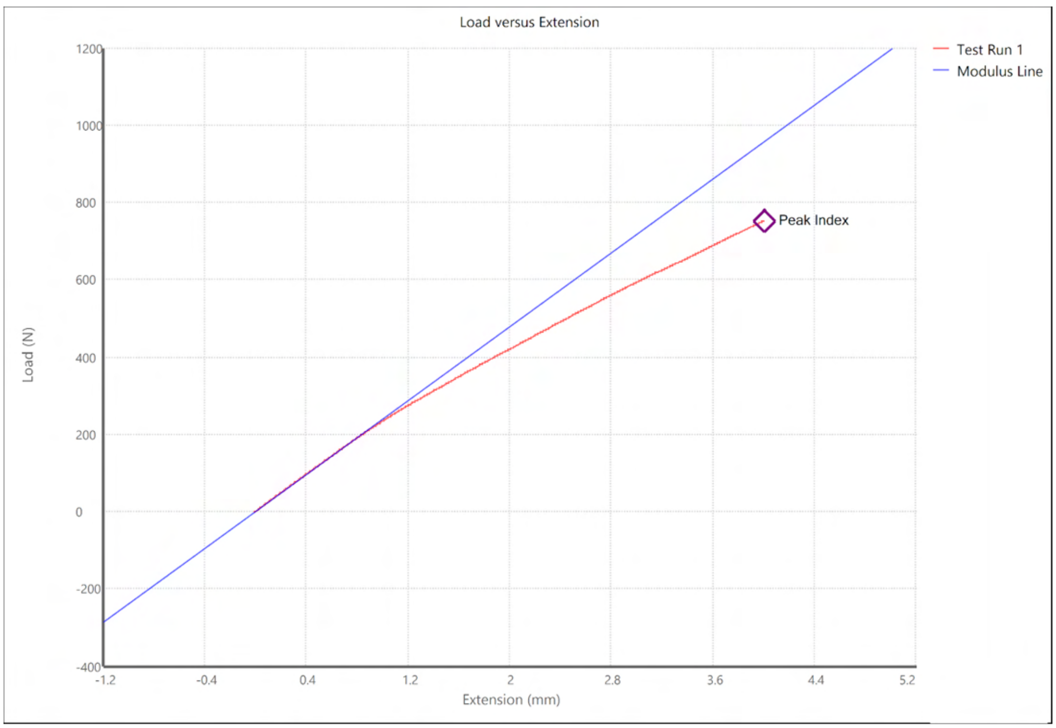
Goals: Test that the 3D printed bones are able to handle compression forces.

Content:

- MTS machine, EM Compression (Simplified)
- 1 kN cell, stopped manually at 750 N
- Femur placed vertically, with part attaching to hip at top and knee connection at bottom


File Controller Tools Preferences Display Help
MTS TestSuite
tw elite
Controller
Select
Pretest
Value
Unit
Width 12.700 mm
Thickness 3.175 mm
Platen Separation 50.800 mm
Test Rate 0.02 mm/s
Strain End Point 0.100 mm/mm
Data Acquisition Rate 10.0 Hz





Citation & Link: N/A

Conclusions/action items: While we were unable to put in correct bone dimensions on the machine due to size limitations (ex. thickness was set such that it could not exceed 5 mm), we were able to see how the bone would respond to up to 750N of compression. It bent, but was able to return to normal position. We also have a video of the deformation. Next, we hope to do 3-point compression testing until failure and possibly some tensile tests with one of our muscles.

2022/12/2: Life in Service Durability Testing Results

Cora Williams - Dec 14, 2022, 1:17 PM CST

Title: Life in Service Durability Testing Results

Date: December 2, 2022

Content by: Cora

Present: Cora and Maggie

Goals:

- Measure the force needed to remove the muscles from the attachment points before extended use
- Use the model for extended period of time
- Measure the force needed to remove the muscles from the attachment points after extended use

Content:

- Life in Service Durability Testing was performed according to the protocol detailed in the "Life in Service Durability Testing Protocol" notebook entry

- Raw Data

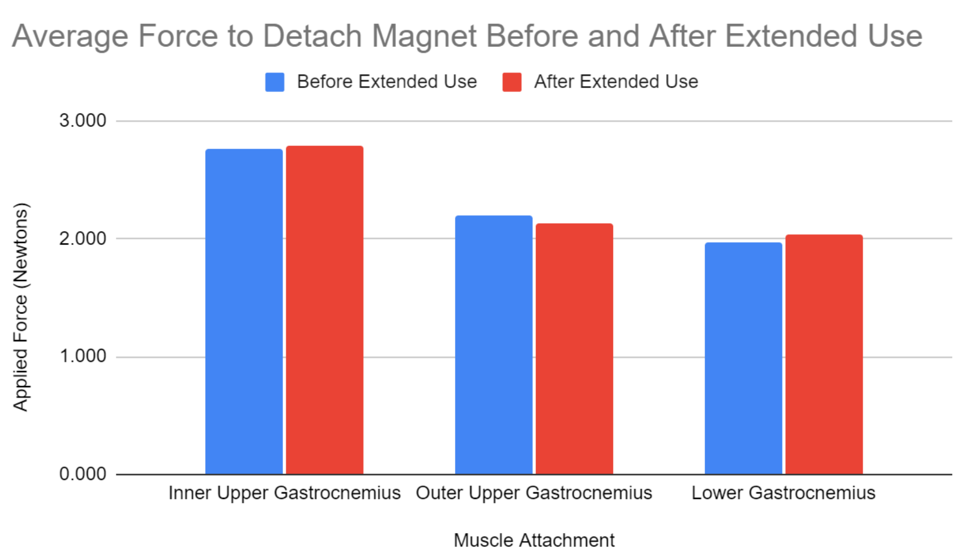
BEFORE Stretching 50 times

- Lower Gastrocnemius
    - Test 1 - 2 N
    - Test 2 - 2 N
    - Test 3 - 1.9 N
- Inner Upper Gastrocnemius
    - Test 1 - 2.7 N
    - Test 2 - 2.8 N
    - Test 3 - 2.8 N
- Outer Upper Gastrocnemius
    - Test 1 - 2.2 N
    - Test 2 - 2.2 N
    - Test 3 - 2.2 N

AFTER Stretching 50 times

- Lower Gastrocnemius
    - Test 1 - 2 N
    - Test 2 - 2 N
    - Test 3 - 2.1 N
- Inner Upper Gastrocnemius
    - Test 1 - 2.6 N
    - Test 2 - 2.8 N
    - 2.9 N
- Outer Upper Gastrocnemius
    - Test 1 - 2.1 N
    - Test 2 - 2.1 N
    - Test 3 - 2.2 N

- Analysis
    - Bar Graph Comparing Required Force Before and After



- p-value: 0.68
- Standard Deviation: 0.05 N

Citation & Link: N/A

Conclusions/action items: After testing the strength of the magnetic attachments both before and after extended use, we saw no statistically significant difference between the forces needed to remove the muscle before and after extended use. This means that the magnetic attachments can withstand extended use in a classroom environment and that our Life in Service Design Criteria has been met successfully.

2022/12/14: MTS Testing Session 2

Zach Spears - Dec 14, 2022, 5:49 PM (

Title: MTS Testing Session 2

Date: 12/14/22

Content by: Lauren Fitzsimmons

Present: Lauren Fitzsimmons, Molly Paras, Zach Spears

Goals: The team needed to meet for a second time to fully break the 3D printed bones to determine their max load.

Content:

The first time that the team met, a 1k load cell was used, and the bone did not fully fracture. In order to get the bone to fully fracture to determine the peak load, the team instead used a 10k lo cell as it could provide more force.

Load Cell: 10k

Fixture: 3-point bend test

Figure 1: MTS Testing to determine peak load using a 3-point bend test.


```
2022-12-02T22:16:09.4265595Z    TestRunLog      Information     -1      0       BME-TLI-2102    C:\Program Files (x86)\MTS
Systems\MTS TestSuite\mtstwe.exe        MtsStrings.LoadingTestRunControllerName <LogList><String>MTS EM Flexure (3-Point Bend)
8</String><String>(Insight) C43.104</String></LogList>
2022-12-02T22:16:09.7965929Z    TestRunLog      Information     -1      0       BME-TLI-2102    C:\Program Files (x86)\MTS
Systems\MTS TestSuite\mtstwe.exe        MtsStrings.TestRunLoadedSuccessfully    <LogList><Object>&lt;?xml version="1.0"
encoding="utf-16"?&gt;&lt;ObjectXmlData ObjectTypeName="LocalizedString"&gt;&lt;LocalizedString&gt;&lt;UniqueId&gt;{477963fb-be4b-
4419-983b-
948a33645235}&lt;/UniqueId&gt;&lt;InternalLocalizedStrings&gt;&lt;Entry&gt;&lt;Key&gt;en&lt;/Key&gt;&lt;Value&gt;Sample&lt;/Value&
;&lt;/Entry&gt;&lt;/InternalLocalizedStrings&gt;&lt;/LocalizedString&gt;&lt;/ObjectXmlData&gt;</Object></LogList>
2022-12-02T22:16:12.7840125Z    TestRunLog      Information     -1      0       BME-TLI-2102    C:\Program Files (x86)\MTS
Systems\MTS TestSuite\mtstwe.exe        MtsStrings.SignalAutoOffset     <LogList><String>_Extension</String></LogList>
2022-12-02T22:16:12.7840125Z    TestRunLog      Information     -1      0       BME-TLI-2102    C:\Program Files (x86)\MTS
Systems\MTS TestSuite\mtstwe.exe        MtsStrings.SignalAutoOffset     <LogList><String>Time</String></LogList>
2022-12-02T22:17:24.4736329Z    TestRunLog      Information     -1      0       BME-TLI-2102    C:\Program Files (x86)\MTS
Systems\MTS TestSuite\mtstwe.exe        MtsStrings.BreakDetectionTriggered      <LogList><String>Break Detection: Load</String>
<String>_Load</String></LogList>
2022-12-02T22:17:24.4746326Z    TestRunLog      Information     -1      0       BME-TLI-2102    C:\Program Files (x86)\MTS
Systems\MTS TestSuite\mtstwe.exe        MtsStrings.ActivityInvokedAction        <LogList><String>Break Detection: Load</String>
<String>No Action</String></LogList>
2022-12-02T22:17:32.6947789Z    TestRunLog      Information     -1      0       BME-TLI-2102    C:\Program Files (x86)\MTS
Systems\MTS TestSuite\mtstwe.exe        MtsStrings.TestStopped
```


Figure 2: Test Log of MTS run with 3D printed femur. We did not export the files correctly and were therefore unable to get graphical data of the test run. Therefore, we decided to meet again a later date to re-test another set of bones.

During this second testing session, we also experimented with testing the silicone muscles via stretch testing in order to determine the amount of force they could withstand before ripping. However, after several trials, no sufficient graph could be created because the silicone kept slipping out of the clamps on the MTS.

	Muscle Width	Muscle Thickness (mm)	Gauge Length (mm)	Test Rate (mm/s	Span (mm)				
Silicone Cylinder (with fabric)	42	5	34	1		22	11.6	0.5 * pi * (11.6)^	211.:
Hip Muscle (no fabric)	47	3	34	1	13.1	13.7	13.4		[illegible]
							6.7	pi * 6.7^2	141

Figure 3: Parameters used for the stretch testing of the silicone muscles. No relevant data could be obtained from these tests due to factors outlined above.

Figure 4: Model moments before failure

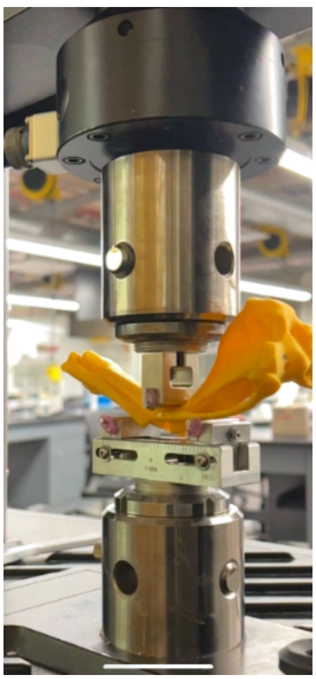


Figure 5: Model right after failure. The model underwent very little plastic deformation prior to fracture.

Citation & Link:

Conclusions/action items: The team will need to meet again for additional MTS testing since no graphs were exported successfully.

2022/12/14- MTS Testing Session 3

LAUREN FITZSIMMONS - Dec 14, 2022, 1:35 PM (

Title: MTS Testing Session 3

Date: 12/14/22

Content by: Lauren Fitzsimmons

Present: Lauren Fitzsimmons, Molly Paras, Zach Spears

Goals: The goal of this document is to relay information obtained from the final MTS testing session of the PLA bones as compared to the Axis Scientific model.

Content:

Several team members met for a third and final time to finish up MTS testing and obtain conclusive graphical data.

	Muscle Width	Muscle Thickness	Guage Length (mm)	Test Rate (mm)	Span (mm)
3 Point Bend Test					
Tibia	50	5	20	1	51.
	45	5	20	1	51.
3 Point Bend Test (Axis Scientific)	14	10.3			

Figure 1: Parameters inputted into the MTS machine for the two tests ran: one for the PLA printed bone, and one for the Axis Scientific bone. 3 point bend tests were performed on both.

Default Test Run Report	
Project Name	**Project 2**
User Name	**MTS**
Test Name	**MTS EM Flexure (3-Point Bend) 10**
Test Run Name	**Test Run 1**
Test Run Date	**12/6/2022 4:02:05 PM**

Test Run Review Graph

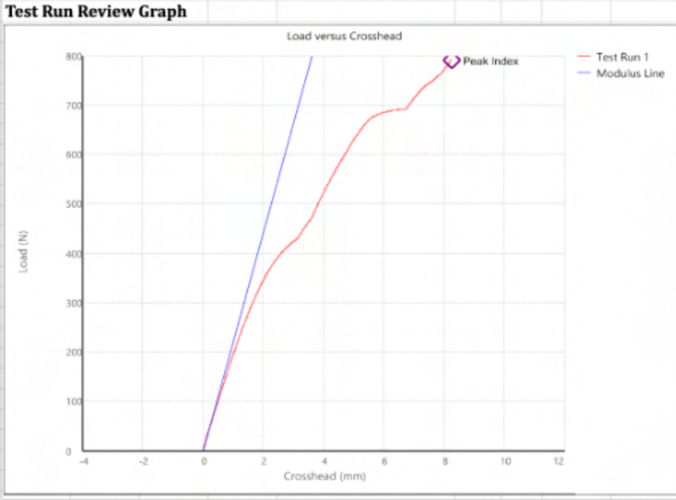


Figure 2: Test Run Report for the Axis Scientific bone, including Stress/Strain curve depicting peak load.

Test Run Results:

Display Name	Value	Unit
Test Run E	Test Stopped	
Peak Load	791.425	N
Peak Stres	139.4	N/mm²
Stress at B	#NUM!	N/mm²
Strain at B	#NUM!	mm/mm
Width	48.060	mm
Thickness	3.000	mm

Figure 3: Test Run Results for the MTS Testing of the Axis Scientific bone. Peak load was found to be 791.425 N.

Default Test Run Report

Project Name	**Project 2**
User Name	**MTS**
Test Name	**MTS EM Flexure (3-Point Bend) 10**
Test Run Name	**Test Run 1**
Test Run Date	**12/6/2022 4:12:44 PM**

Test Run Review Graph

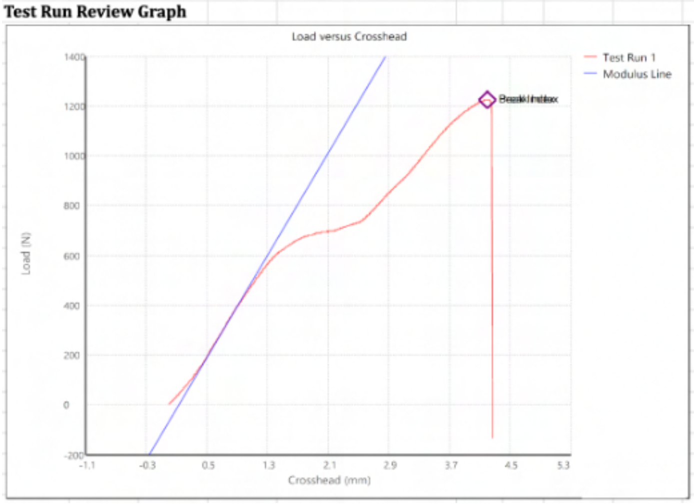


Figure 4:Test Run Report for the 3D printed bone, including the stress/strain curve depicting peak load values.

Test Run Results:

Display Name	Value	Unit
Test Run E	Break Detected	
Peak Load	1225.161	N
Peak Stres	81.2	N/mm²
Stress at B	81.180	N/mm²
Strain at B	0.047	mm/mm
Width	46.000	mm
Thickness	5.000	mm

Figure 5: Test Run Results of the MTS testing of the 3D printed bone. The peak load was found to be 1225.161 N.

Expected force: 890 N (force of a 200 lb person stepping on the model)

Only PLA bone could withstand expected force.

Peak load of PLA bone > Peak load of Axis Scientific Model.

Citation & Link:

Conclusions/action items: Since Peak load of PLA bone > Peak load of Axis Scientific Model, the team can conclude that the prototype meets the Durability criterion of the Product Design Specifications.

2022/12/14- Vet Student Demo Photos

LAUREN FITZSIMMONS - Dec 14, 2022, 1:45 PM CST

Title: Vet Student Demo Photos

Date: 12/14/22

Content by: Lauren Fitzsimmons

Present: Team

Goals: The goal of this document is to present graphics of the vet students interacting with the prototype.

Content:

The following photos were taken during the Vet Student testing that the team performed with the veterinary medical students. The team has been using these photos to analyze how the veterinary students interact with the model so they can use this feedback to improve the prototype in the future.

Figure 1: Vet student interacting with the middle gluteal muscle.

Figure 2: Vet students interacting with the gastrocnemius muscle.

Figure 3: Vet med student removing the muscle attachment on the gastrocnemius muscle.

Figure 4: Vet med student experimenting with the mechanism of the adductor muscle by removing the magnetic attachment.

Citation & Link:

Conclusions/action items: The veterinary students were able to identify which canine muscles the silicone muscles were modeling, which is promising. However, they were rougher on the prototype than expected, and the muscle attachments frequently popped off when being played with. The team will improve this as a part of their future work.

2022/09/23: PDS

Molly Paras - Oct 08, 2022, 2:02 PM CDT

Title: Product Design Specifications

Date: September 23rd, 2022

Content by: Team

Present: Team

Goals: Finish and submit PDS.

Content:

The actual PDS can be found attached below or on our website. The overall process of how we went about creating our PDS is listed here:

- Created a template of PDS with required categories and their definitions
- Split PDS into parts that we could each work on ourselves
- Researched competing designs, specifications that might apply to ours or similar products, and asked our client more clarifying questions
- Came together to edit and review our PDS

Citation & Link: N/A

Conclusions/action items: Some of the main categories of the PDS focus on accuracy of the product (does it properly resemble real canine hindlimb musculoskeletal anatomy) and durability (can be flexed and extended and used by almost 100 students for up to 12 hours a week for 5 years). Overall it included the client requirements and researched specifications that seemed applicable. Now that the PDS is completed we should begin narrowing down possible designs and creating a design matrix.

Molly Paras - Oct 08, 2022, 1:56 PM CDT

Structural and Mechanical Functions of Bones, Muscles and Joints by use of 3D Models in Veterinary Medical Education

Product Design Specifications

Client

Dr. McLean Gunderson

Advisor

Dr. Bill Murphy

Team

Lauren Fitzsimmons (Co-leader)

Zach Spears (Co-leader)

Cora Williams (Communicator)

Molly Paras (BSAC)

Maggie LaRose (BPAG)

Emily Hutsell (BWIG)

Section

305

September 23, 2022

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9_23_2022_3D_Printed_Veterinary_Models_PDS.pdf (104 kB)

2022/09/29: Design Matrix

Molly Paras - Oct 08, 2022, 2:09 PM CDT

Title: Design Matrices

Date: September 29th, 2022

Content by: Team

Present: Team

Goals: Complete our design matrices such that there is a winning design and explain how everything was rated/weighted.

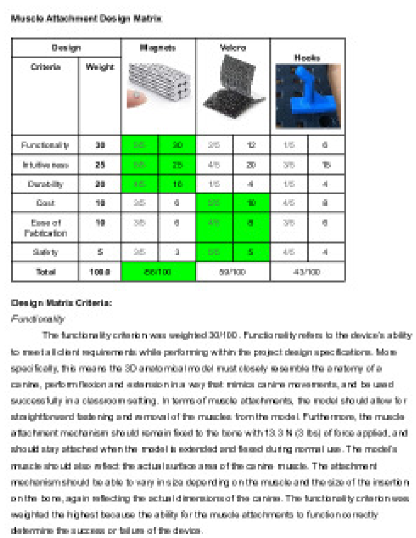
Content:

Information on design options and how we ended up with the materials can be found in the design process folder under 2022/09/27: Design Options Meeting, and the completed design matrix is linked below. Overall we decided on going with a design that utilizes magnets and a spandex material since those seemed to function the best and were reasonable to create given our current time constraints.

Citation & Link: N/A

Conclusions/action items: Now that our design matrix is completed, we need to start figuring out our fabrication process, order materials, work on our presentation, and begin the preliminary report. There is still a lot we all need to learn about 3D printing, so we'll hopefully be meeting with the UW Makerspace soon. We also need to do a little more research about where and how the different muscles attach to the bones.

Molly Paras - Oct 08, 2022, 1:56 PM CDT



Muscle Attachment Design Matrix

Design		Magnets		Velcro		Hooks	
Criteria	Weight						
Functionality	30	5/5	30	2/5	12	1/5	6
Intuitiveness	25	5/5	25	4/5	20	3/5	15
Durability	20	4/5	16	1/5	4	1/5	4
Cost	10	3/5	6	5/5	10	4/5	8
Ease of Fabrication	10	3/5	6	4/5	8	3/5	6
Safety	5	3/5	3	5/5	5	4/5	4
Total	100.0	86/100		59/100		43/100	

Design Matrix Criteria:

Functionality

The functionality criterion was weighted 30/100. Functionality refers to the device's ability to meet all client requirements while performing within the project design specifications. More specifically, this means the 3D anatomical model must closely resemble the anatomy of a canine, perform flexion and extension in a way that mimics canine movements, and be used successfully in a classroom setting. In terms of muscle attachments, the model should allow for straightforward fastening and removal of the muscles from the model. Furthermore, the muscle attachment mechanism should remain fixed to the bone with 13.3 N (3 lbs) of force applied, and should stay attached when the model is extended and flexed during normal use. The model's muscle should also reflect the actual surface area of the canine muscle. The attachment mechanism should be able to vary in size depending on the muscle and the size of the insertion on the bone, again reflecting the actual dimensions of the canine. The functionality criterion was weighted the highest because the ability for the muscle attachments to function correctly determine the success or failure of the device.

Download

Design_Matrix.pdf (1.53 MB)

2022/10/12: Preliminary Report

Molly Paras - Oct 12, 2022, 12:25 PM CDT

Title: Preliminary Report

Date: October 12th, 2022

Content by: Team

Present: Team

Goals: Complete preliminary report based on feedback from preliminary presentation.

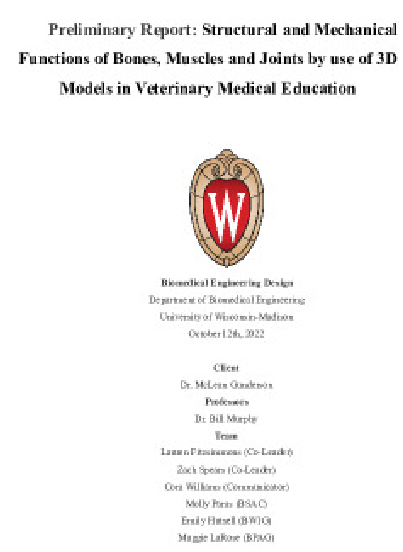
Content:

The completed report is attached below as a pdf.

Citation & Link: N/A

Conclusions/action items: The report contains background research, design requirements, design matrices, final designs, materials, and conclusions, along with the PDS and Materials List included. This was completed by splitting parts between the entire team, but all of it was edited and reviewed by everyone. Now that the report is done, we can focus on fabrication and similar next steps.

Molly Paras - Oct 12, 2022, 12:22 PM CDT



Preliminary Report: Structural and Mechanical Functions of Bones, Muscles and Joints by use of 3D Models in Veterinary Medical Education

Biomedical Engineering Design
Department of Biomedical Engineering
University of Wisconsin-Madison
October 12th, 2022

Client
Dr. McLean Gunderson
Professors
Dr. Bill Murphy
Team
Lauren Fitzsimmons (Co-Leader)
Zach Speirs (Co-Leader)
Ciera Wilkins (Communicator)
Molly Paras (BSAC)
Emily Hassell (BWIG)
Maggie LaRose (BPAG)

Download

Preliminary_Report.pdf (903 kB)

2022/12/09: Final Poster

Molly Paras - Dec 14, 2022, 10:00 AM CST

Title: Final Poster

Date: December 9th, 2022

Content by: Team

Present: Team

Goals: Present finished poster.

Content:

We presented our final poster during the poster session today. Our client Dr. Gunderson, many students, and advisors came to see our presentation. The poster is linked below.

Citation & Link: N/A

Conclusions/action items: Now we need to finish our final report and give materials/product to our client. We also need to follow up with WARF so that they have our poster before they make their decision on December 15th. It was really cool to get to share our project with everyone.

Molly Paras - Dec 14, 2022, 10:00 AM CST

[Download](#)

BME_200_300_Final_Poster_3D_Printed_Veterinary_Models.pptx (13.5 MB)

2022/12/14: Final Report

Molly Paras - Dec 14, 2022, 9:18 PM CST

Title: Final Report

Date: December 14th, 2022

Content by: Team

Present: Team

Goals: Complete the final report.

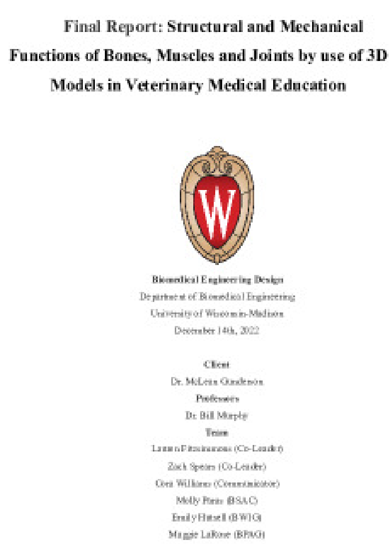
Content:

Attached is the final report.

Citation & Link: N/A

Conclusions/action items: Send final materials to our advisor and client and post them on the website.

Molly Paras - Dec 14, 2022, 9:12 PM CST



Final Report: **Structural and Mechanical Functions of Bones, Muscles and Joints by use of 3D Models in Veterinary Medical Education**

Biomedical Engineering Design
Department of Biomedical Engineering
University of Wisconsin-Madison
December 14th, 2022

Client
Dr. McLain Gunderson
Professors
Dr. Bill Murphy
Team
Lauren Fitzsimmons (Co-Leader)
Zach Speirs (Co-Leader)
[illegible] Wilkins (Communicator)
Molly Paras (BSAC)
Emily [illegible] (BWIG)
Maggie LaRose (BPAG)

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BME_Final_Report.pdf (3.02 MB)

The role of 3D printed models

Zach Spears - Oct 12, 2022, 12:10 PM CDT

Title: The role of 3d printed models in teaching anatomy

Date: 9/18/22

Content by: Zach Spears

Present: Zach Spears

Goals: To learn about why a 3d printed model may be advantageous to the students and the professors in teaching anatomy to a wide range of audiences. This article focuses on the human anatomy aspect.

Content:

The use of a 3d printed model can increase the accuracy and response time for students answering questions about the anatomy of a model. The study showed that the difference between the students who used the 3d printed models and conventional models was statistically significant. They found that 3d models can be more beneficial to cadavers when teaching anatomy for the first time around and is better than using either 2d models or slides and presentations.

These models were found to be especially helpful for residents who were being trained to perform surgeries and would need to know the exact location of tissue.

One aspect that this paper did not cover was the cost effectiveness of these 3d printed models. One of the biggest upsides to 3d printed models is the scale and price at which models can be created. Conventional models can be thousands of dollars whereas a 3d printed model could be a couple hundred.

Link: https://bmcmededuc.biomedcentral.com/articles/10.1186/s12909-020-02242-x#citeas

Citation:

1. Z. Ye *et al.*, “The role of 3D printed models in the teaching of human anatomy: a systematic review and meta-analysis,” *BMC Medical Education*, vol. 20, no. 1, p. 335, Sep. 2020, doi: 10.1186/s12909-020-02242-x.

Conclusions/action items:

As I learned in this article, it is beneficial to use 3d models for a variety of reasons. For our use you can better teach the veterinary students and increase the amount of knowledege they are able to retain. For this class 3d printing is pertinent since it can allow us to prototype and iterate even quicker than was previously available.

Final Design Muscles

Zach

Title: Final Design Muscles

Date: 12/14/22

Content by: Zach Spears

Goals: To establish which muscles were chosen for the final design and why

Content:

The three muscles chosen for the final design were the gastrocnemius, the gluteus medius and the adductor. The gluteus medius and adductor were selected since they counteract one anothe of our project. We then subsequently choose the gastrocnemius since this muscles runs parallel to the tibia and fibula and attaches to the foot. This allows for the whole model to have muscles in turn gives the vet students a better experience.

Figure 1: The location of the gastrocnemius in a canine depiction.

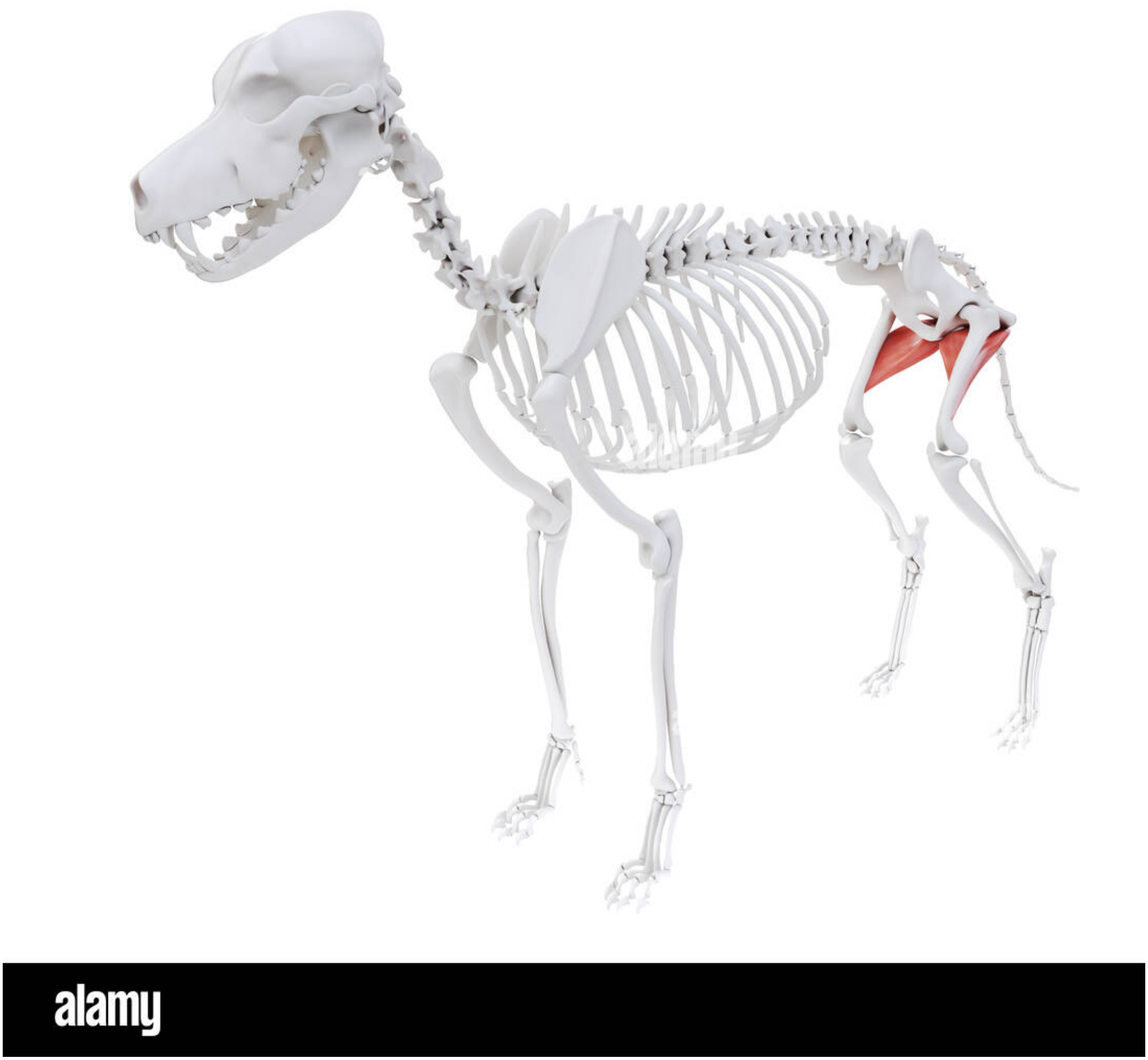


Figure 2: The location of the adductor in a canine depiction

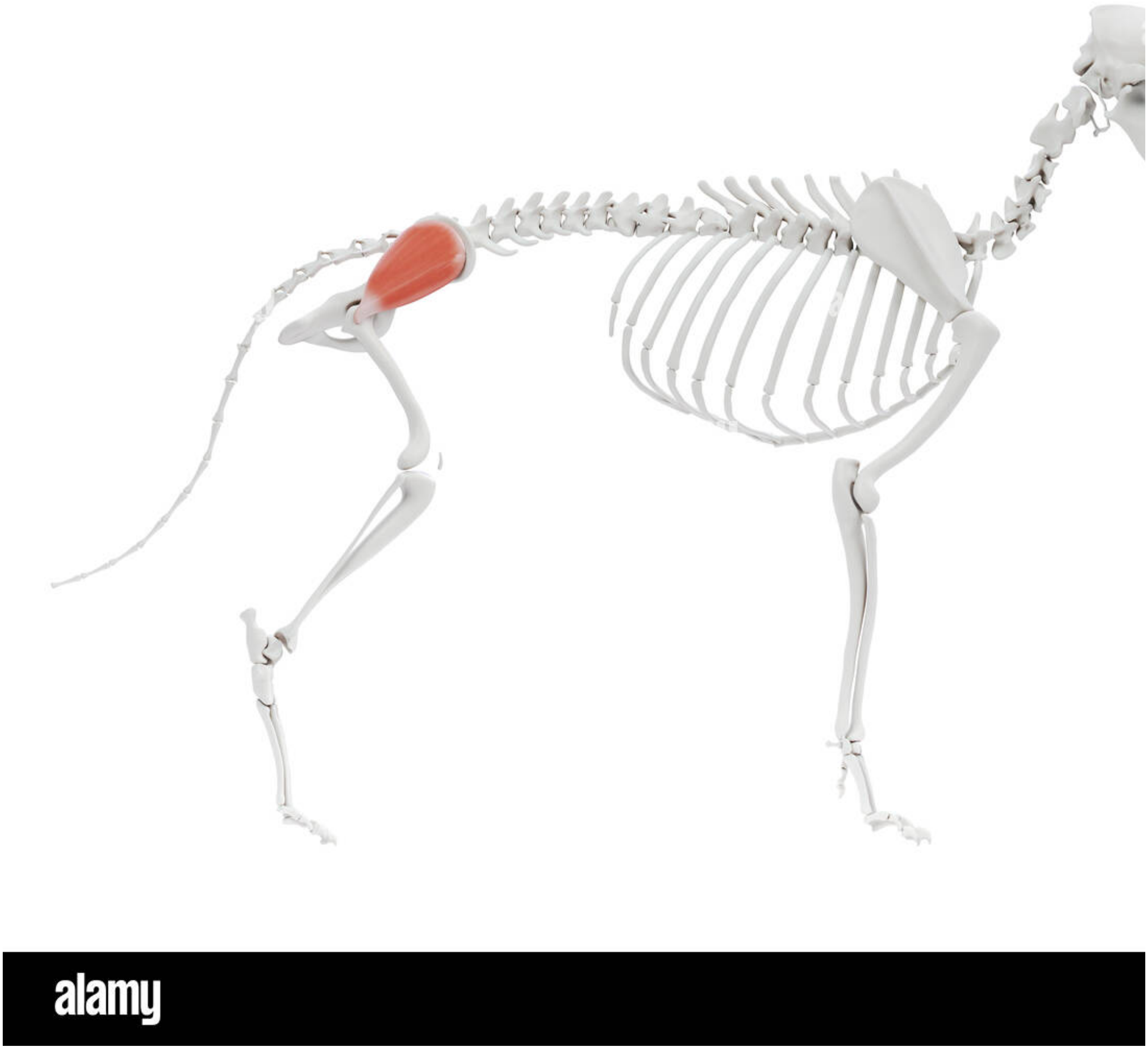


Figure 3: The location of the gluteus medius in a canine depiction

Citation & Link:

[1 K. Yoshikawa, S. Tsubakishita, T. Sano, T. Ino, T. Miyasaka, and T. Kitazawa, “Functional assessment of the gluteus medius, cranial part of the biceps femoris, and vastus lateralis in Beagle phase classification,” *J. Vet. Med. Sci.*, vol. 83, no. 1, pp. 116–124, 2021, doi: 10.1292/jvms.20-0127.

Conclusions/action items: Future teams will have the potential to add additional muscles and will be able to make the model even more complex.

3D Printed Bone Models

Zach Spears - Oct 03, 2022, 1:49 PM CDT

Title: 3d printed bone models competing designs

Date: 10/3/22

Content by: Zach Spears

Goals: To dig into the previous work undertaken by other research groups regarding the viability of 3d printed bone models

Content:

Image 1: Purdue's 3d printed bone models used to help veterinarian students learn orthopedic surgery practices

Overview

- 3D printing for bone models is not a new practice, but has become more prolific in recent years
- They have been used to create imitation surgery scenarios for students
- They can be printed using resin or conventional plastics
- There are large scale companies creating models as well but these can be expensive and not as customizable

Purdues usage of 3d printed models

- CT Scans of an affected dog were taken and then converted into an slx file
- These files were then printed and a physical model was used to model fixation plates for surgery
- These fixation plates could be created in excess and then applied to the model to make sure an accurate fit is achieved
- When the dog arrives for surgery the vet already has a fixation plate that they know will fit the affected bones and will not cause additional issues
- These bone models were so accurate that they could also create imitation surgery scenarios for their students

Image 2: Practice surgery on a 3d printed bone

As shown above the 3d printed bone was given a fracture and then the students used this model to learn how to clamp, pin, and wire a broken bone.

Additionally students learned to use polymer resins to fill said fractures

Our product does not need to simulate fractures, but that could be a future project in a different semester

Citation & Link:

https://vet.purdue.edu/newsroom/2017/pvr-3d-printed-bones.php

[1] P. V. Medicine, "Purdue 3D Printing Service Fabricates Bone Models for PVM surgery training," *Purdue University College of Veterinary Medicine*. [Online]. Available: https://vet.purdue.edu/newsroom/2017/pvr-3d-printed-bones.php. [Accessed: 03-Oct-2022].

Conclusions/action items: This model of creating 3d printed bone models could be extremely useful in our decision on how to create model using a 3d printer. We have access to 3d scans which we could then attempt to turn into

Commercially available 3d printed bone model

Zach Spears - Oct 12, 2022, 12:10 PM CDT

Title: Commercially available 3d printed bone model

Date: 10/3/22

Content by: Zach Spears

Goals: To explore a commercially available 3d printed bone model

Content:

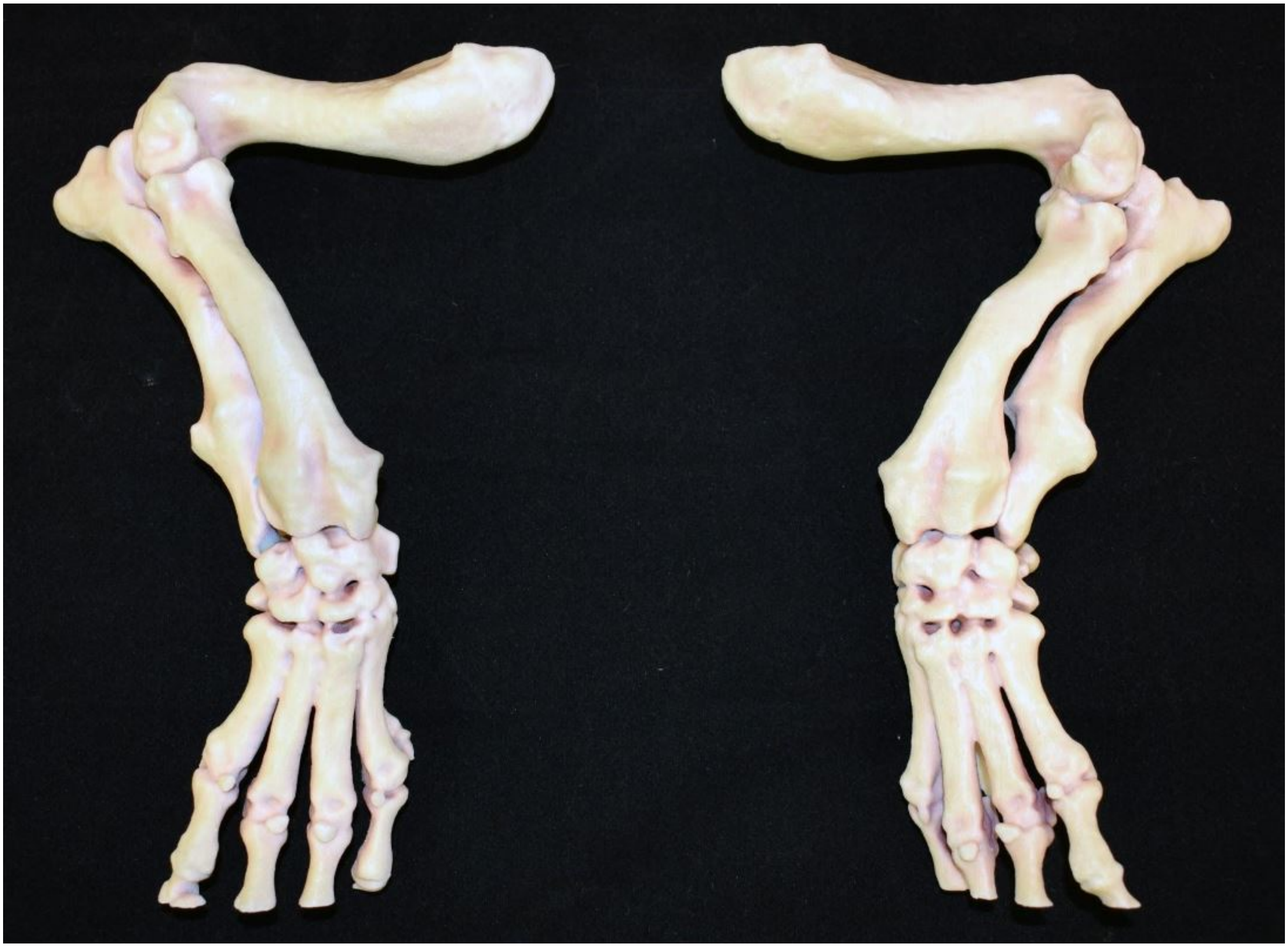


Image [1]: 3D Printed bone model by WhiteClouds

WhiteClouds:

- Company that creates 3d printed bone models for a variety of customers
- They specialize in turning mri's into 3d printed models
- Great for testing out certain surgery techniques and fixtures prior to surgery
- Can visualize where a tumor may lie within an animal

Image [2] 3d printed bone model with a tumor (green)

The above photo shows a 3d printed bone model of an animal that has had a tumor take over a large section of the body. This can help vet students visualize how a tumor might affect different parts of the skull wether it be nerves or important blood vessels.

Citation & Link:

https://www.whiteclouds.com/services/veterinary-models/

[1]“Veterinary 3D printed custom models services,” *WhiteClouds*, 26-Jan-2022. [Online]. Available: https://www.whiteclouds.com/services/veterinary-models/. [Accessed: 12-Oct-2022].

Conclusions/action items: While theses mockups are very precise they are also more expensive and require in depth knowledge of not only the animals anatomy but also algorithms which are able to turn the MRI into a clear and 3d printable model. This is out of our expertise but the idea of MRI to 3d printed models is cool nevertheless.

Axis Scientific Bone Model

Zach Spears - Oct 12, 2022, 12:01 PM CDT

Title: Axis Scientific Bone Model

Date: 10/11/22

Content by: Zach Spears

Goals: To learn more about the axis scientific bone model we will be ordering

Content:

Figure [1] Axis Scientific Canine Hind Limb Bone Model

The bone model pictured above has the following characteristics which will help us in creating our model and using it as a prop for future prototypes

- The leg folds at the knee and gives the model an accurate range of motion which is great for showing off how the joints work and makes it very portable

- The model weighs in at only .25 lbs which is light enough to be held for extended periods of time

- The model contains toe nails which contain the "Quick". This is a bundle of nerves which helps the model be more anatomically correct but will not be incorporated into our final design.

Citation & Link:

https://anatomywarehouse.com/axis-scientific-canine-hindlimb-with-foot-a-109194

[1] “Axis scientific canine hindlimb with Foot,” *Anatomy Warehouse*. [Online]. Available: https://anatomywarehouse.com/axis-scientific-canine-hindlimb-with-foot-a-109194. [Accessed: 12-Oct-2022].

Conclusions/action items: Building upon my current knowledge of the canine anatomy and learning about how this bone model was constructed will help our team make better choices for how we approach our design.

Spandex Synthetic Muscle Research

Zach Spears - Oct 08, 2022, 8:26 AM CDT

Title: Conducting preliminary research on potential synthetic muscle options (Spandex)

Date: 10/8/22

Content by: Zach Spears

Goals: To learn about potential synthetic muscle options for our design

Content:

Figure [1] Spandex fabric that could be used in our final design

Spandex has many characters that would be good for our final design

- Spandex can be repeatedly stretched without loosing much mechanical strength

- It has an extensibility of 500-700%

- Spandex wants to hold its original shape so will be able to pull the muscles back together once pulled taught

- Is available in multiple different colors and thicknesses

- Depending on the thickness we choose we can change the strength of how much the muscle pulls

Stress-strain curves of a covered yarn with elastic core and covering... | Download Scientific Diagram

Figure [2] Stress strain curve for different types of yarn we could use in our design

Citation & Link: https://www.researchgate.net/figure/Stress-strain-curves-of-a-covered-yarn-with-elastic-core-and-covering-yarns-Images_fig1_325779220

IEEE:

“Stress-strain curves of a covered yarn with elastic core and covering ...” [Online]. Available: https://researchgate.net/figure/Stress-strain-curves-of-a-covered-yarn-with-elastic-core-and-covering-yarns-Images_fig1_325779220. [Accessed: 08-Oct-2022].

Conclusions/action items: Continue researching other types of fabric and materials that could be used in our final design

Silicone Muscle Research

Zach Spears - Oct 08, 2022, 9:15 AM CDT

Title: Silicone rubber research for potential muscle options

Date: 10/8/22

Content by: Zach Spears

Goals: To research the feasibility of using Silicone as a muscle option

Content:

Silicone rubber is another viable option for potential muscles

Pros:

- Allows one to create a muscle that is much more anatomically accurate and can be the same size as the real muscles

- Can easily be colored to give the appearance of real muscles

- Depending on the thickness can be modulated so that the force pulling the muscles back together is changed

Cons:

- The least flexible of the potential materials I am researching. Could maybe still be used for our project but might hinder the extension of the limb and not allow for full extension.

- The repair of a broken muscle would be close to impossible and if a small. tear starts to form at any point in the silicone it can easily propagate and ruin the muscle

- Could potentially be harder to attach to the muscle attachment mechanism devised since we cant simply sew it into anything.

Figure [1] Pouring of silicone rubber into a mold

One potential selection of silicone rubber is dragon skin. This material can easily mimic a muscle both in appearance and in stretch.

Figure [2] Dragon skin rubber

Dragon skin makes highly realistic skin like silicone that can easily be colored to give the appearance of human ski. This could also be changed into giving the appearance of muscles for our project

Citation & Link:

https://www.smooth-on.com/product-line/dragon-skin/

[1] “Dragon Skin™ series, High Performance Silicone Rubber,” *Smooth*. [Online]. Available: https://www.smooth-on.com/product-line/dragon-skin/. [Accessed: 08-Oct-2022].

Conclusions/action items: It appears that silicone rubber will not be the most viable material to be used in our final design

Elastic Band Muscle Research

Zach Spears - Oct 10, 2022, 9:56 PM CDT

Title: Elastic Band Muscle Research

Date: 10/8

Content by: Zach Spears

Goals: To learn more about elastic bands as a potential option for muscles between bones in our project

Content:

Figure [1] Commercially available elastic Bands

Pros:

- Allows for different strength bands to be used for different muscles which might be of different strengths

- Very cheap with a multipack costing less than $10

- Easier to incorporate into the muscle attachment mechanism given its strong hesitance to tearing

Cons:

- Not similar to an anatomically correct muscle

- May be too strong for most of our applications even with the weakest of bands

Citation & Link: https://www.researchgate.net/figure/Rubber-bands-simulate-the-connection-of-knee-tendons_fig3_327026673

"Rubber bands simulate the connection of knee tendons." [Online]. Available: https://www.researchgate.net/figure/Rubber-bands-simulate-the-connection-of-knee-tendons_fig3_327026673. [Accessed: 11-Oct-2022].

Conclusions/action items: Rubber bands could be a viable option for use in our anatomically correct model but would sacrifice the appearance in certain ways we might not be willing to accept. Continued research will help us to determine if this is a viable option.

Future Work

Title: Future Work

Date: 12/14/22

Content by: Zach Spears

Goals: To summarize potential directions for future work

Content:

In the future the project can be taken in many different directions and can also be refined and made more complex.

The major next step would be to create additional muscles so that the users could see how a wide range of muscles interact with one another and see how taking off one muscle affects the wh canine. The team avoided doing this muscles this semester since the muscle has very complex attachment points but is nevertheless one of the most important muscles in the hind limb syster

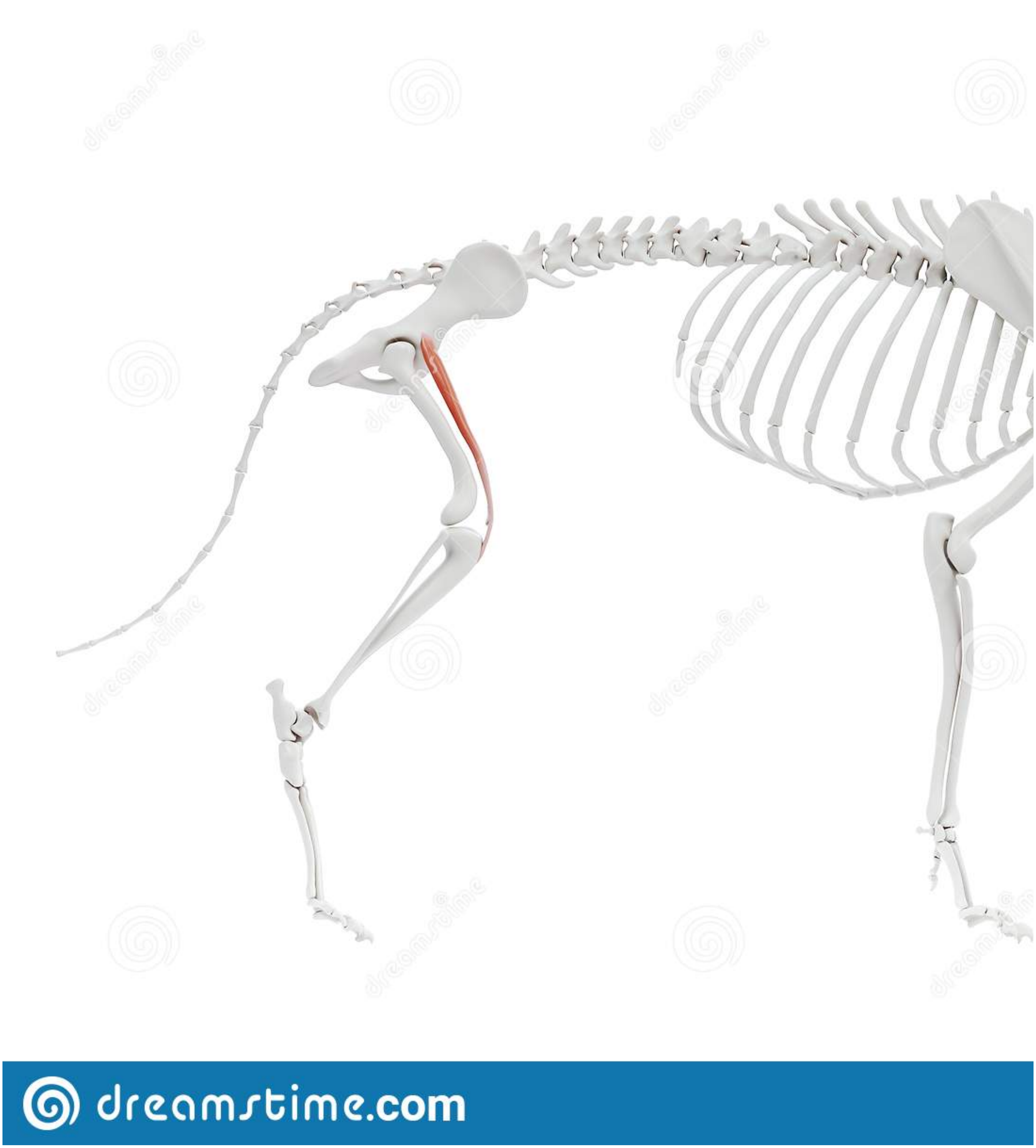


Figure 1: Quadriceps muscle on a canine bone model.

Another potential for next semester would be to give our final prototype some long term testing in one of the vet anatomy classrooms and see how it holds up over time and how the students w

The team this semester spent a lot of time working on how the muscle attachment mechanism could be enhanced, but we realize that it is still not perfect. The attachment mechanism can still
This is one of the fundamental issues with the current design that would need to be improved in the future.

Lastly, the accuracy of the muscles can be improved as well. The size and shape of the muscles is not perfect and the muscles texture could also be improved by applying a coating of some n

Citation & Link:

[1] S. Pinna and N. Romagnoli, “Radiographic measurement of the quadriceps angle in dogs,” *PLoS ONE*, vol. 12, no. 10, p. e0185833, Oct. 2017, doi: 10.1371/journal.pone.0185833.

Conclusions/action items: There is still a lot of work that can be done on this project and it will be very cool to see where future teams take it!

Biosafety and chemical Safety Training

Zach Spears - Jan 27, 2022, 2:57 PM CST

Training Information Lookup Tool

WISCONSIN
UNIVERSITY OF WISCONSIN-MADISON

This certifies that Zach Spears has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety Required Training	Biosafety Required Training Quiz	[illegible]	
Chemical Safety: The OSHA Lab Standard	Final Quiz	[illegible]	

Data Last Imported: [illegible]

[Download](#)

Screen_Shot_2022-01-25_at_2.04.34_PM.png (241 kB)

Green pass

Zach Spears - Jan 27, 2022, 2:58 PM CST

Download

IMG_1715.HEIC (1.59 MB)

2022/09/19- "3D scanning and printing of skeletal tissues for anatomy education" Notes

LAUREN FITZSIMMONS - Sep 19, 2022, 9:43 PM CDT

Title: "3D scanning and printing of skeletal tissues for anatomy education" Notes

Date: September 19, 2022

Content by: Team

Present: Lauren Fitzsimmons

Goals: The goal of this document is to articulate notes taken from the following journal article: "3D scanning and printing of skeletal tissues for anatomy education" by Thomas, Hiscox, Dixon, and Potgeiger. These notes will help understand competing designs and methodology.

Content:

3D printed horse foot -- produced from MRI scans.

Plastic anatomical models may be oversimplified and result in false knowledge of the anatomy, as they "do not account for biological variation" (Thomas 474)

3D Scanning

Digital replica created using HD Desktop 3D Laser Scanner (Next Engine, Inc.) and an SLS-2 structured light scanner (DAVID Vision Systems). The light scanning was performed in a sunlit room without contrasting paint, whereas the laser scan was performed in a dark room.

Light scanning setup included: 1280 x 9960 pixel CMOS monochrome camera (DAVID-CAM-3.1-M;DAVID Vision Systems), K132+DLP projector (Acer Incorpo-rated, New Taipei City, Taiwan).

The surface of the skeleton was produced in 8 seperate scans, with rotation of the skeleton by 45 degrees between each scan. Final image resolution was fused at 500 resolution and 0.20 mm between vertices.

Laser scanning setup included: A scanning unit with eight 650-nm 10 mW lasers and two 3 megapixel CMOS cameras (Next Engine HD Desktop 3Dlaser scanner). Scanning unit was attached to a turntable, an adjustable arm, and adjacent to a lab computer.

The skeleton was 3D scanned in 4 orientations on the turntable. 32 scans were completed in each orientation - posterior, anterior, dorso-ventral and ventro-dorsal. Final image resolution was fused at 700 resolution with 0.20 mm between vertices.

Small sizes (30 MB) are ideal for 3D printing and online display.

3D Printing

Selective laser sintering system used to create 3D models. One advantage to this method is supports are not needed for elevated features, unlike printing with standard PLA.

1:1 ratio between original bones and scanned models. Almost all key details translated onto the 3D models (24 of 28 key features retained in 3D replica of dogfish)

Moderate investment in scanning equipment, production costs are low. 3D scanning equipment costed around $2000. Actual printing costed around $10. Scanning time took 1-2 hours per specimen.

Specimens printed in nylon are robust and have ductility -- can bend a little bit before breaking.

SLS-2 light scanning system is more versatile and and better for scanning cartilage.

Details are in the caption following the image

The above image compares the details of the original specimen, the 3D replica, and the model.

Link: https://onlinelibrary.wiley.com/doi/epdf/10.1111/joa.12484

Citation:

D. B. Thomas, J. D. Hiscox, B. J. Dixon, and J. Potgieter, “3D scanning and printing skeletal tissues for anatomy education,” *Journal of Anatomy*, vol. 229, no. 3, pp. 473–481, 2016.

Conclusions/action items: The methods outlined above prove that 3D modeling is suitable for veterinary education and can be applied to animal structures. 3D printing is accurate enough for veterinary students and may even solve problems caused by studying plastic bones made from pourable molds. It is a "significant advancement" for veterinary education.

20122/09/22- "Veterinary Students and Faculty Partner in Developing a Virtual Three-Dimensional (3D) Interactive Touch Screen Canine Anatomy Table" Notes

LAUREN FITZSIMMONS - Sep 22, 2022, 10:14 AM CDT

Title: "Veterinary Students and Faculty Partner in Developing a Virtual Three-Dimensional (3D) Interactive Touch Screen Canine Anatomy Table" Notes

Date: September 22nd, 2022

Content by: Team

Present: Lauren Fitzsimmons

Goals: The goal of this document is to present notes taken from the following research journal article: "Veterinary Students and Faculty Partner in Developing a Virtual Three-Dimensional (3D) Interactive Touch Screen Canine Anatomy Table" written by Little et.al. This will help note already existing competing designs, in order to evaluate their pros and cons. Hopefully the team can implement went well in this design while accounting for the limitations.

Content:

A prototype of a 3D touch-screen canine anatomy table ("APEX") was tested by several veterinary students at the Ross University Veterinary School. They were surveyed before, during and after the learning experience on the effectiveness of 3D modeling in veterinary education versus more traditional (cadaver) methods. Students have identified with other experts concerns of cadavers in veterinary education, as it may cause stress or anxiety. Additionally, cadavers are increasingly hard and costly to obtain reliably.

This study was based in evidence that "simulation-based healthcare tools lead to superior outcomes compared with traditional clinical education alone" (Little 1). Although the teams model will be physical and not virtual, simulation will be necessary to create accurate 3D models, and therefore its effects on education should be noted. Simulation-based tools could also be developed in tandem to the 3D model in the future, and therefore should not be dismissed.

The APEX table was developed on a Windows system with high speed simulation capability and very high quality graphics. Through this table, the students were able to virtually dissect a virtual 3D model of a dog through touch responsive organ removal and specific anatomical structure identification. An external file that holds a picture, illustration, etc. Object name is 40670_2018_675_Fig2_HTML.jpg

The above image depicts the APEX virtual simulation table. Not only would this model would be super helpful to have access to to coordinate veterinary education with the physical 3D model, but it would also be super helpful to the team to learn the anatomy of the dog so that they can effectively create the model in general.

The students were surveyed on a scale ranging from 2-5 on the learning experience, usability, and effectiveness of the APEX table. Generally, utilization of the APEX table was found to be enjoyable (median score of 4/5) and that they would recommend it to future learners (median 4.5/5). The faculty, however, did not think that they prototype was ready to be integrated into the veterinary school curriculum, and that it could never fully replace cadaveric dissection.

Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8368567/

Citation:

W. B. Little, E. Artemiou, C. Fuentealba, A. Conan, and C. Sparks, “Veterinary students and faculty partner in developing a virtual three-dimensional (3D) interactive touch screen canine anatomy table,” *Medical Science Educator*, vol. 29, no. 1, pp. 223–231, 2019.

Conclusions/action items:

The APEX table shows that the advancement of technology can be utilized to a veterinary school's advantage by supplementing veterinary education with 3D simulation of anatomical models. Students that used these models were able to accurately identify veterinary gross anatomical structures in a timely manner.

The team could use this simulation in a variety of ways beneficial to their project -- as a learning tool for their own knowledge in creating the physical model, as a virtual resource that may be implemented in tandem with the physical 3D model in the future, or as a way to supplement the education in the future.

2022/11/12- Patent Research -- Competing Designs

LAUREN FITZSIMMONS - Nov 12, 2022, 12:11 PM CST

Title: Patent Research -- Competing Designs

Date: 11/12/22

Content by: Lauren

Present: N/A

Goals: The goal of this document is to research more in depth if there are other competing designs similar to our bone and muscle model. If not, we can move forward with applying for a patent with WARF. If so, the team will not be able to file for a patent.

Content:

"A three dimensional musculoskeletal model of the dog"

Stark, H., Fischer, M.S., Hunt, A. *et al.* A three-dimensional musculoskeletal model of the dog. *Sci Rep* 11, 11335 (2021). https://doi.org/10.1038/s41598-021-90058-0

This article describes a full-scale muscle and bone model of a dog with "84 degrees of freedom and 134 muscles." It is 3D, scalable, and modular. Torques of each bone were analyzed during movement, as well as muscle activation through static optimization in order to create a model that represents movements, contraction of joints, and specific muscle geometry.

However, there is no evidence that this model is a physical model. All of the calculations and data were analyzed online via various computer softwares, which makes me speculate that the dog model is completely virtual. If this is the case, our team's model would be completely different. However, if the model is a physical prototype, our projects may be too similar to file a patent.

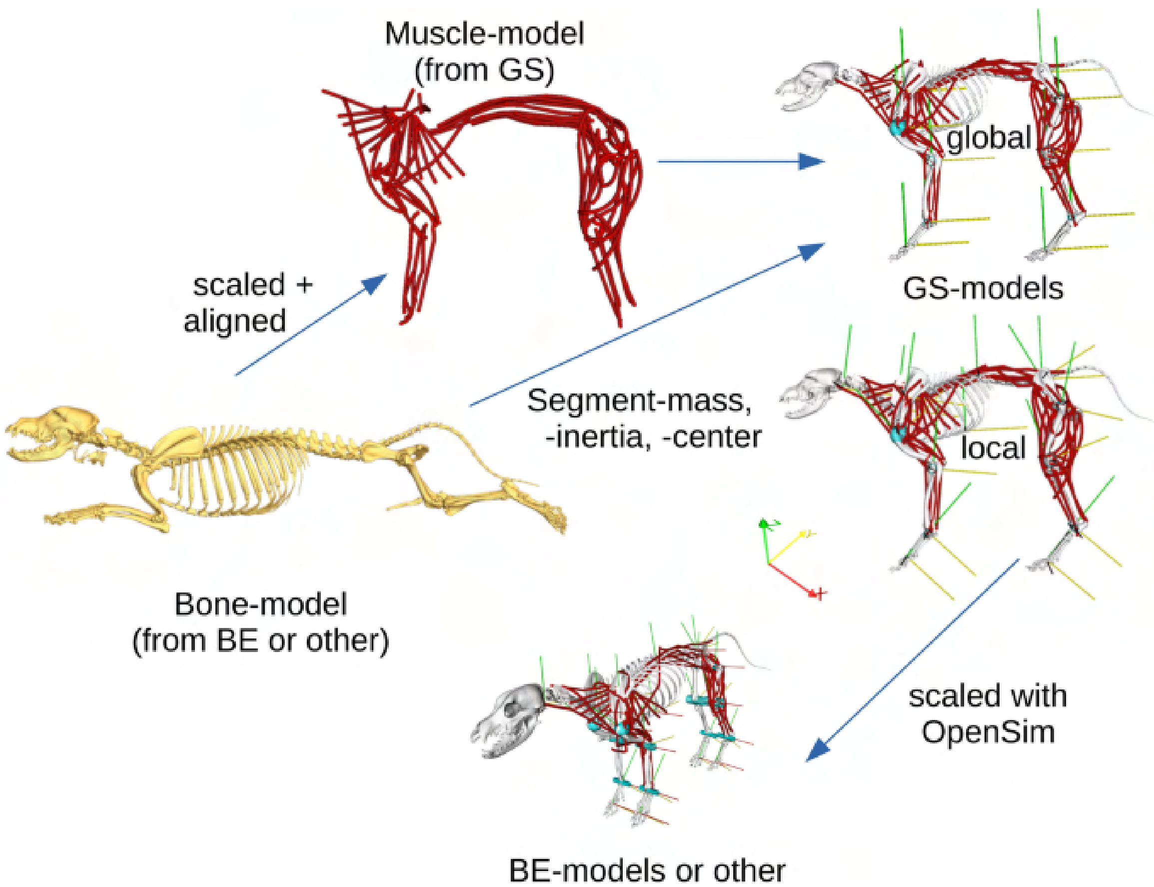


Figure 1: Musculoskeletal model of the dog. It seems as if these models are completely virtual.

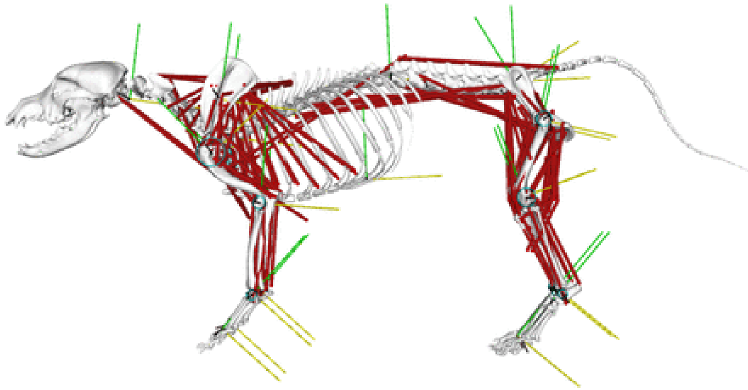


Figure 2: Completed musculoskeletal model of the dog.

file:///Users/laurenfitzsimmons/Downloads/fbioe-08-00150.pdf

The above article details a computer based musculoskeletal model to evaluate gait and kinematics of a dog. This is similar to the purpose of our project, however, the article details that the model is completely computer based and also rigid. This sets our project apart from this one.

"Musculoskeletal modeling in dogs: challenges and future perspectives"

Dries, B., Jonkers, I., Dingemanse, W., Vanwanseele, B., Vander Sloten, J., van Bree, H., & Gielen, I. (2016). Musculoskeletal modelling in dogs: challenges and future perspectives. *Veterinary and comparative orthopaedics and traumatology : V.C.O.T, 29 3*, 181-7 .

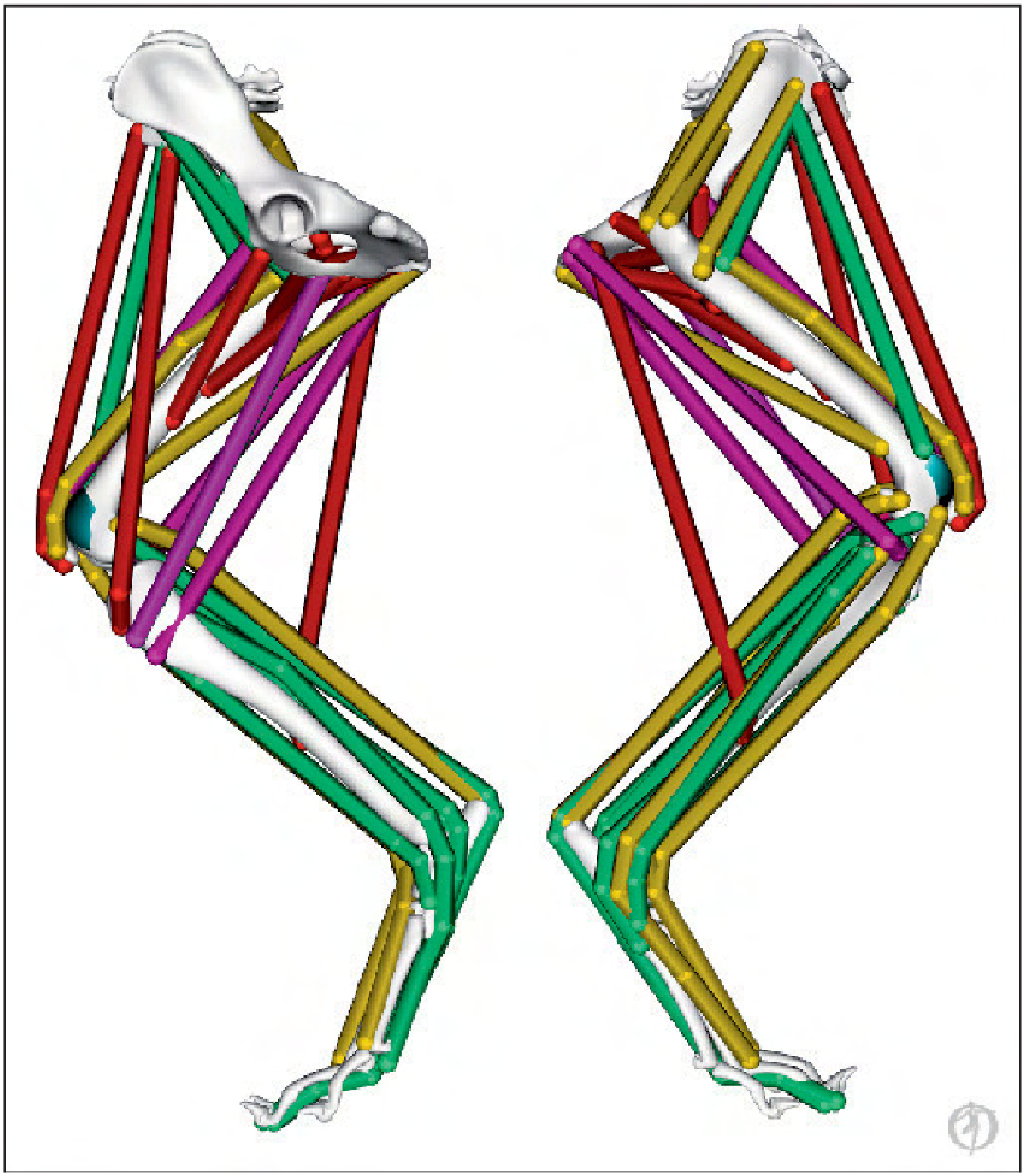


Figure 3 (above): Computer model of the canine hindlimb.

The figure above shows a muscle model that is similar to our project's goals. However, the muscles are all the same shape and size, and have similar attachment point surface areas. Therefore, I do believe that our model is unique as it is physical and dynamic.

Citation & Link:

Dries, B., Jonkers, I., Dingemanse, W., Vanwanseele, B., Vander Sloten, J., van Bree, H., & Gielen, I. (2016). Musculoskeletal modelling in dogs: challenges and future perspectives. *Veterinary and comparative orthopaedics and traumatology : V.C.O.T, 29 3*, 181-7 .

Stark, H., Fischer, M.S., Hunt, A. *et al.* A three-dimensional musculoskeletal model of the dog. *Sci Rep* 11, 11335 (2021). https://doi.org/10.1038/s41598-021-90058-0

Conclusions/action items:

Based on the research above, I do think that our team can move forward with patent application through WARF. I was not able to find a similar model on the market that is a) a physical model, b) is moveable, c) has detachable muscles, and d) is make of 3D printed parts and silicone muscles.

2022/09/11- "Adult Learning in Veterinary Education -- Theory to Practice" Notes

LAUREN FITZSIMMONS - Sep 11, 2022, 7:37 PM CDT

Title: Adult Learning in Veterinary Education -- Theory to Practice Notes

Date: 09/11/2022

Content by: Team

Present: Lauren Fitzsimmons

Goals: The goal of these notes is to articulate information learned from the following article - Adult Learning in Veterinary Education -- Theory to Practice. This will aid in background knowledge of the project to define the problem statement.

Content:

The following notes were taken from the article Adult Learning in Veterinary Education -- Theory to Practice by Vicki H.M. Dale, Martin, Sullivan, Stephen A. May, et.al.

<u>Why hands-on learning is important in Veterinary Education:</u>

<u>Andragony</u> -- Shifting focus away from lectures and towards learning by doing -- "experimental techniques that make use of the learners experience" (Dale 581)

This is a curriculum based on self-directive learning, in which the student is motivated intrinsically to learn rather than by external factors. The modeling system would be key to be implemented in this approach due to its hands-on nature and ability to be integrated into practice.

<u>Veterinary Curriculum:</u>

- In the 1960's-70's Armistead campaigned for more flexibility in veterinary education, as he saw that the practice had been stagnant for over 50 years. He saw for the need to "instill in students the habits and skills of lifelong education" (Dale 584)
- Pew Report stated that memorization and other traditional learning techniques were no longer serving veterinary education
- This led to the following techniques emerging: Problem-Based Learning (PBL) and Problem Solving, Critical Thinking and Reflection, Communcation and Cooperative Learning

We can help assist this shift in veterinary curriculum to aid students in hands-on learning, which is proven to be much more effective than memorization.

<u>Experiential Learning:</u>

- The need for problem-solving skills to be developed in terms of a real problem
- Future of veterinary education: "new learning environments that simulate practice, underpinned by carefully designed process-oriented learning objectives to allow self-directed learners to develop the lifelong learning skills essential to their continued professional development" (Dale 586) -- the Structural and Mechanical BME project will directly impact this goal. Creating models that students can interact with repeatedly will develop skills they need and allow them to continue to refine these skills.
- Design curriculum with adult learning and pedagogy in mind, as these learners do not thrive off of traditional methods

Link: https://jvme.utpjournals.press/doi/pdf/10.3138/jvme.35.4.581

Citation:

Dale, Vicki HM, et al. *Adult Learning in Veterinary Education: Theory to Practice*. A Veterinary Education Academy, https://jvme.utpjournals.press/doi/pdf/10.3138/jvme.35.4.581.

Conclusions/action items:

There needs to be a shift in veterinary education, from traditional methods of memorization to hands-on approaches. The Structural and mechanical functions of bones, muscles and joints BME project will directly contribute to the success of veterinary education by this function. The team and I will work to provide a new method for veterinary students to learn about the curriculum that aligns with their professional goals and creates a mode for repetitive learning and practice throughout their veterinary career.

2022/09/11 - "The Production of Anatomical Teaching Resources Using 3D Technology" Notes

LAUREN FITZSIMMONS - Sep 11, 2022, 8:36 PM CDT

Title: "The Production of Anatomical Teaching Resources Using 3D Technology" Notes

Date: 09/11/2022

Content by: Team

Present: Lauren Fitzsimmons

Goals: Take notes from the following journal article -- "The Production of Anatomical Teaching Resources Using 3D Technology" by Paul McMenamin, Colin McHenry and Michelle Quayle.

Content:

Why 3D Printing Technology Is Needed:

- Using cadavers for teaching of medical anatomy has always been a "significant social controversy"
- Reduction in dissection-based teaching practices, although many still believe it is foundational in teaching, due to cost considerations
- Rapid prototyping via 3D printing technology is rapidly expanding due to ease and speed
    - Considered one of the "most significant technological advances in our modern era"

Methods:

- Printer resolution must be greater than scan resolution in order to not hinder accuracy
- Original cadaver resolution must be high quality
- 3D printing also has the capability to depict fluid or air filled spaces
- Automatic thresholding with manual editing allows bone tissue to be separated
- 3D-Coat -- digital painting approach
- 3D Systems Z650 printer -- large build tray, fast build speed

-Structures larger than 10mm were accurate in size (error increased with structures smaller)

<u>Advantages of 3D printing of anatomical specimens </u>-- durability, accuracy, ease of production, cost effectiveness, and "the avoidance of health and safety issues associated with wet fixed cadaver specimens or plastinated specimens" (McMenamin 6)

-Important that slice thickness is as close to layer thickness in chosen 3D printer

<u>Disadvantages of 3D printing of anatomical specimens -- </u> specimens must be able to be sliced to be compatible with 3D printer, lack of pliability

Citation:

McMenamin, Paul, et al. *The Production of Anatomical Teaching Resources Using Three-Dimensional ...* Anatomical Sciences Education , Nov. 2014, https://www.researchgate.net/publication/263549897_The_Production_of_Anatomical_Teaching_Resources_Using_Three-Dimensional_3D_Printing_Technology.

Link: https://www.researchgate.net/publication/263549897_The_Production_of_Anatomical_Teaching_Resources_Using_Three-Dimensional_3D_Printing_Technology

Conclusions/action items:

There is large potential in the use of 3D printing of anatomical specimens for teaching of medicine and veterinary medicine due to cost effectiveness, durability, sensibility, and more. It is likely that these methods will be integrated into medical education practices in the near future. There are some technical methods that must be taken into account when 3D printing in order to ensure success of prints.

2022/09/11 - "3D Printing Comes to Veterinary Medicine" Notes

LAUREN FITZSIMMONS - Sep 11, 2022, 7:38 PM CDT

Title: "3D Printing Comes to Veterinary Medicine" Notes

Date: 09/11/2022

Content by: Team

Present: Lauren Fitzsimmons

Goals: The goal of this document is to convey notes taken from the article from the Canadian Veterinary Journal titled "3D Printing Comes to Veterinary Medicine" article, written by Carlton Gyles. These notes will aid in background knowledge of the project and help the team define their problem statement.

Content:

3D Printing:

The method of producing a physical product from a digital model via the method of addition successive layers of thin material. May either be done with ink melted and deposited, then cooled rapidly. Another method is the stereolithography (SLA) process in which a polymer is cured with a UV laser beam to cure the resin layer by layer. 3D printing is advantageous because it is accurate and repeatable with low cost.

3D Printing in Medicine:

- First used in practice in the 1990's
- Involved production of dental implants and custom prosthetics
- Greatly improves the planning for complex surgeries, and allows hands-on experience prior to surgery, improving patient outcomes
- Most functional for printing of human organs (organoids) -- toxicology and oncology research

3D Printing in Veterinary Medicine:

- Dr. Michelle Oblack at Ontario Veterinary College -- 3D printed model of a dog with a brain tumor -- allowed for her to be more well prepared for the surgery
- Drill guides including "placement of pedicle screws in vertebrae and stabilization of fractures in dogs" (Glyes 1)
- Customized implants -- tibial tuberosity advancement

Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6741827/

Citation:

Gyles, Carlton. “3D Printing Comes to Veterinary Medicine.” *The Canadian Veterinary Journal = La Revue Veterinaire Canadienne*, Canadian Veterinary Medical Association, Oct. 2019, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6741827/.

Conclusions/action items:

3D printing has become increasingly popular for both medical and veterinary medical practices, both in education and training, in the operating room, and beyond. It is relatively new in veterinary medicine, with Dr. Oblack making history in the veterinary world with her 3D printed model of a tumor in a dog's brain in 2018. The method is relatively cheap and extremely accurate, making it an extremely functional practice. The team and I's 3D model of structural and mechanical functions of bones, muscles and joints will make an impact due to these reasons.

2022/09/22- "Teaching anatomy without cadavers" Notes

LAUREN FITZSIMMONS - Sep 22, 2022, 10:35 AM CDT

Title: "Teaching anatomy without cadavers" Notes

Date: 09/22/22

Content by: Team

Present: Lauren Fitzsimmons

Goals: The goal of this document is to record notes taken from the following journal article "Teaching anatomy without cadavers" by McLachlan et.al. This information will help the team gain additional knowledge on the background of cadaveric use in anatomy education.

Content:

- Cadaver use is generally seen as essential to anatomy education
- Cadavers have been used in anatomy teaching since the Renaissance -- the Greek roots of the word anatomy indicate "cutting up."
- Advantages of cadaver use include:
    - Gives important 3D view of human anatomy -- can our model also achieve this to the same degree of effectiveness without cadavers?
    - Variability in real human material
    - Dissection as "death in a controlled manner"
- Disadvantages of cadaver use include:
    - Cross-sectional view does not readily translate into "plan" view -- so dissection is not as useful as many think
    - Many students find cadaver use stressful -- Nigerian study showed that close to 1/4 of students reported an "increase in physical and mental symptoms at the commencement of dissection, with 5% reporting that they were highly upset during the course"
    - Handling of physical remains is a challenge -- many reports of human remains being dealt with improperly, which raises concerns
    - Diseases in cadaveric material
    - Expensive

Citation:

J. C. McLachlan, J. Bligh, P. Bradley, and J. Searle, “Teaching anatomy without cadavers,” *Medical Education*, vol. 38, no. 4, pp. 418–424, 2004.

Conclusions/action items: There are lots of pros and cons of cadaveric dissection in anatomical education. It has been used for thousands of years in medical education, but that does not mean that it is the sole way to teach students about the anatomy of the human body. There may be alternate methods, as cadaver use may not be not as effective, informative, and meaningful as many may think. These alternate methods may include the project that the team is working on this semester.

2022/12/13 -- MTS Research

LAUREN FITZSIMMONS - Dec 13, 2022, 11:59 AM CST

Title: Mechanical Testing System Background

Date: 12/13/2022

Content by: Team

Present: Lauren

Goals: To document background information pertaining to the Mechanical Testing System that was used for testing.

Content:

Information summarized from https://www.mts.com/en/products/materials/static-materials-test-systems/exceed-electromechanical

MTS stands for Mechanical Testing System. It is a machine that can be used to generate stress/strain curves while testing an object to see the force it can withstand before undergoing plastic deformation.

It has force capacities of 5 kN to 600 kN. The load cell placed on the MTS must match the range of expected force, otherwise the machine will break. There are a variety of load cells to choose from, including 50 kN, 500 kN, 1k kN, 10k kN, and more.

We need to use the 10k load cell because we expect our model to withstand more than 1000 N of force, and we do not want to break the machine.

The MTS has four main applications: tension, compression, flex/bend, and shear. We will be using the bend test (more specifically, the three point bend test) to see how much force the Axis Scientific model and the 3D printed model can withstand.

The MTS can be used with a wide variety of materials, including: ceramics, metals, and polymers. We will be testing using PLA and regular plastic, which are polymers.

Figure 1 (above): 3-point bend test of a 3D printed canine bone using the MTS machine.

Figure 2 (above): There are a wide variety of MTS machines on the market.

Citation & Link: https://www.mts.com/en/products/materials/static-materials-test-systems/exceed-electromechanical

Conclusions/action items: The team will utilize a Mechanical Testing System (MTS) to perform a 3-point bend test on PLA to determine peak load before plastic deformation.

2022/12/13- Computer diagram of modeled muscles

LAUREN FITZSIMMONS - Dec 13, 2022, 12:11 PM CST

Title: Computer diagram of modeled muscles

Date: 12/13/2022

Content by: Lauren Fitzsimmons

Present: Lauren Fitzsimmons

Goals: The goal of this document is to provide a diagram of the muscles that will be modeled on the final prototype so that the general public has a greater understanding of the project.

Content:

Figure 1 (above): A drawing that I created using ProCreate for iPad to depict the muscles that would be diagramed on the final prototype. The middle gluteal is shown in dark blue, the adductor is shown in light blue, and the gastrocnemius is shown in light green.

According to feedback given to us by the veterinary medical students, our team should include color coding muscles on our prototype in our future work. Right now, our prototype consists of three muscles that are all the same color. However, the students suggested that it may be helpful create a color coded set of muscles that the students could use for memorization and practice purposes.

Citation & Link:

Conclusions/action items: Future work: expand on this diagram and apply it to the final prototype.

2022/09/26- Muscle Attachments Materials Brainstorming

LAUREN FITZSIMMONS - Sep 26, 2022, 9:01 PM CDT

Title: Materials Brainstorming -- Muscle Attachments

Date: 09.26.2022

Content by: Team

Present: Lauren Fitzsimmons

Goals: The goal of this document is to record brainstorming ideas for what the team could use for muscle attachment points in their 3D printed model. This will help narrow down ideas for the design matrix.

Content:

Ideas for attachments of muscles:

Magnets could prove to be an efficient way to demonstrate muscle attachment, as they are able to be removed and reattached efficiently. The client has expressed that she would be impressed with magnets on the model (customer preferences). However, magnets that are the correct amount of magnetic force must be found, which may prove to be a challenge.

Types of magnets that may be feasible:

1. Magnetic Strips: https://www.amazon.com/Flexible-Magnet-Strip-Laminate-Height/dp/B00BNDWHL8

The website says that they can withstand 12 pounds of linear pull per square foot, which may or may not be enough to withstand the amount of force the team required in the PDS.

Pros of magnetic strips would be that they are flexible, they can be cut and easily customizable for the surface area required, and they are relatively thin.

Cons of magnetic strips: Are they strong enough?

2. Magnetic disks: https://www.amazon.com/Thin-Round-Disc-Magnets-4x1/dp/B07VV6R5K5

Pros: Perhaps a stronger magnetic force than the magnetic strips

Cons: Bulky, unable to customize size or shape

Other ideas besides magnets:

-Velcro.

May sound too simplistic but it definitely would be strong enough and reliable. Cons: Not aesthetically pleasing as magnets. May be harder to attach and detach to the model.

Conclusions/action items: The team will discuss these ideas during their weekly meeting. They may/ may not be included in the design matrix due this upcoming Thursday 9/29.

2022/09/26- Muscle Fiber Materials Brainstorming

LAUREN FITZSIMMONS - Sep 26, 2022, 9:25 PM CDT

Title: Muscle Fiber Materials Brainstorming

Date: 09.26.2022

Content by: Team

Present: Lauren Fitzsimmons

Goals: The goal of this document is to record ideas for the materials used for the muscle fibers in the team's 3D model. These ideas will help the team decide on their design matrix to narrow the scope of their project.

Content:

There are several viable matierals that the team could use for muscle fibers.

A simple idea would be nylon fiber. In the following article, https://news.mit.edu/2016/nylon-muscle-fibers-1123, describes a breakthrough made by MIT engineers to use nylon to simulate muscle fibers. Previously, the scientists had used expensive, complex materials, but they realized that they are not neccesarily needed for proper function. The engineers shaped the nylon to create a square-shaped cross section, then selectively heated the fiber in order to control its movement. This fiber is said to retain its shape for over 100,000 bending cycles.

I am not sure how feasible this heating system would be for us to replicate, however, it goes to show that more complex/expensive materials are not neccesarily more effective to model muscle tissue.

Another idea would be to use elastic dielectric polymers. https://www.nature.com/articles/539333c

This material is formed by linking together polymer strands in a "bottlebrush-like structure." This resulted in a strong, stretchy, and durable material that allows for tuning without comprimising the material itself.

Another idea would be the most traditional. some sort of silicone/ rubber material. Trials and experiments conducted in the following study (https://www.wcu.edu/WebFiles/PDFs/KS_Sparks_Tanaka.pdf) show that silicone mimics actual muscle tissue in its loading patterns, however, stress and stiffness levels exceeded those of normal muscle tissue.

Citations:

M. Vatankhah-Varnoosfaderani, W. F. Daniel, A. P. Zhushma, Q. Li, B. J. Morgan, K. Matyjaszewski, D. P. Armstrong, R. J. Spontak, A. V. Dobrynin, and S. S. Sheiko, “Bottlebrush elastomers: A new platform for freestanding electroactuation,” *Advanced Materials*, vol. 29, no. 2, p. 1604209, 2016.

J. L. Sparks, N. A. Vavalle, K. E. Kasting, B. Long, M. L. Tanaka, P. A. Sanger, K. Schnell, and T. A. Conner-Kerr, “Use of silicone materials to simulate tissue biomechanics as related to deep tissue injury,” *Advances in Skin & Wound Care*, vol. 28, no. 2, pp. 59–68, 2015.

Conclusions/action items: These ideas for materials used to simulate real muscle tissue will be discussed with the team and weighed on a variety of factors. The best ideas will be analyzed further in the team's design matrix.

2022/10/04- Muscle Attachment Design Figures

LAUREN FITZSIMMONS - Oct 04, 2022, 9:18 AM CDT

Title: Muscle Attachment Design Figures

Date: Oct 4, 2022

Content by: Team

Present: Lauren Fitzsimmons

Goals: The goal of this document is to visually convey the teams three design ideas for muscle attachments.

Content:

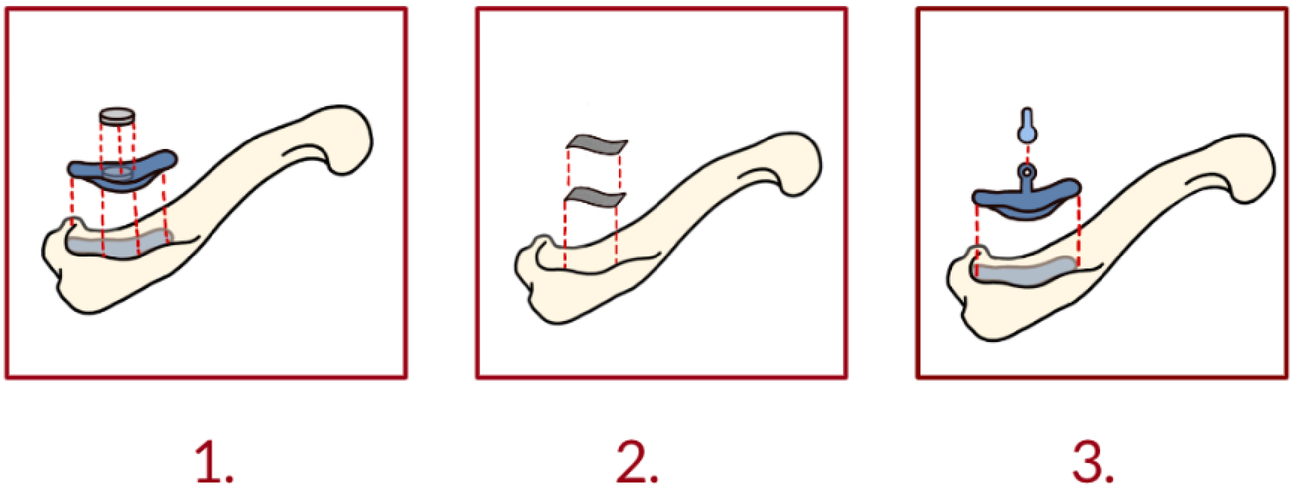


Figure 1 above details the three different ideas for muscle attachment points.

1: Neodymium magnet integrated 3D printed system

2: Velcro attachment system

3: Hook attachment system

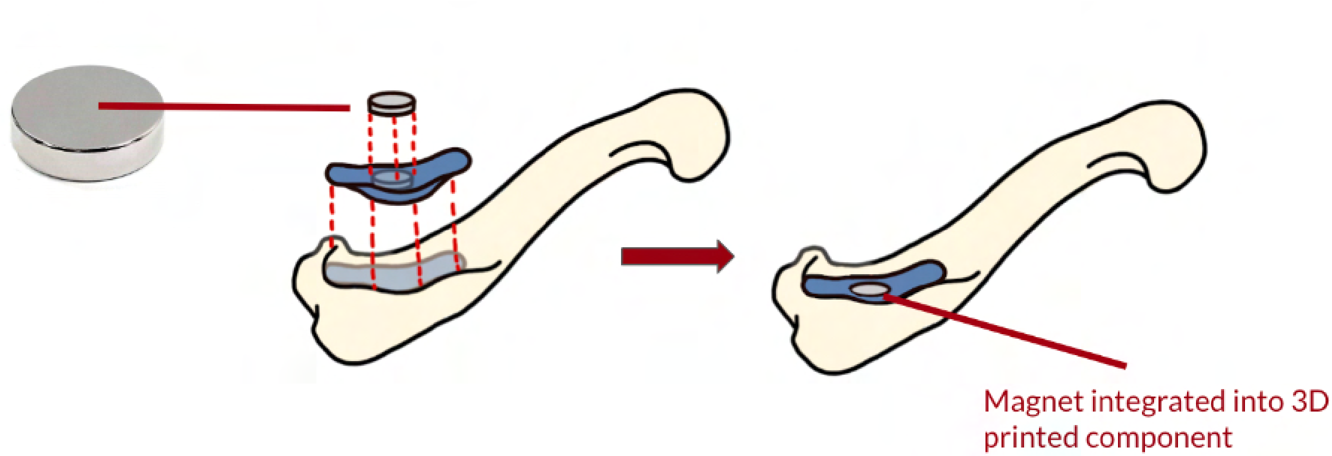


Figure 2 above gives more detail into the 3D printed magnet integrated system. A small, thin neodymium magnet will be fit into a 3D printed component that will be specially designed for each bone attachment point. The magnet will have a counterpart sewn into the muscle, so the user can snap them into place together. This is the most practical design, as magnets are reliable, long lasting, strong, and sleek.

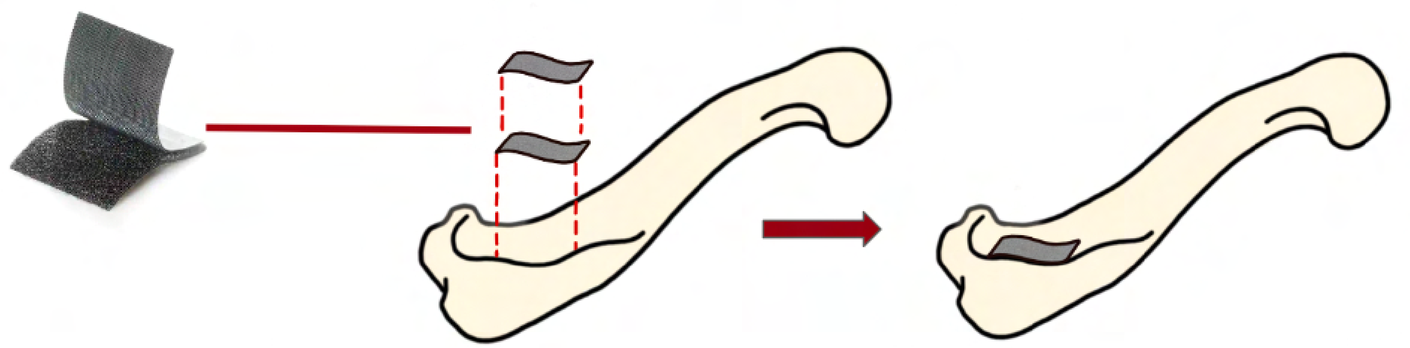


Figure 3 above details the velcro attachment system. Velcro will be glued to the 3D printed bone. The other component of the velcro will be attached onto the muscle fabric similarly. The user will stick and unstick the velcro to attach and detach the muscles. This design will last the shortest of all three, as velcro readily loses its stick and must be replaced frequently.

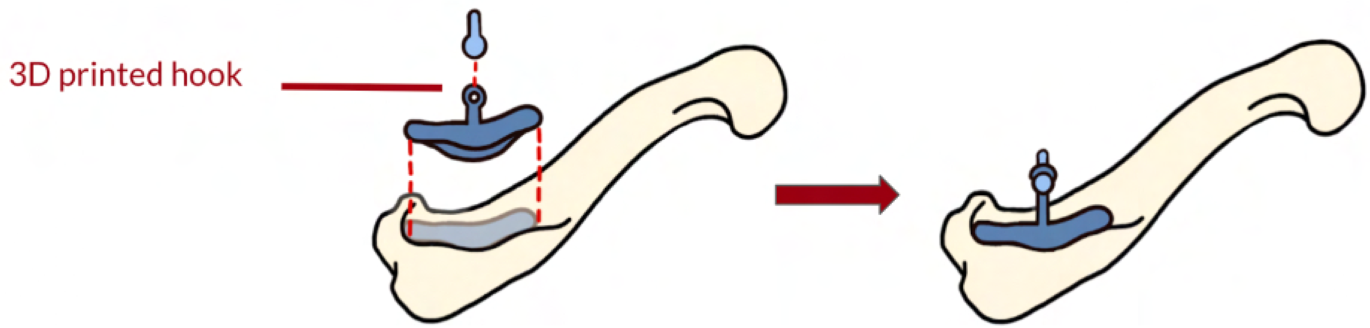


Figure 4 above depicts the hook attachment system. The hook will take the general shape of a ball and socket that can attach together to create an attachment point of bone to muscle. This design is the least practical, as the hooks will not reliably stay attached for the duration of the user.

Citation & Link: N/A

Conclusions/action items: The team will evaluate each of these designs in their Preliminary Design Presentation, Design Matrix, and Preliminary Report.

2022/10/04- Muscle Material Design Figures

LAUREN FITZSIMMONS - Oct 04, 2022, 9:28 AM CDT

Title: Muscle Material Design Figures

Date: Oct 4, 2022

Content by: Team

Present: Lauren Fitzsimmons

Goals: The goal of this document is to visually present the team's three design ideas for muscle materials.

Content:

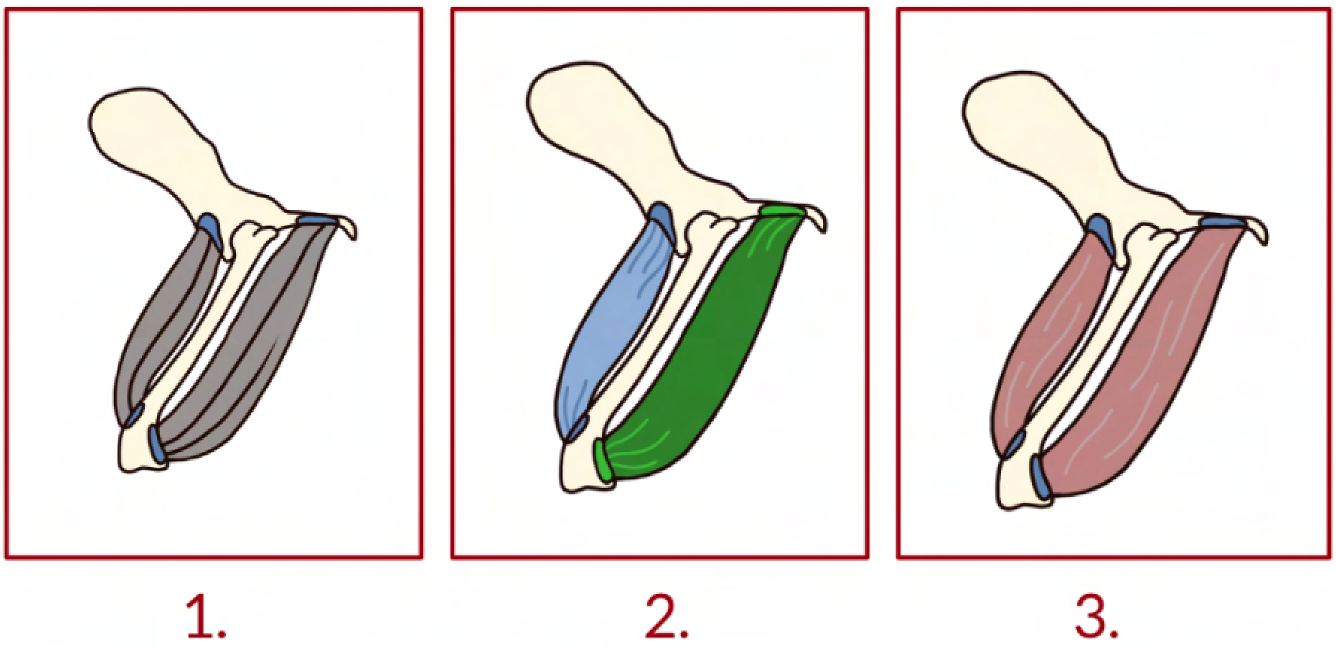


Figure 1 above depicts the teams three design ideas for muscle materials.

1: Elastic/ Rubber Band Muscle

2: Fabric (Nylon/Spandex) Muscle

3: Silicone Rubber Muscle

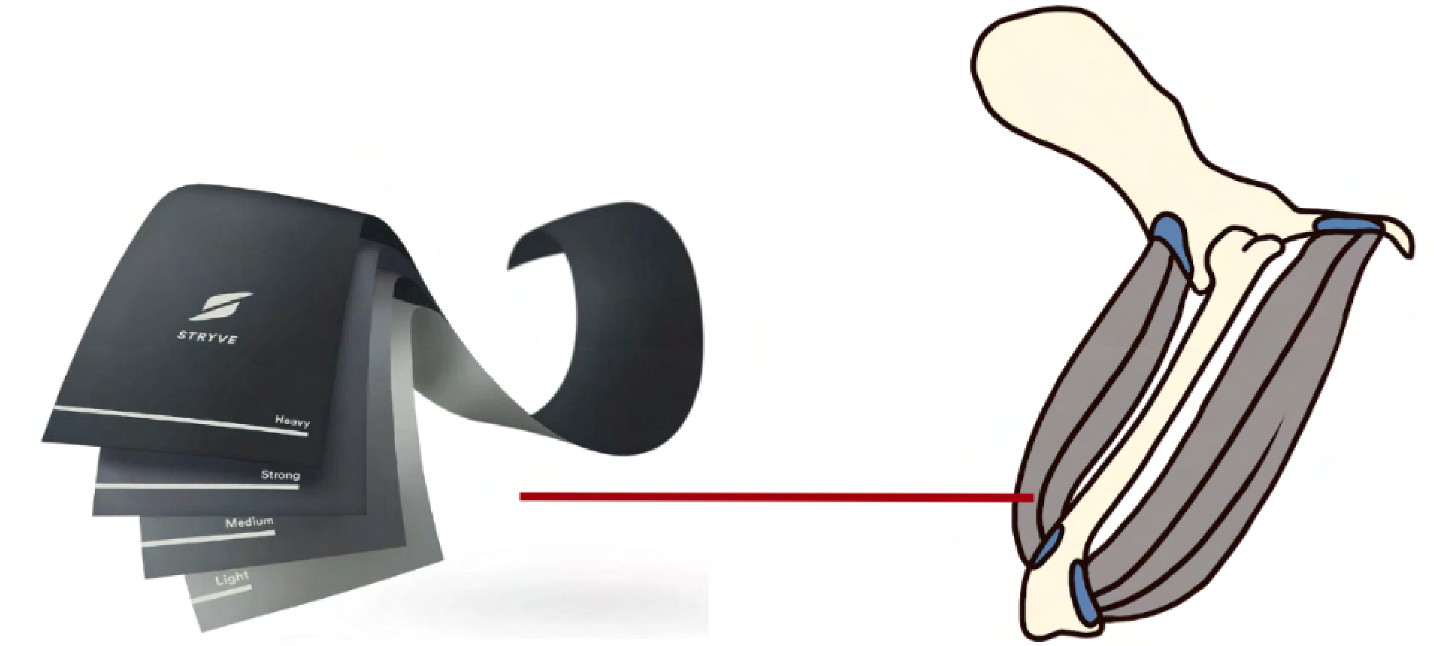


Figure 2 above depicts a greater detailed version of muscle material design option 1. The muscle will be made of rubber resistance bands. This design is not very feasible, as it will be hard to create realistic, 3D looking muscles using 2D flat rubber band material. Additionally, it may be too stretchy.

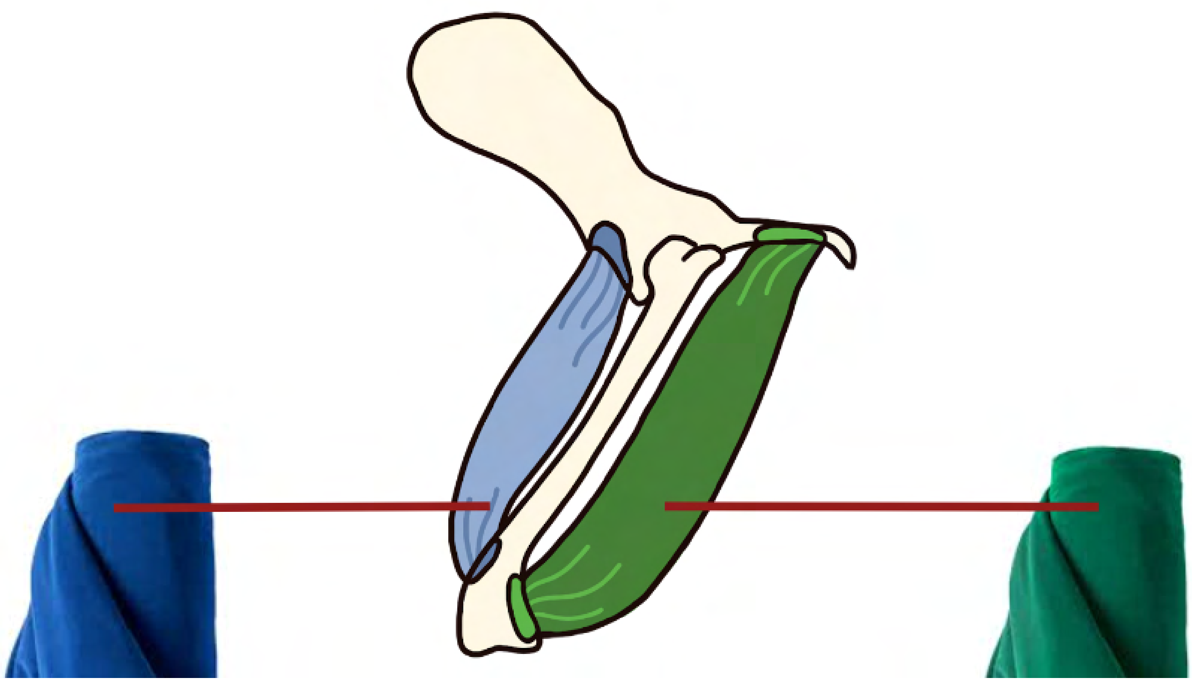


Figure 3 above depicts design option 2, fabric muscles. The fabric will consist of 80% nylon and 20% spandex fabric material, which provides the muscle an appropriate amount of elasticity to simulate accurate muscle motion. The fabric is long lasting and durable.

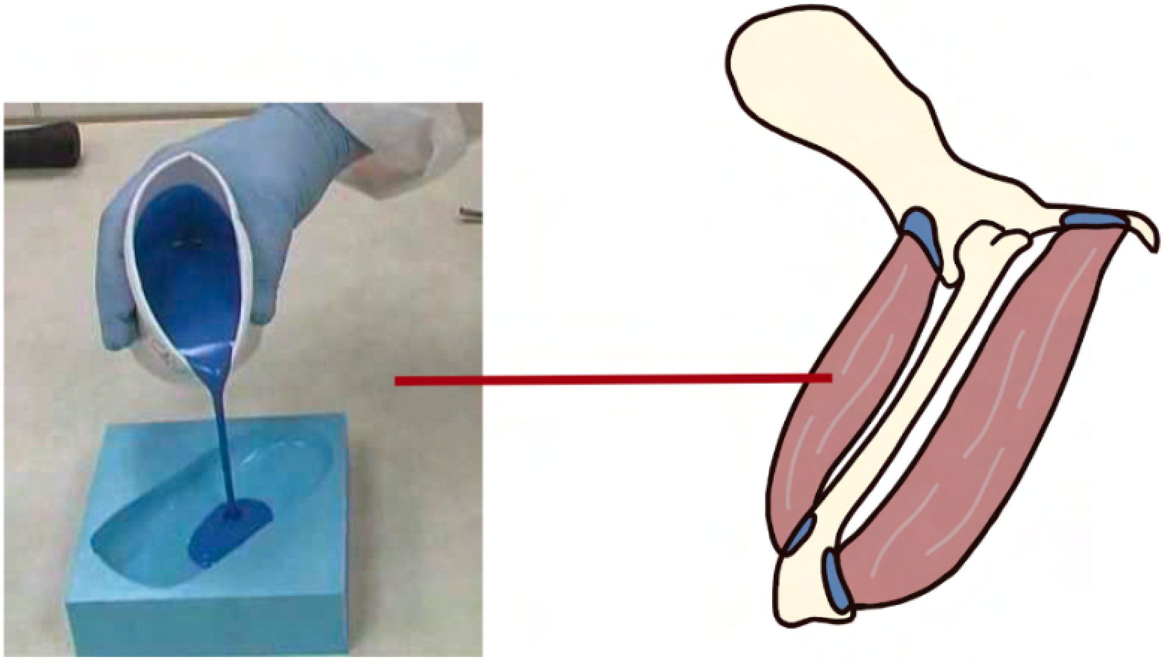


Figure 4 above depicts the teams third design option for muscle material -- silicone rubber. These muscles will be created first by creating a mold. Then, silicone rubber will be poured into the mold and set. Each muscle would have to be created and poured seperately, which may be difficult given the time constraints of a single semester. The rubber also may be too heavy and thick for the model to handle.

Citation & Link: N/A

Conclusions/action items: The team will evaluate each of these muscle material design options in their Design Matrix, Preliminary Design Presentation, and Preliminary Report.

2022/10/04-Final Design Figure

LAUREN FITZSIMMONS - Oct 04, 2022, 9:32 AM CDT

Title: Final Design Figure

Date: 10/04/22

Content by: Team

Present: Lauren Fitzsimmons

Goals: The goal of this document is to present a visual figure of the teams final chosen design -- the neodymium magnet integrated fabric muscle 3D model.

Content:

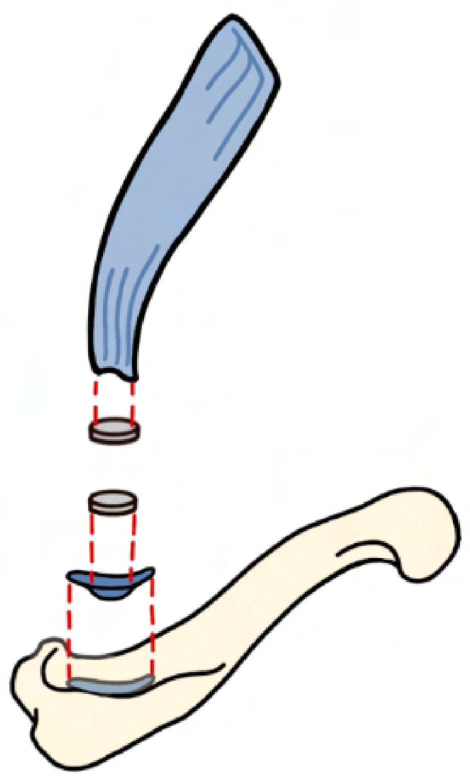


Figure 1 above depicts the schematic for the teams final design: the neodymium magnet integrated fabric muscle 3D model. A neodymium magnet will be inserted into a 3D printed component. The 3D printed component will be designed to specially fit the insertion point on the bone as well as have a slot for the magnet. The magnets outer component will be sewn into the fabric muscle and allow for each attachment/detachment. This design is the most durable, efficient, aesthetic, and functional.

Citation & Link: N/A

Conclusions/action items: This design will be presented in the Preliminary Design Presentation and discussed in the Preliminary Report. The team will move forward with fabricating this design.

2022/10/26- Fabrication Meeting Diagrams

LAUREN FITZSIMMONS - Oct 26, 2022, 1:54 PM CDT

Title: Fabrication Meeting Diagrams

Date: 10/26/22

Content by: Team

Present: Lauren

Goals: To document diagrams created during the team's muscle fabrication meeting.

Content:

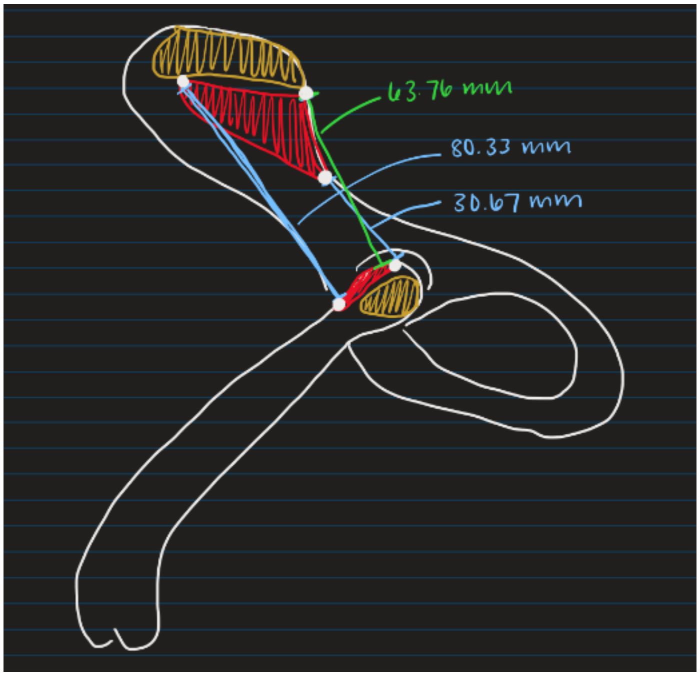


Figure 1 (above): Diagram of the hip and tibia bones and the two muscles that the team was attempting to fabricate. Dimensions between orgins and insertions are also included.

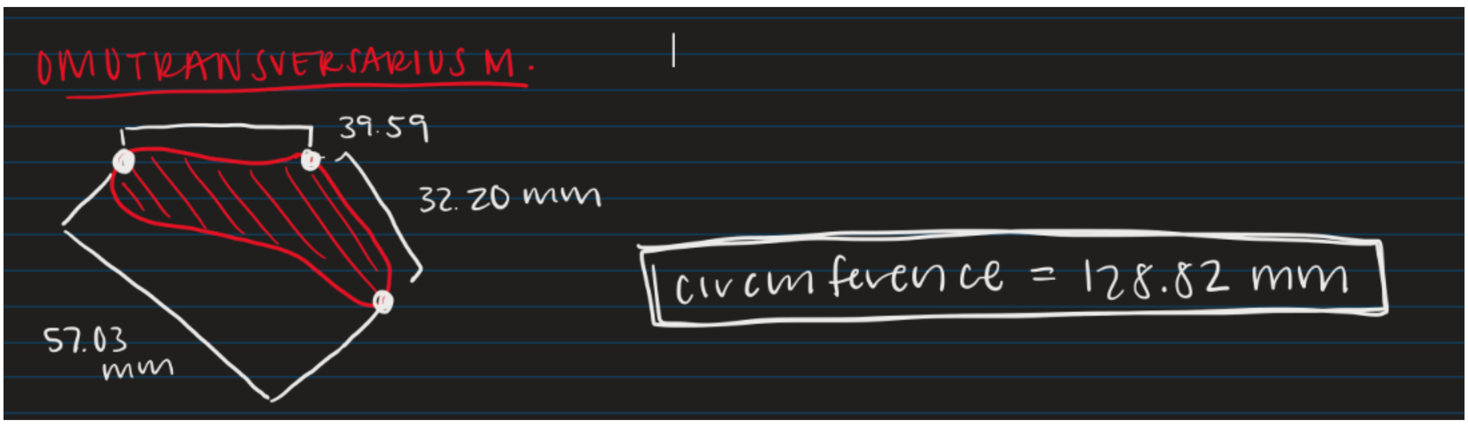


Figure 2 (above): More specific dimensions of the longest possible distance between two points, height and width of the origin of the omotransversarius m. muscle. The rough circumference of the origin was also calculated.

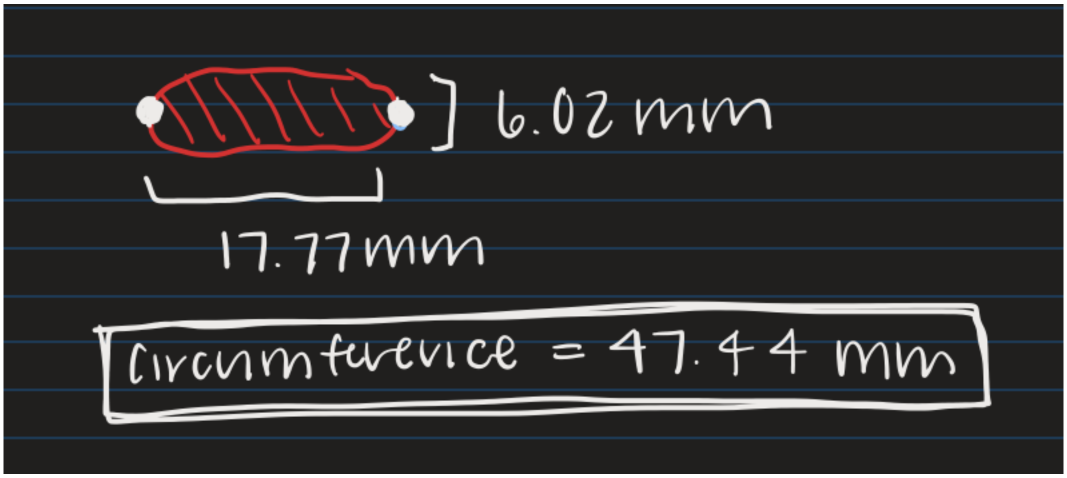


Figure 3 (above): More specific dimensions of the height and width of the insertion point of the omotransversarius m. muscle. The rough circumference of the insertion was also calculated.

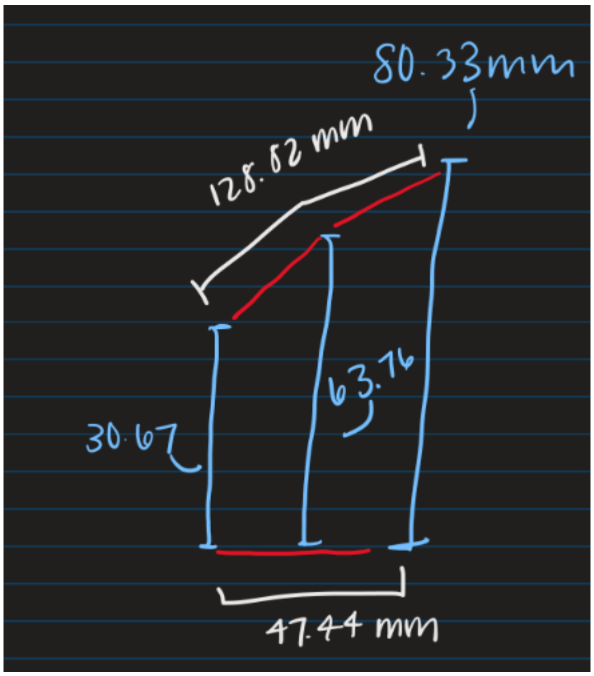


Figure 4 (above): The teams first attempt at creating a muscle fabric pattern for the omotransversarius m. muscle.

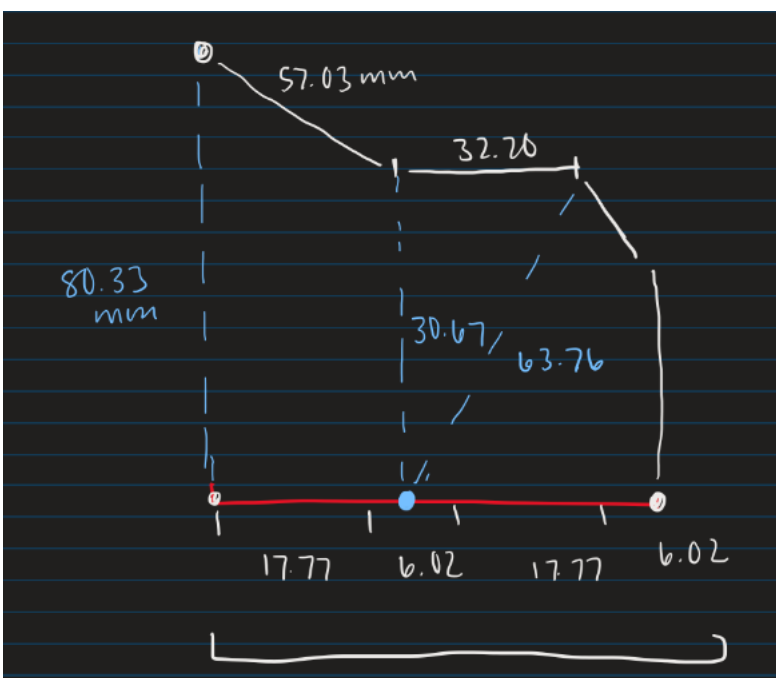
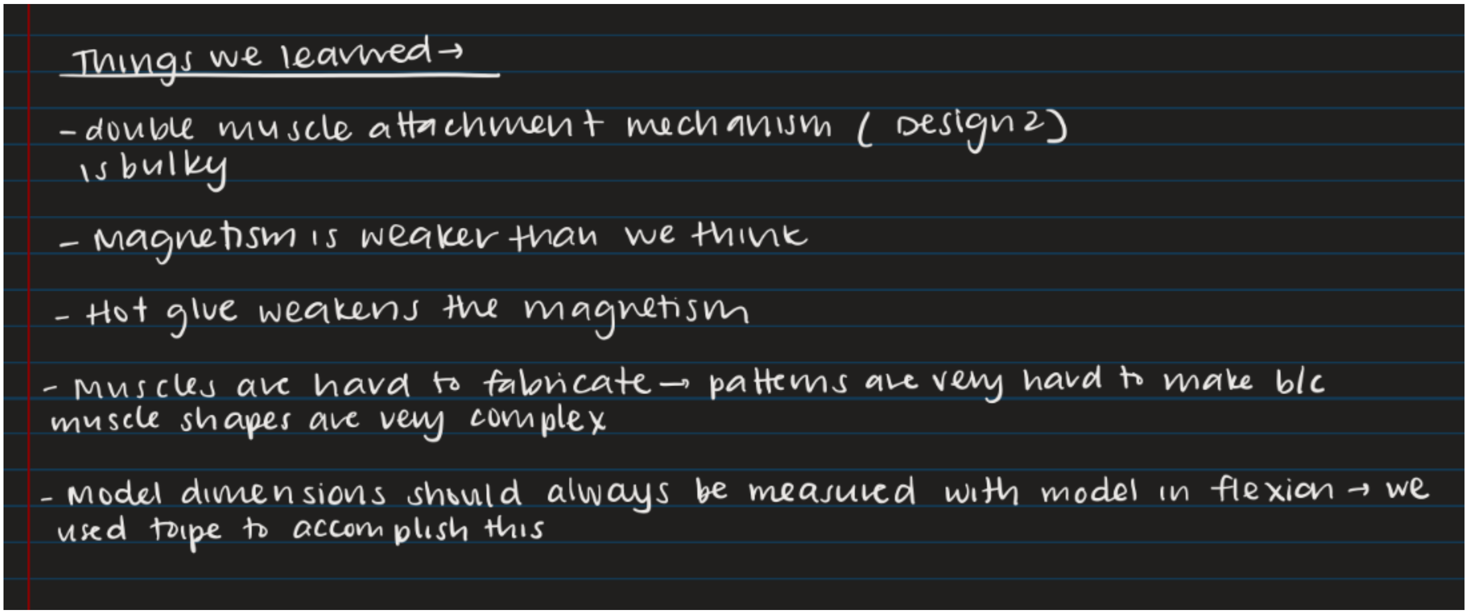


Figure 5 (above): The team's second attempt at fabricating a muscle pattern for the omotransversarius m. muscle.



Things we learned →

- double muscle attachment mechanism (Design 2) is bulky
- Magnetism is weaker than we think
- Hot glue weakens the magnetism
- Muscles are hard to fabricate → patterns are very hard to make b/c muscle shapes are very complex
- Model dimensions should always be measured with model in flexion → we used tape to accomplish this

Figure 6 (above): The team's takeaways from the first muscle fabrication session.

Citation & Link: n/a

Conclusions/action items: See figure 6 above.

2022/11/12- Silicone Rubber Muscle Material Research

Title: Silicone Rubber Muscle Material Research

Date: 11/12/2022

Content by: Lauren

Present: N/A

Goals: The goal of this meeting document is to present information relating to silicone rubber as a possible muscle material. The team has been experimenting with fabric and we no long think
with.

Content:

Silicone Research

Smooth On Ecoflex 00-50

-The silicone with the best reviews is the Smooth On Ecoflex silicone. (https://www.smooth-on.com/products/ecoflex-00-10/)

- This silicone rubber is used for realistic modeling of skin for costumes as well as prostheses, so it seems like it would work for our purposes.

- It's kind of expensive, but not too bad ($50 for 2 lbs). Amazon link: https://www.amazon.com/Smooth-Ecoflex-00-50-Platinum-Silicone/dp/B00GJ80HIC/ref=sr_1_2_sspa
35+fast+platinum+cure+silicone+rubber&qid=1668273508&s=arts-crafts&sprefix=smooth+on+ecoflex%2Carts-crafts%2C104&sr=1-2-spons&psc=1&smid=A1B7M9EQGI

Info from website:

"Cured rubber is very soft, very strong and very "stretchy", stretching many times its original size without tearing and will rebound to its original form without distortion." -Smooth On ----> This r

"Ecoflex™ rubbers are suitable for a variety of applications including making prosthetic appliances, cushioning for orthotics and special effects applications (especially in animatronics where re
actually work really well.

Product specs:

Pot life: 18 mins

Cure time: 3 hours

Silicone to Silicone Molding

- We want to create the muscle model out of silicone. But, we also want to create the mold out of silicone. In order to make sure that these materials do not stick toge
https://www.amazon.com/Smooth-Release-Making-Molds-Casting/dp/B07P96CXRT/ref=sr_1_4?
gclid=Cj0KCQiApb2bBhDYARIsAChHC9vDKKFH17Pt6gh_rBQ6CxAP8aYEg5VKLhKJ6EP2sv4meFmu2zMKb7AaAqFiEALw_wcB&hvadid=616990817225&hvdev
38284150888&hydadcr=24659_13611768&keywords=ease+release+200&qid=1668274014&sr=8-4) or, the site said that you could "sometimes" use a solution of t
- Full info on mold release: https://www.smooth-on.com/support/faq/94/#:~:text=A%20mixture%20of%202%20parts,with%20minimal%20visible%20brush%20strokes

Other Info:

- Article link: https://www.wcu.edu/WebFiles/PDFs/KS_Sparks_Tanaka.pdf
- This research article uses Ecoflex to model tissue. It also performs several test strategies to make sure this muscle is strong enough. We could possibly emulate ar

Above (left): Mann Ease Release 200. This is a potential spray that we could use to release the muscle from the mold.

Above (right): Smooth On Ecoflex 00-50 parts A and B. This is what we would use to create our molds as well as create the muscles.

Conclusions/action items:

-Silicone could be a viable option for muscle modeling. If it is, the Smooth On Ecoflex 00-50 seems like the most durable, high quality silicone to use.

2022/09/10: "Dual-extrusion 3D printing of anatomical models for education"

Molly Paras - Sep 10, 2022, 11:31 PM CDT

Title: Dual-extrusion 3D printing of anatomical models for education

Date: September 10, 2022

Content by: Molly Paras

Present: N/A

Goals: Understand how 3D printing with multiple materials works and if it would be good for our project.

Content:

- There are free files available online and in this paper
- Muscles and bones were modeled using FilaFlex3D flexible and polylactic acid (PLA) filament and a 0.4mm nozzle
- Can make functional, dissectible, layered, multi-part models
  - not constrained by rigid plastic anatomical models anymore
- Color printing allows for more realistic models
- Formaldehyde levels have been limited, making it harder to preserve cadavers and use for anatomical education
- Some printers can be jetting multiple materials at the same time
  - this printer was super expensive, but the dual-extrusion FDM is a more cost efficient printer and can still do two at a time (just adding materials takes a long time)
- Layer height of 0.1mm and shell thickness of 0.4mm was the best parameters for the materials to print best (but took longest time)
- PLA used for hard materials like bones, the FilaFlex3D modeled the muscles and tissues
- Multiple materials allows for the user to better manipulate the model and is more realistic
- The materials used may limit the scale of structures possible to print due
- Functional models are possible to print!

Search term: Recommended by client

Citation:

M. L. Smith and J. F. X. Jones, “Dual-extrusion 3D printing of anatomical models for education,” *Anatomical Sciences Education*, vol. 11, no. 1, pp. 65–72, 2018, doi: 10.1002/ase.1730.

Link: https://anatomypubs-onlinelibrary-wiley-com.ezproxy.library.wisc.edu/doi/pdfdirect/10.1002/ase.1730

Conclusions/action items: If good materials are chosen, a combination of materials are very useful for modeling both hard bones and soft tissues and allows them to be connected. We should continue researching the best settings (like layer height) for our printer, materials, and what we want to print along with looking into more possible materials to use.

Molly Paras - Sep 19, 2022, 11:17 PM CDT

Printer Settings and Resultant Spatial Resolution for Two Materials

Material	Layer height (mm)	Shell thickness (mm)	Retraction distance (mm)	Narrowest lumen diameter (mm)	Minimal wall thickness (mm)	Narrowest space (mm)	Narrowest angle (degrees)	Duration of print (hours:minutes)
PLA	0.2	0.6	3.0	0.7	0.70	0.5	40	0:38
PLA	0.1	0.6	3.0	1.0	0.65	0.5	40	1:04
PLA	0.1	0.4	4.5	0.5	0.78	0.3	25	1:38
FilaFlex^{3D}	0.2	0.6	3.0	1.5	0.68	0.6	40	0:38
FilaFlex^{3D}	0.1	0.6	3.0	1.5	0.85	0.4	25	1:04
FilaFlex^{3D}	0.1	0.4	4.5	1.6	0.80	0.3	25	1:38

This table provides the printer settings for polylactic acid (PLA) and FilaFlex^{3D} filaments and the resulting print times and spatial resolution.

Download

3D_Printer_Settings.jpg (93.3 kB)

2022/09/10: "What Is the Role of 3D Printing in Undergraduate Anatomy Education? A Scoping Review of Current Literature and Recommendations"

Molly Paras - Sep 10, 2022, 5:19 PM CDT

Title: What Is the Role of 3D Printing in Undergraduate Anatomy Education? A Scoping Review of Current Literature and Recommendations

Date: September 10, 2022

Content by: Molly Paras

Present: N/A

Goals: Learn more about the importance of the project.

Content:

- 3D models are a more popular method of teaching instead of cadavers due to the cost and reproducibility
  - useful for studying anatomy overall, but texture and colors of tissues are not often modeled very accurately
- Often used for postgraduate students, and will likely be added to undergraduate education as well
- Online 3D model databases are available
- Traditional cadaver learning risks breaking ethical and cultural boundaries of some students along with the added health risk
- Price of 3D printing has greatly decreased, making it more affordable for schools
- CT and MRI scans can be used to form the 3D models
- **Knowledge and performance increases with 3D and colored models**
- The 3D models created nowadays can be very similar to the real thing
- Useful for abnormal anatomy as well
- Active learning and visual aids help students to pay attention and retain information
- Always be cautious of how well they model the true anatomy of the organism
- This study was focused on 3D printing in undergrad students and came from many different countries, but a lot of other research has found similar results in postgrad students

Search term: Article that cites "Dual-extrusion 3D printing of anatomical models for education," which was recommended by the client

Citation:

J. Yuen, “What Is the Role of 3D Printing in Undergraduate Anatomy Education? A Scoping Review of Current Literature and Recommendations,” *Med Sci Educ*, vol. 30, no. 3, pp. 1321–1329, Jun. 2020, doi: 10.1007/s40670-020-00990-5.

Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8368521/

Conclusions/action items: The use of 3D printed models in medical education seems very valuable and useful to how well the students learn. We should consider color-coding our models as well.

2022/09/17: Relevant Standards

Molly Paras - Sep 17, 2022, 10:48 AM CDT

Title: "CPSC Approves New Federal Safety Standard for Magnets to Prevent Deaths and Serious Injuries from High-Powered Magnet Ingestion"

Date: September 17, 2022

Content by: Molly Paras

Present: N/A

Goals: Determine if there are any safety standards or regulations that must be met with our product.

Content:

- There are some standards relevant to use of magnets in products, like making sure they are safe enough in the event of someone swallowing them or large enough that they cannot be swallowed. This does not need to be taken in consideration by us though, as products distributed solely to school educators, researchers, or professionals for the use of research or education are exempt from this standard.

Citation: "CPSC Approves New Federal Safety Standard for Magnets to Prevent Deaths and Serious Injuries from High-Powered Magnet Ingestion," *U.S. Consumer Product Safety Commission*. https://www.cpsc.gov/Newsroom/News-Releases/2022/CPSC-Approves-New-Federal-Safety-Standard-for-Magnets-to-Prevent-Deaths-and-Serious-Injuries-from-High-Powered-Magnet-Ingestion (accessed Sep. 17, 2022).

Link: https://www.cpsc.gov/Newsroom/News-Releases/2022/CPSC-Approves-New-Federal-Safety-Standard-for-Magnets-to-Prevent-Deaths-and-Serious-Injuries-from-High-Powered-Magnet-Ingestion

Conclusions/action items: While the use of small, detachable magnets could pose a danger to children, if we ended up using magnets in our product there would be no standards to follow since educational products are exempt. We should continue to look for more standards that could be relevant to our product.

2022/11/11: Silicone Research

Molly Paras - Dec 14, 2022, 10:34 AM CST

Title: Silicone Research

Date: November 11th, 2022

Content by: Molly Paras

Present: Molly Paras

Goals: Learn more about how to use silicone.

Content:

- usually made with a 2-part epoxy mixture, what forms is a semi-elastic polymer that is stretchy but also strong
- often used for medical training devices since similar to skin
- most things do not stick to silicone besides silicone itself
  - there are a few type of repair products found on this website
- using mesh fabric in the silicone is very helpful in preventing tears
  - having mesh also makes it easier to repair if it does break

Citation & Link: S. Crawford, “Tips, Tricks & Hacks - Silicone Repair Technique,” *SIMGHOSTS*, Feb. 19, 2021. https://simghosts.org/news/552860/Tips-Tricks--Hacks---Silicone-Repair-Technique.htm (accessed Nov. 11, 2022).

Conclusions/action items: We are getting some silicone to try to fabricate our muscles with. We should do some testing and learn more about different ways to make it thinner/thicker and how to make a good mold. More research should be conducted on this.

2022/10/04: "Bones of the Pelvic Limb" in Miller's Anatomy of the Dog

Molly Paras - Oct 04, 2022, 6:28 PM CDT

Title: "Bones of the Pelvic Limb" in Miller's Anatomy of the Dog

Date: October 4th, 2022

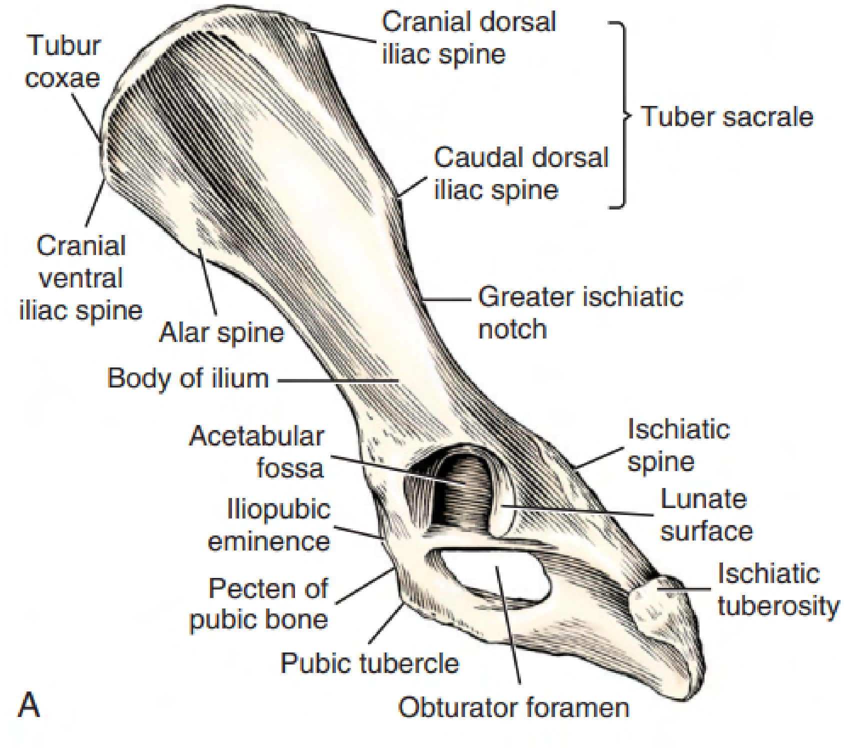
Content by: Molly Paras

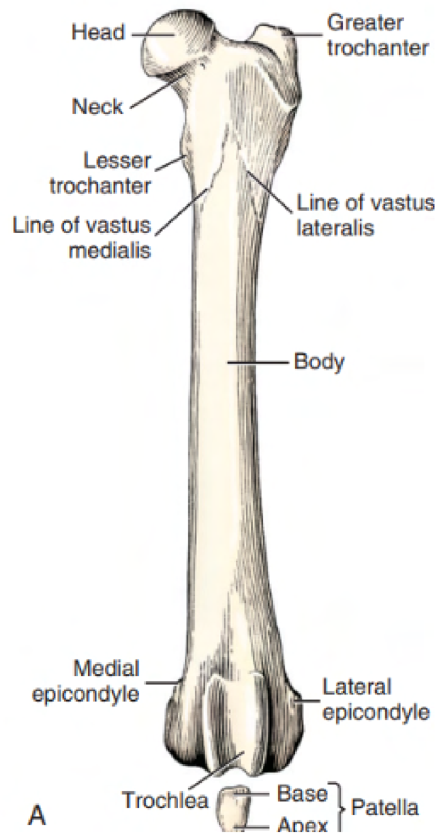
Present: N/A

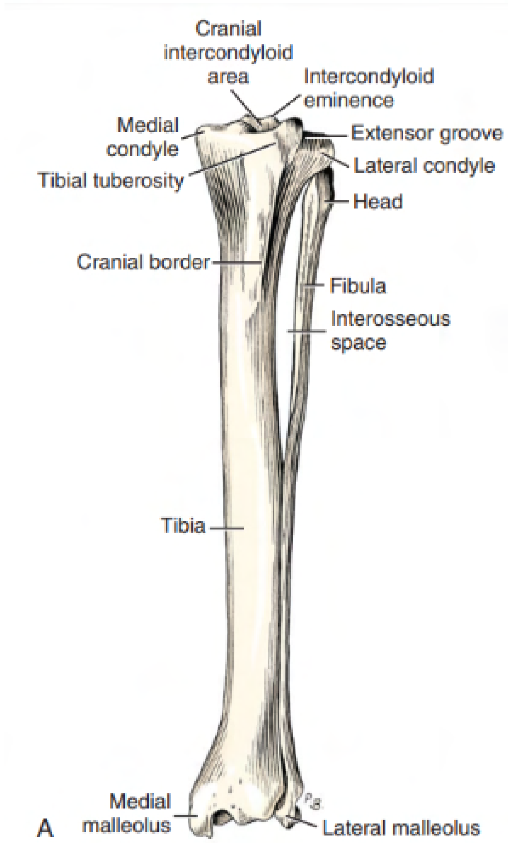
Goals: Learn more about the bones in the hindlimb of a dog.

Content:

- hindlimb = pelvic limb
- hip is made from ilium, ischium, pelvis, and acetabular bone
- thigh includes femur and sesamoids
    - sesamoid = bone embedded within a muscle or tendon
- lower leg is tibia and fibula
- hind paw has lots of bones, including tarsals, metatarsals, phalanges and sesamoids
- Femur:
    - forms 110 degree flexor angle with tibia (caudally)
    - femur is made of a smooth head with a small circular pit (where ligaments attach), neck, two processes/trochanters, body
        - grater trochanter is the one proximal to head/neck, muscles like mm. gluteus medius, gluteus profundus, and piriformis attach here
        - mm. gemelli, obturatorius internus, and obturatorius externus connect to trochanteric fossa (between neck and greater trochanter)
        - m. quadratus femoris connects to intertrochanteric crest (connection between greater and lesser trochanter), m. iliopsoas attaches to lesser trochanter
        - m. gluteus superficialis connects to third trochanter on body, m. adductor longus connects to lateral lip (distal to third trochanter), m. adductur magnus et brevis attaches to entire lateral lip (third trochanter to popliteal surface), m. pectineus to distal end of medial femoral lip (proximal to cranial insertion of m. semimembranosus), m. gastrocnemius on tuberosities, m. flexor digitorum superficialis from lateral supracondylar tuberosity
        - patella articulates with trochlea on femur (surrounded by tendon m. quadriceps femoris)
        - m. extensor digitorum longus connects to extensor fossa on trochlea
- Tibia:
    - long and thick, partially triangular but other end is cylindrical
    - articulates with femur proximally, with tarsus distally, and with fibula both proximally and distally
    - connections
        - m. quadriceps femoris and mm. biceps femoris and sartorius connect to tibial tuberosity
        - mm. gracilis and semitendinosus and part of ^ connect to cranial border, m. semimembranosus on medial condyle (caudally), m. tibialis cranialis on lateral condyle
        - m. popliterus on proximal medial part of caudal surface
        - mm. flexor digitorum lateralis, tibialis, caudalis, and flexor digitorum medialis from proximal caudal surface (mentioned laterally to medially)
        - mm. semitendinosus, gracilis, and sartorus in medial surface of tibia
        - m. flexor digitorum lateralis on lateral border of tibia, along with m. fibularis brevis on lateral surface of both fibula and tibia
- Fibula
    - long, slender, laterally compressed
    - articulates with lateral condyle of tibia (proximally) and talus and tibia (distally)
    - main purpose is muscle attachment (not weight support)
    - "The muscles that attach to various parts of the fibula include the head of fibula—m. flexor digitorum medialis; the head and adjacent shaft—mm. extensor digitorum lateralis and fibularis longus; the medial part of the proximal end—m. tibialis caudalis; caudal surface of proximal three-fifths—m. flexor digitorum lateralis: cranial border between proximal and middle thirds—m. extensor digiti I longus; distal two-thirds—m. fibularis brevis."







Citation & Link: H. E. Evans and A. de Lahunta, “Miller’s Anatomy of the Dog,” 4th ed., Elsevier Saunders, pp. 140–151.

Conclusions/action items: The main bones in the dog hindlimb are the femur, patella, tibia, and fibula, and it connects to the hip bones and paw. There are lots of muscles/tendons that connect to the bones, and knowing which bone is which is important to creating our model. Next we will scan the femur, patella, tibia, and fibula from the bone box to make the files to 3D print. I will also read about the muscles of the pelvic limb (starting on page 254 in Miller's Anatomy of the Dog).

2022/10/04: "Muscles of the Pelvic Limb" in Miller's Anatomy of the Dog

Molly Paras - Oct 04, 2022, 9:09 PM CDT

Title: "Muscles of the Pelvic Limb" in Miller's Anatomy of the Dog

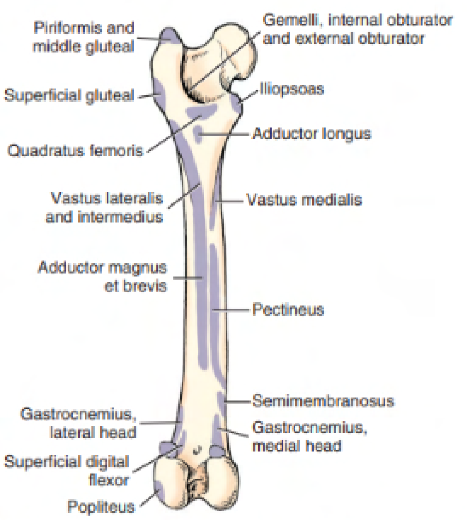
Date: October 4th, 2022

Content by: Molly Paras

Present: N/A

Goals: Determine which muscles attach to the bones we are printing.

Content:



URE 6-72 Left femur, showing areas of muscle attachment, caudal aspect.

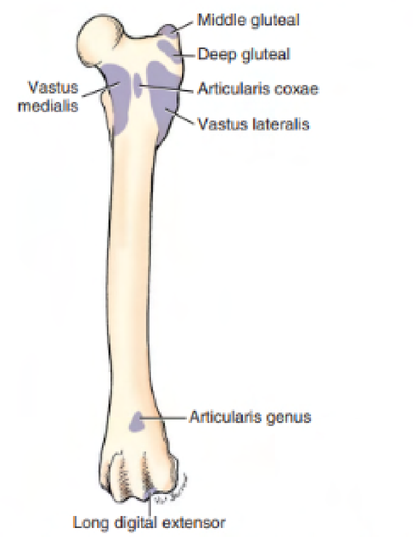


FIGURE 6-74 Left femur, showing areas of muscle attachment, cranial aspect.

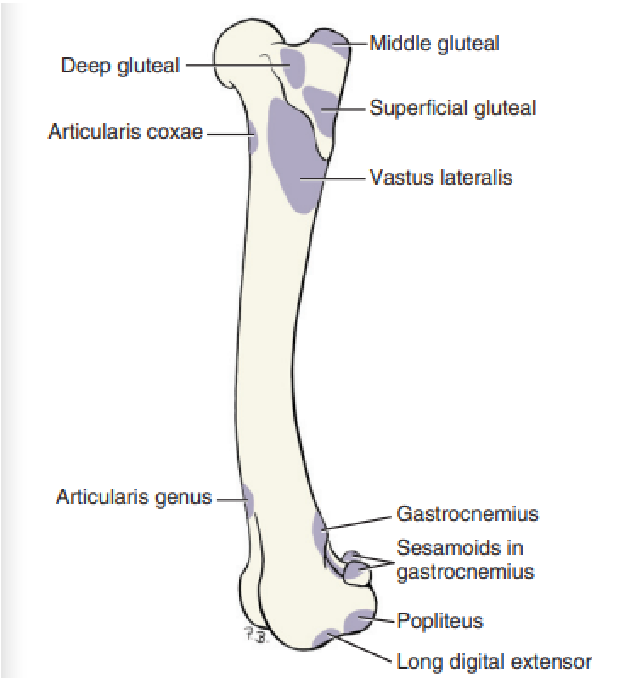


FIGURE 6-73 Left femur, showing areas of muscle attachment, lateral aspect.

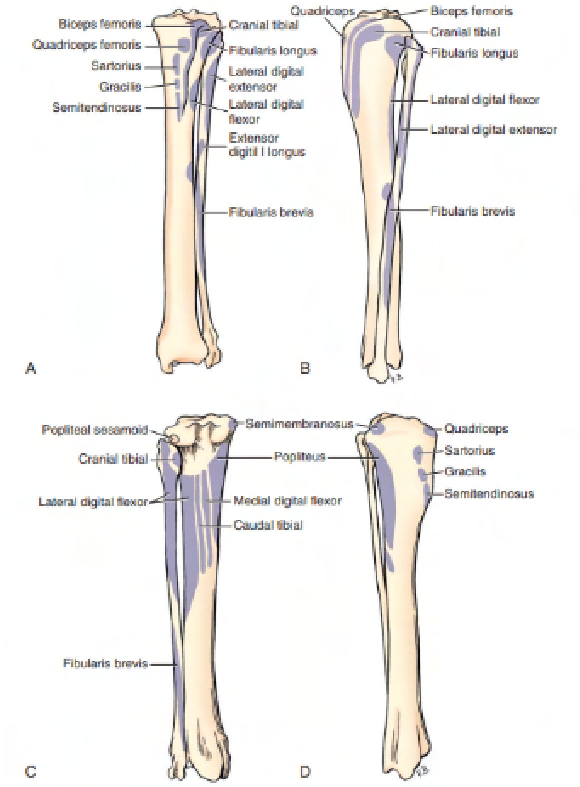


FIGURE 6-81 **A**, Left tibia and fibula, showing areas of muscle attachment, cranial aspect. **B**, Left tibia and fibula, showing areas of muscle attachment, lateral aspect. **C**, Left tibia and fibula, showing areas of muscle attachment, caudal aspect. **D**, Left tibia and fibula, showing areas of muscle attachment, medial aspect.

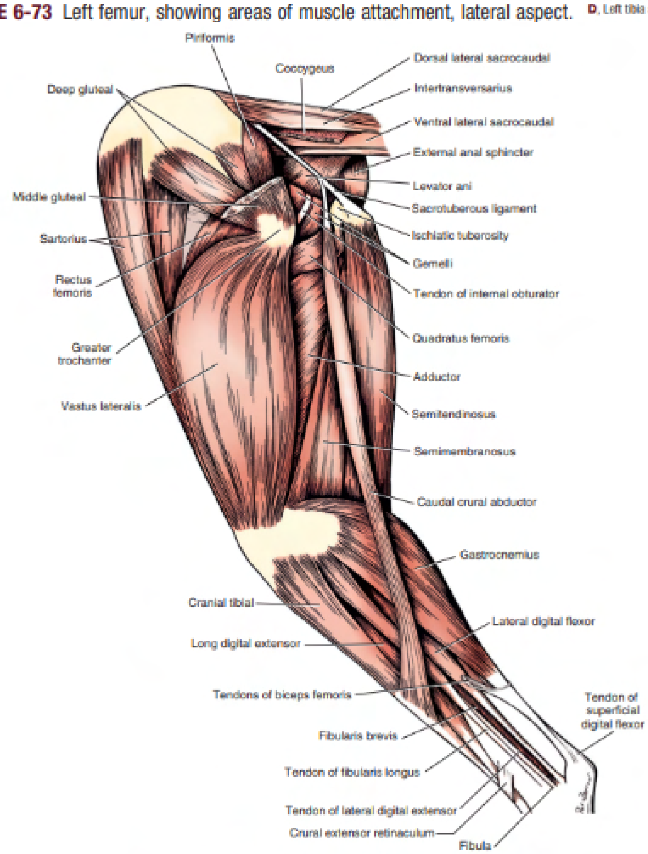


FIGURE 6-82 Deep muscles of pelvic limb, lateral aspect.

Citation & Link: H. E. Evans and A. de Lahunta, “Miller’s Anatomy of the Dog,” 4th ed., Elsevier Saunders, pp. 254–276.

Conclusions/action items: This book has lots of images and notes on where the muscles attach and how they do so. I am not going to read it all since there are tons of muscle names and parts of the bones that I do not know, but I will make sure to refer back to the book if I need more information on attachment. For now, these images seem like they will be very helpful in understanding what attachment points look like on the bones. Having this information, we can begin to make our model muscles but will need to know a little more about sizing before 3D printing the muscle attachment point.

2022/09/12: "Production of accurate skeletal models of domestic animals using three-dimensional scanning and printing technology"

Molly Paras - Sep 12, 2022, 5:02 PM CDT

Title: Production of accurate skeletal models of domestic animals using three-dimensional scanning and printing technology

Date: September 12, 2022

Content by: Molly Paras

Present: N/A

Goals: Discover how others have 3D printed animal skeletal models.

Content:

- FDM printer (CreatBot DG03) and structured light scanner (EinScan-Pro 3D) were used to create the models from bovine bones in this study
- Almost all features can be preserved in the models, and there is a very small standard deviation between the measurements of the models compared to the real bones
- The models are sufficient alternatives in terms of teaching anatomy and veterinary education
- Scans (CT, MRI, etc.) can be used to create the computer models, but are often costly; 3D scanners and photogrammetry is a more inexpensive method to create these images
- PLA was used for printing
- Calipers were used to measure and compare the accuracy of the models, along with a 3D comparison via the point cloud and Geomagic Qualify software --> ANOVA test showed that there was no significant difference between the real, digital, and 3D printed models
- The largest deviations from the real bones occurred in bones with large curves and narrow parts, along with some of the edges (but the models still represented the real thing well)
- The cost seems to be cut by ten-fold for a 3D printed model rather than a real specimen, and each model took less than 24 hours to print

Search term: UW Libraries Search: "3D printed skeletal models"

Citation:

F. Li, C. Liu, X. Song, Y. Huan, S. Gao, and Z. Jiang, “Production of accurate skeletal models of domestic animals using three-dimensional scanning and printing technology,” *Anatomical Sciences Education*, vol. 11, no. 1, pp. 73–80, 2018, doi: 10.1002/ase.1725.

Link: https://pubmed.ncbi.nlm.nih.gov/28914982/

Conclusions/action items: Some of the methods/techniques used in this study could be valuable to us since we could do some of those to test our products too.

2022/09/10: "Three-dimensional printing educational anatomical model of the patellar luxation in dogs"

Molly Paras - Sep 10, 2022, 8:20 PM CDT

Title: Three-dimensional printing educational anatomical model of the patellar luxation in dogs

Date: September 10, 2022

Content by: Molly Paras

Present: N/A

Goals: Learn how others have 3D printed anatomical models for educational purposes.

Content:

- They modeled the femorotibiopatellar joint as healthy and with medially deviated and shifted tibial tuberosity (and the reactions to that)
    - this models luxation/dislocation of a joint
- Made with elastics to make it more anatomically correct
- Learned about the change in position of different ligaments caused by the shift/deviations
- 3D printing is beneficial for educational purposes along with designing surgeries and other procedures
- The bones used to create the 3D model were placed in a 50% hydrogen peroxide solution to make them lightened and then they were colored, an the soft tissues went through the process of removal, boiled in water, cleaned, and dried
- Digitized through the use of "3D Go! SCAN®", which used cameras, a projector, and LEDs; processed and edited using other software
- They used a printer with fused deposition modeling (FDM) technology using acrylonitrile-butadiene-styrene (ABS) with support resin (which then gets washed off with Econoworks Tables Cleaning Agent®)
- Models took about 10 or 11 hours to produce in real scale
- 3D scanning, editing, printing, and using it to simulate different things allows for a deeper knowledge of the bones and problems/diseases/lesions that happen

Search term: UW Library Search: "3D Print Dog Bone Model"

Citation:

B. Ribeiro Gaspar and A. C. de Assis Neto, “Three-dimensional printing educational anatomical model of the patellar luxation in dogs,” *PLoS One*, vol. 16, no. 7, p. e0255288, Jul. 2021, doi: 10.1371/journal.pone.0255288.

Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8323952/

Conclusions/action items: As 3D printing is growing in the veterinary field, it can be used in many situations to better understand the structural, functional, and overall biomechanical properties of bones in animals. The technology, techniques, and material used may be beneficial to our project.

2022/09/17: "A three-dimensional musculoskeletal model of the dog"

Molly Paras - Sep 17, 2022, 9:51 PM CDT

Title: "A three-dimensional musculoskeletal model of the dog"

Date: September 17, 2022

Content by: Molly Paras

Present: N/A

Goals: Find products already available that might be similar to ours.

Content:

- Simulation includes 134 muscles
- Main pros to this model are its scalability, modularity, and 3 dimensionality
- Was tested dynamically with results from a beagle walking and thus is accurate and useful for analyzing different characteristics and how they impact dog movement
    - used 3D kinematic data from previous studies
- Heatmap of which muscles are activated at different times as the dog walks
    - lots of data (dendrogram, heatmap, graphs) showing which muscles are activated first, second, third, etc. during normal dog movement
        - starts with serratus muscles and ends with brachiocephalicus

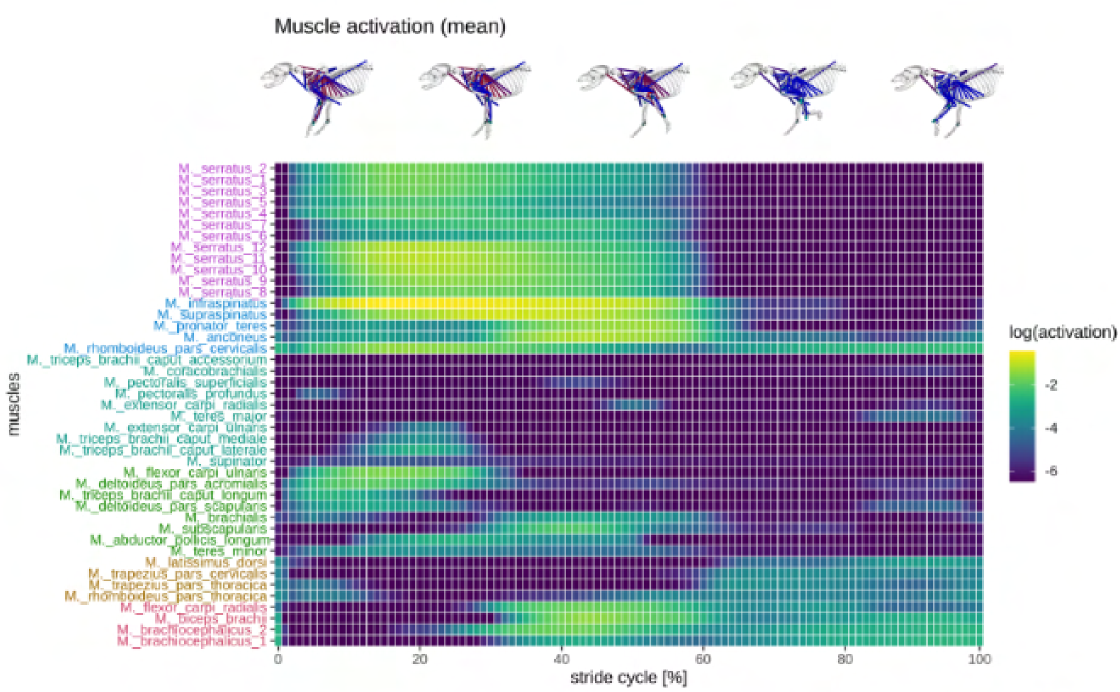


Figure 3. Simulated forelimb muscle activation in a walking Beagle during one gait cycle, shown as a heatmap of logarithmic values (log2). The plot shows how individual muscles were activated based on consecutive strides of the same trial. The muscle groups (colours) were arranged according to hierarchical clustering (method—ward.d2) and minimal leaf sorting. The figures were created with the software packages OpenSim[28,29] and R[70].

Muscle activation (dendrogram)

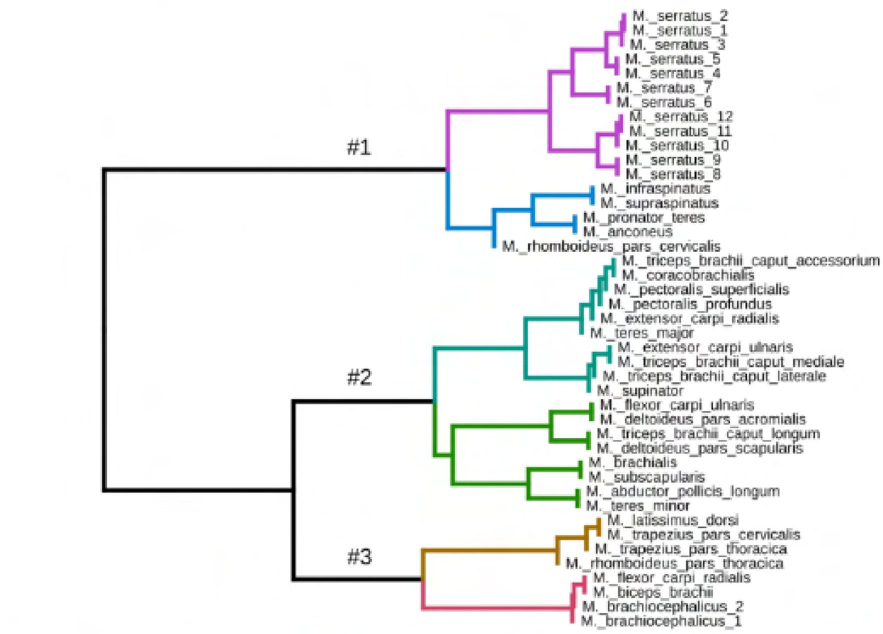
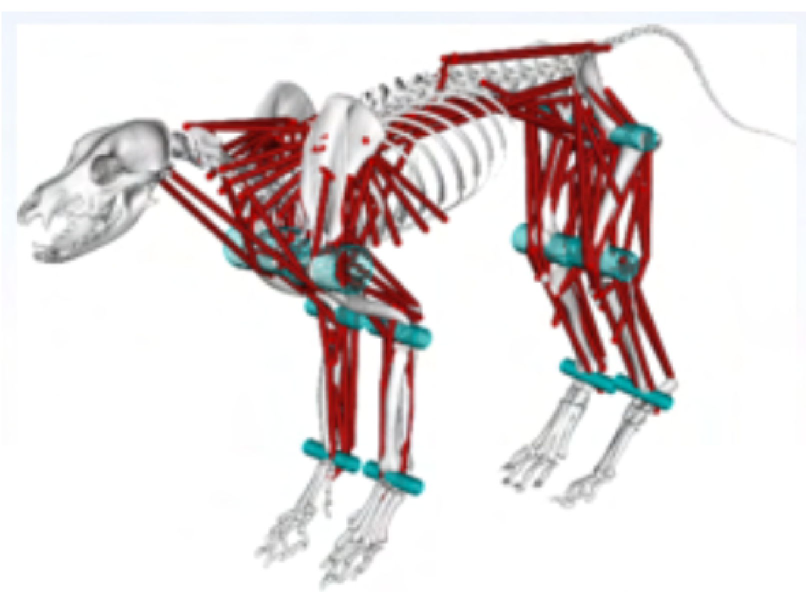


Figure 4. Hierarchical clustering (method—ward.d2) and minimal leaf sorting of simulated forelimb logarithmic muscle activation (log2) in the walking Beagle. The dendrogram shows how individual muscles were activated based on consecutive strides of the same trial. Groups represent a distance between activation patterns. The distance is displayed in the dendrogram as branch length. The longest lengths from the root were used as criteria to separate groups. The figure was created with the software package R[70].

- Used Amira software to convert CT scan of dog bones to the individual reconstructed bones
- Forelimbs are hard to model since the scapular joint has high mobility, but the ball and socket joint makes the hindlimbs a little easier to model
- The way they created it allows them to just model a certain limb or to combine it all into a full scale model of a dog
- Can download the simulation file (OpenSim)
    - file includes 3D images of each of the bones to make the skeleton along with the combined musculoskeletal file
    - could be useful but might need other software to better see/utilize it



Search term: Google: "physical models of dog limbs"

Citation:

H. Stark, M. S. Fischer, A. Hunt, F. Young, R. Quinn, and E. Andrada, “A three-dimensional musculoskeletal model of the dog,” *Sci Rep*, vol. 11, no. 1, Art. no. 1, May 2021, doi: 10.1038/s41598-021-90058-0.

Link: https://www.nature.com/articles/s41598-021-90058-0

Conclusions/action items:

While this is a competing design, it is still not a physical product that students could use, it is a virtual product that simulates muscle movement while showing the musculoskeletal structure of a dog. Having something that students can physically touch and move like our product will be beneficial for their learning, so our product is very necessary even with products like this simulator out there. Their simulation may be helpful to us in determining what muscles should be modeled and how they work.

2022/09/19: Anatomy Warehouse Model

Molly Paras - Sep 19, 2022, 11:41 PM CDT

Title: Dog Skeleton Flexibly Mounted Anatomy Model on Wood Base by Anatomy Warehouse

Date: September 17, 2022

Content by: Molly Paras

Present: N/A

Goals: Explore competing designs.

Content:

- On sale for $2042-$2118
- Mounted but movable, able to demonstrate natural movements of dogs --> similar to what we want to do, but ours should include muscles and not use real bones since so expensive
- Skeletons come from real bones of domestic dogs after death and are properly cleaned
  - Often out of stock since don't know when a dog is going to pass for them to get to use a real skeleton and form this model
- Includes every bone and is very accurate since literally is from a real dog
- Created by 3B Scientific, sold by Anatomy Warehouse

Link: https://anatomywarehouse.com/anatomical-models/veterinary-models/canine-anatomical-models/

Citation:

"Dog Skeleton Flexibly Mounted Anatomy Model on Wood Base," *Anatomy Warehouse*. https://anatomywarehouse.com/dog-skeleton-anatomy-model-flexibly-mounted-a-100296 (accessed Sep. 19, 2022).

Conclusions/action items: This is a very nice skeletal model of a dog and is even made of real dog bone. While it is good that it is able to be moved in the ways a dog could move its own joints, it is unpractical for the client since it is very expensive and does not show the muscles, where they attach, or how they work.

2022/09/26: "Nylon fibers made to flex like muscles"

Molly Paras - Sep 26, 2022, 9:56 PM CDT

Title: "Nylon fibers made to flex like muscles"

Date: September 26, 2022

Content by: Molly Paras

Present: N/A

Goals: Look into materials currently being used to model muscles.

Content:

- Nylon fibers are simple, low cost, and mimic natural muscle tissue bending motions
  - When heat is applied, get shorter in length but larger in diameter --> selectively heating different sides of the fibers can get it to move in different ways
    - Laser beam can be used as one of the ways to apply heat
- Previous models included nylon filament and twisted coils, but that only created linear movement
- Carbon nanotube yarns and shape-memory alloys are good at mimicking some of the characteristics of muscles, but are very expensive or don't last very long
- The most important thing about creating nylon fibers is making them the correct shape
  - rectangular/square cross section
- Can quickly bend and retract (17 cycles/sec)
- Could be used in clothing to produce better fitting clothes, in the medical field for things like self-adjusting catheters, and even in vehicles to change shape to adapt to outside conditions

Search Term: Google: "what is used to model muscles and is flexible"

Link: https://news.mit.edu/2016/nylon-muscle-fibers-1123

Citation: "Nylon fibers made to flex like muscles," *MIT News | Massachusetts Institute of Technology*. https://news.mit.edu/2016/nylon-muscle-fibers-1123 (accessed Sep. 26, 2022).

Conclusions/action items: This seems like a really cool technology, being able to mimic the actions that muscle tissues go through. However, this would not be a good option for our model since we will not be applying heat or electrical input into our design to make it move. Thus, continued research on materials to model the muscles should be done.

2022/11/20: WARF Presentation Research

Molly Paras - Nov 22, 2022, 11:07 PM CST

Title: WARF Presentation Research

Date: November 20, 2022

Content by: Molly Paras

Present: Molly Paras

Goals: Get a better understanding of the current market and models available.

Content:

Market -- who would license this and use it for prototypes? What are companies that would be interested?

- Roughly 150 medical schools and 32 veterinary schools. Other schools could also be interested in it for their undergraduate students, along with hospitals which might find it useful if they are teaching hospitals or want to show patients which muscle(s) are injured and how they are supposed to function normally.
- Anatomy Warehouse sells models from a couple different brands: Axis Scientific (skeletons, models with rigid muscles), American 3B Scientific (models used for learning different procedures), GPI Anatomicals (models as educational displays), Denoyer-Geppert (full body models with removable parts)
    - https://anatomywarehouse.com/denoyer-geppert/
    - https://anatomywarehouse.com/axisscientific
    - Note: they sell a couple other brands too, but these seemed most similar to ours. Highlighted in yellow are the ones whose products are the most like ours.
- Biomedical Models has products that are relatively related to ours from Somso and Erler Zimmer
    - https://biomedicalmodels.com/somso-catalog/

Conclusions/action items: There seem to be companies selling similar products, but really nothing exactly like what we are producing. However, one of these companies may be interested in producing a product like ours, which would be cool. Continue to research and prepare for the meeting on Tuesday.

2022/09/26: Netting Design

Title: Netting Design

Date: September 26, 2022

Content by: Molly Paras

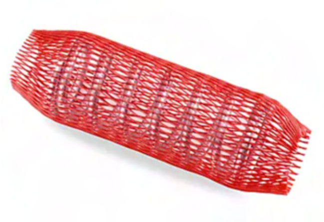
Present: N/A

Goals: Develop a design that could potentially be used in the design matrix.

Content:

An image of the design is attached following this entry. Some possible materials are listed here.

Muscle netting:



https://www.uline.com/Product/Detail/S-6581R/Netting/Protective-Netting-2-4-x-164-Red

Plastic:

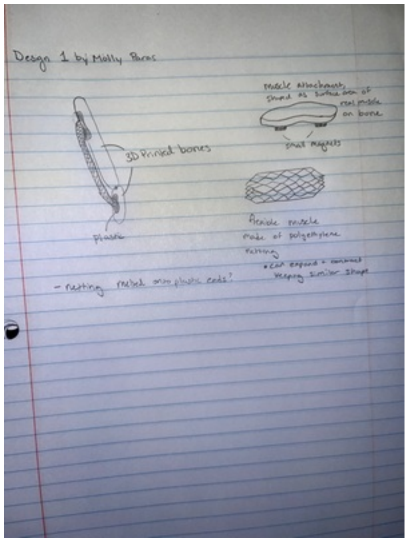
- 3D printed if very small or can use tools in makerspace to cut to shape

Magnets: could use tiny strong magnets such as the ones below and

https://www.amazon.com/FINDMAG-Refrigerator-Magnets-Premium-Whiteboard/dp/B08M3GHMWN/ref=sr_1_3_sspa?
gclid=CjwKCAjwm8WZBhBUEiwA178UnOxvfCw3cwDqoPKaPUMdpsGJptVP269tT0TvQ2QV153y3PPw5QYtUBoCM0MQAvD_BwE&hvadid=174219166229&hvdev=c&hvlocphy=9018948&h
66620330630&hydadcr=24656_9648981&keywords=mini+strong+magnets&qid=1664248426&qu=eyJxc2MiOiI0LjY3IiwicXNhIjoiNC4zMSIsInFzcCI6IjMuNzcifQ%3D%3D&sr=8-3-spons&psc=

Conclusions/action items: This possible design has some pros and cons, like how to netting can expand and contract so the muscles don't have to be too strong to deal with the forces of the netting is. More designs still should be created and evaluated using a design matrix before moving forward with any one design.

Molly Paras - Sep 26, 2022, 10:31 PM CDT



Download

Netting_Design.jpg (132 kB)

2022/11/14: Silicone Mold CAD

Molly Paras - Dec 14, 2022, 2:08 PM CST

Title: Silicone Mold CAD

Date: November 14th, 2022

Content by: Molly Paras

Present: Molly Paras

Goals: Create a design on Solidworks that can be 3D printed to pour the silicone into to test how it works.

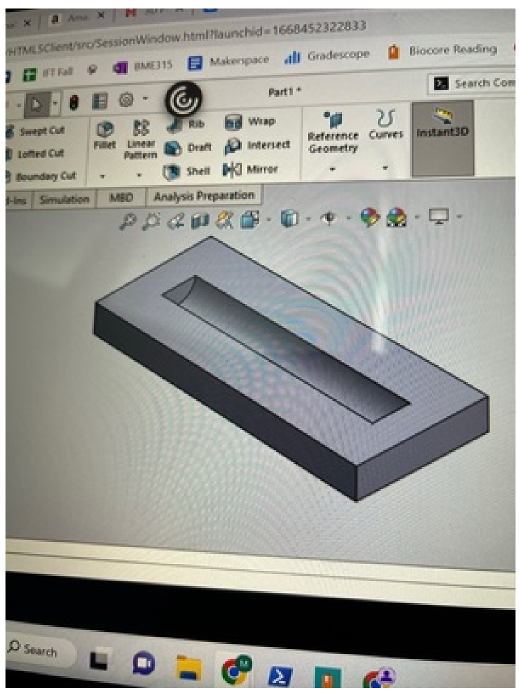
Content:

I created a semicircle cut out of a rectangle design, where the cutout semicylinder is about four inches long and has a radius of an inch. This design will be attached below, along with the 3D printed version of it in PLA when it is done.

Citation & Link: N/A

Conclusions/action items: Print the design, make and pour the silicone, and determine if it is a sufficient method for muscle making. It may be hard to make CAD designs of the muscles for their actual shape, so we are exploring silicone and plaster molds as well.

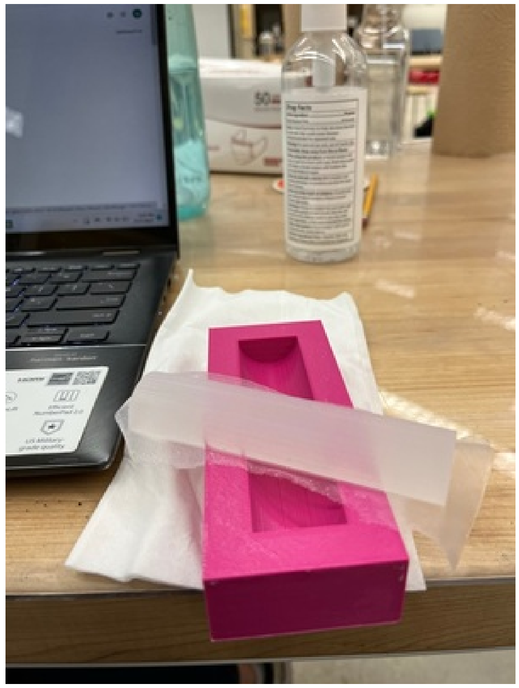
Molly Paras - Dec 14, 2022, 2:10 PM CST



Download

Solidworks_Silicone_Mold_Design.jpg (155 kB)

Molly Paras - Dec 14, 2022, 2:11 PM CST



Download

3D_Printed_Mold_Silicone.jpg (108 kB)

2022/01/29: Green Permit

Molly Paras - Sep 10, 2022, 7:59 PM CDT

Title: Green Permit Certification

Date: 01/29/2022

Content by: Molly Paras

Present: N/A

Goals: Complete the red permit and then green permit for the TEAMLab/Makerspace.

Content:

Below is an image from the EMU website and certifying I got both permits, along with another image of my green permit.

You have the following permits and upgrades:

Name	Date
Green Permit	01/29/2022
Lab Orientation	02/18/2021
Red Permit	01/25/2022

View Upcoming Seminars

You have used the following:

Type	Machine	Hours
Lathe	Lathe 2	2.0
Lathe Total		**2.0**
Mill	Mill 3	2.5
Mill Total		**2.5**
Grand Total		**4.5**

Conclusions/action items:

I completed the required training/seminars for this course, so now I am able to use many of the tools and machines in these spaces. Hopefully I will be able to apply this knowledge to our project this semester.

2022/01/26: Biosafety & Chemistry Certification

Molly Paras -

Title: Chemical & Biosafety Training Certification

Date: 01/26/2022

Content by: Molly Paras

Present: N/A

Goals: Complete the biosafety required training course and the chemical safety course.

Content:

Training Information Lookup Tool **University of Wisconsin-Ma**

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

This certifies that Molly Paras has completed training for the following course(s):

Expand All Collapse All

Course	Assignment	Completion	Expiration
2020-21 HIPAA Privacy & Security Training	HIPAA Quiz	5/29/2022	
Biosafety Required Training	Biosafety Required Training Quiz 2022	1/14/2022	
Chemical Safety: The OSHA Lab Standard	Final Quiz	1/13/2022	
Environmental & Occupational Health	Animal Contact Risk Questionnaire	6/17/2022	6/15/2023

Data Last Imported: 09/10/2022 07:54 PM

Conclusions/action items:

I successfully completed the required biosafety and chemical safety training courses, so am now certified to use such materials/equipment.

2022/09/13-Miller's Anatomy of the Dog Textbook PDF

Cora Williams - Oct 10, 2022, 11:11 PM CDT

Title: *Miller's Anatomy of the Dog* Textbook PDF

Date: Sept. 13, 2022

Content by: Cora Williams

Present: Cora Williams

Goals:

- Add client resources to design notebook

Content:

See PDF below for the *Miller's Anatomy of the Dog* textbook given to the team by our client, Dr. McLean Gunderson

Citation: H. E. Evans and A. de Lahunta, *Miller's Anatomy of the Dog*, 4th ed. St. Louis, MO: Elsevier, 2013.

Link: See PDF attached below

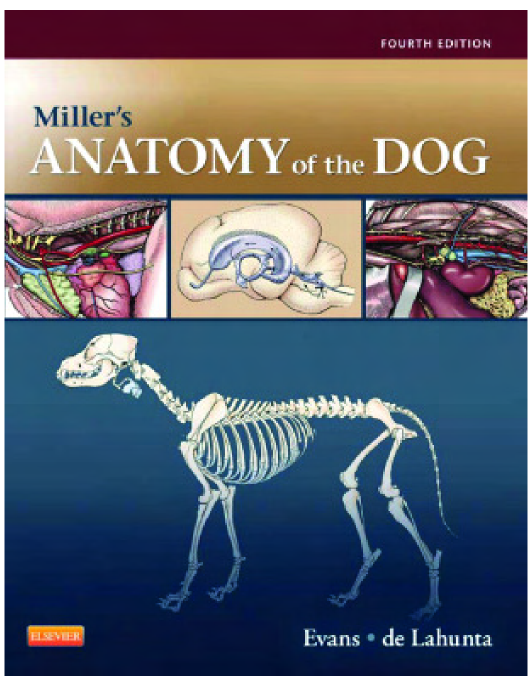
Conclusions:

This is a textbook given to the team by our client Dr. McLean Gunderson. This is the textbook used in the anatomy class taken by first year veterinary students, which is also the class that our model will be used in.

Action items:

- Begin research
- Determine which limb to model
- Determine which muscles to include in our model

Cora Williams - Oct 10, 2022, 11:15 PM CDT



Download

Miller_s_Anatomy_of_the_Dog_1_.pdf (246 MB)

2022/09/16-Canine Muscles in Forelimb

Cora Williams - Oct 10, 2022, 10:47 PM CDT

Title: Canine Muscles in Forelimb

Date: Sept. 16, 2022

Content by: Cora Williams

Present: Cora Williams

Goals:

- Learn about the canine muscles in the forelimb

Content:

Diagram of the Superficial Muscles of the Canine Forelimb (Lateral View):

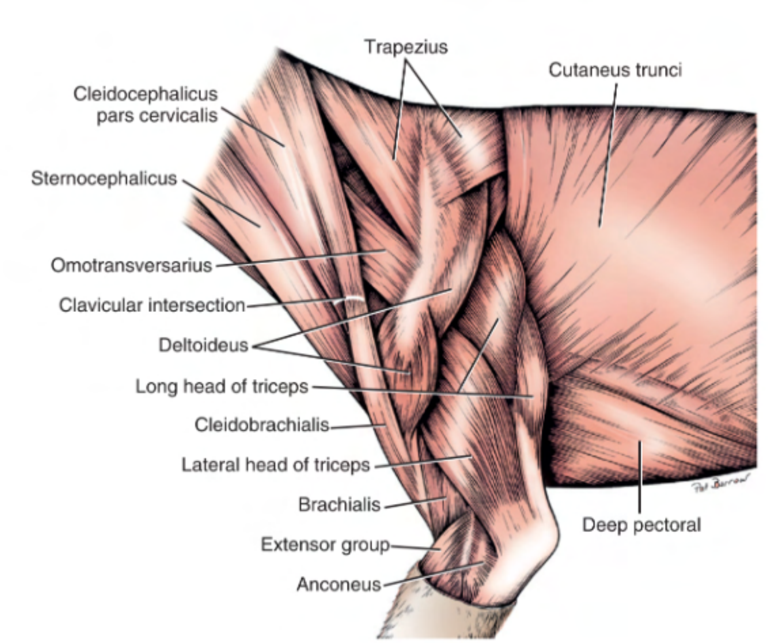


FIGURE 6-48 Superficial muscles of scapula, shoulder joint and arm, lateral aspect.

Diagram of the Muscles of the Left Scapula (Lateral and Medial View):

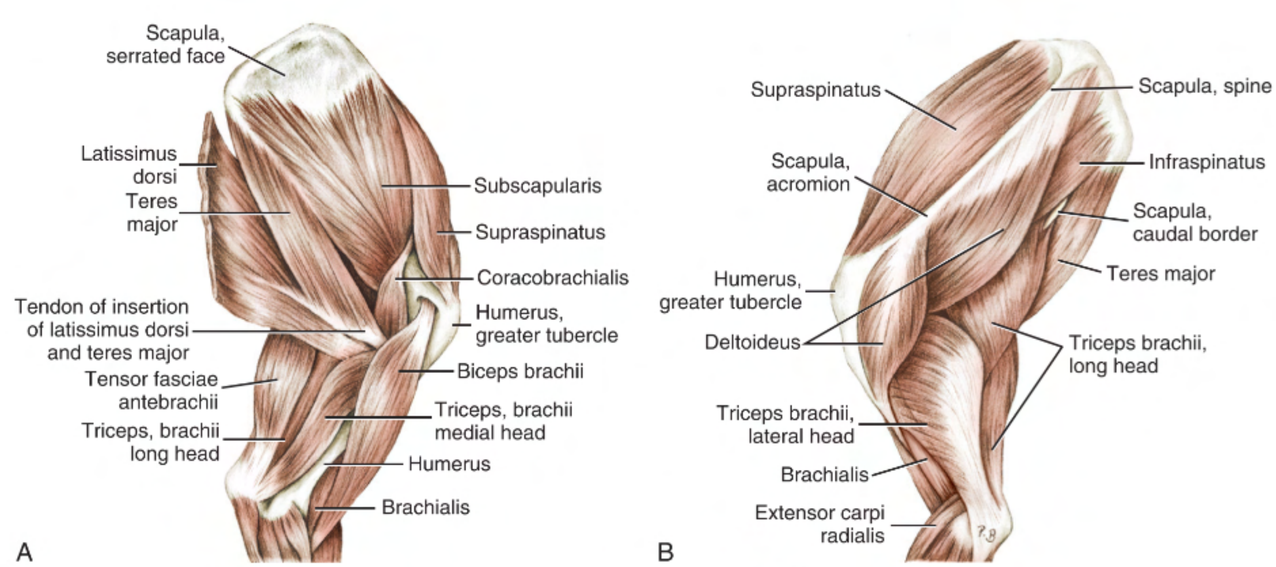


FIGURE 6-50 **A**, Muscles of left scapula, shoulder and arm, medial aspect. **B**, Muscles of left scapula, shoulder and arm, lateral aspect.

Diagram of the Deep Muscles of the Canine Forelimb (Lateral and Medial View):

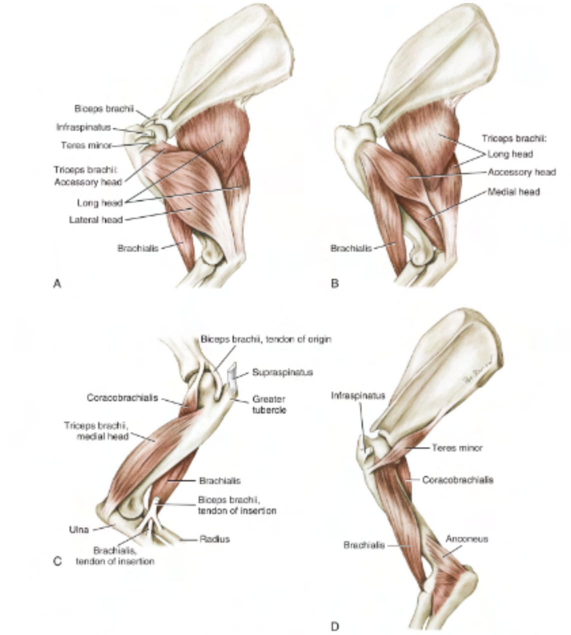


FIGURE 6-51 Deep muscles of the brachium. A, Lateral aspect. B, Lateral aspect. (Lateral head of triceps removed.) C, Medial aspect. (Biceps brachii muscle removed.) D, Caudolateral aspect. (Triceps brachii removed.)

Diagram of the Antibrachial Muscles (Craniolateral View):

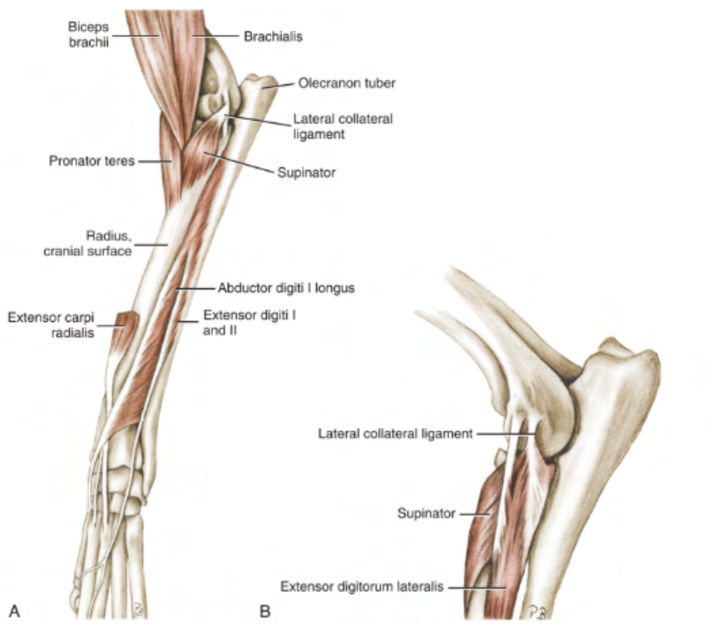


FIGURE 6-58 Antebrachial muscles. A, Deep antebrachial muscles, craniolateral aspect. B, Origins of supinator and extensor digitorum lateralis.

Diagram of the Antibrachial Muscles (Caudal (Back Looking Forward) View):

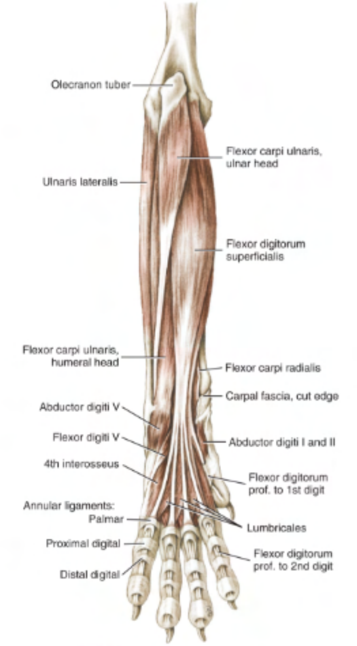


FIGURE 6-61 Antebrachial muscles, caudal aspect.

Citation: H. E. Evans, A. de Lahunta, and J. W. Hermanson, "Chapter 6: The Muscular System," in *Miller's Anatomy of the Dog*, 4th ed., St. Louis, MO: Elsevier, 2013, pp. 233–276.

Link: See "Miller's Anatomy of a Dog" Page

Conclusions:

After examining the sheer number of muscles there are in the forelimb of canines, it is not surprising that veterinary students struggle to learn each muscle's name and function, which makes this project more meaningful and important. I now realize that we will not be able to include all of the muscles on our model (as hinted by our client), which means we will have to decide what muscles are most important. From here, I will examine the muscles of the canine hindlimb and begin identifying which muscles we should include in our model.

Action items:

- Continue research
- Determine which limb to model
- Determine which muscles to include in our model

2022/09/16-Canine Muscles in Hindlimb

Cora Williams - Oct 10, 2022, 11:04 PM CDT

Title: Canine Muscles in Hindlimb

Date: Sept. 16, 2022

Content by: Cora Williams

Present: Cora Williams

Goals:

- Learn about the canine muscles in the hindlimb

Content:

Diagram of the Superficial and Deep Muscles of the Upper Canine Hindlimb (Lateral and Medial Views): (Page 257, 261, 262)

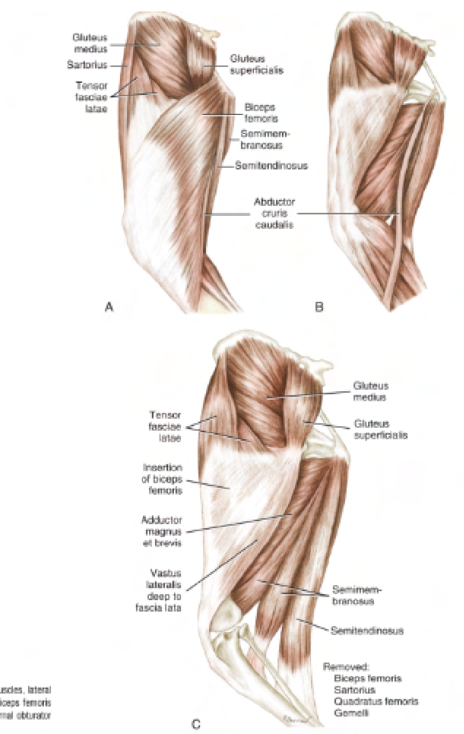


FIGURE 6-71 Muscles of thigh. A, Superficial muscles, lateral aspect. B, Superficial muscles, lateral aspect. (Biceps femoris removed.) C, Deep muscles, lateral aspect. (Internal obturator removed.)

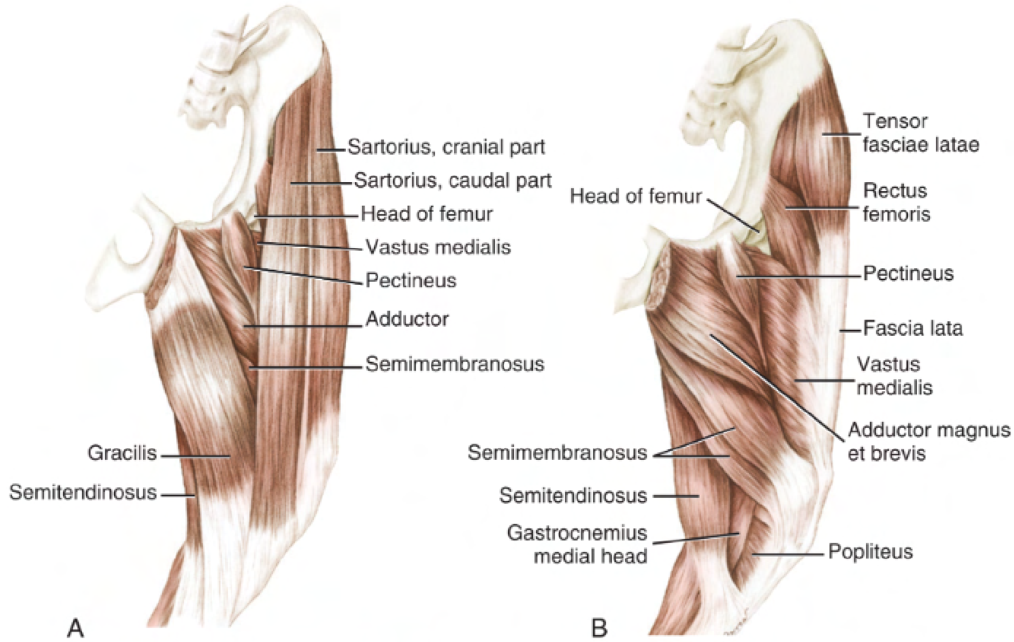


FIGURE 6-78 Muscles of thigh. **A**, Superficial muscles, medial aspect. **B**, Deep muscles, medial aspect.

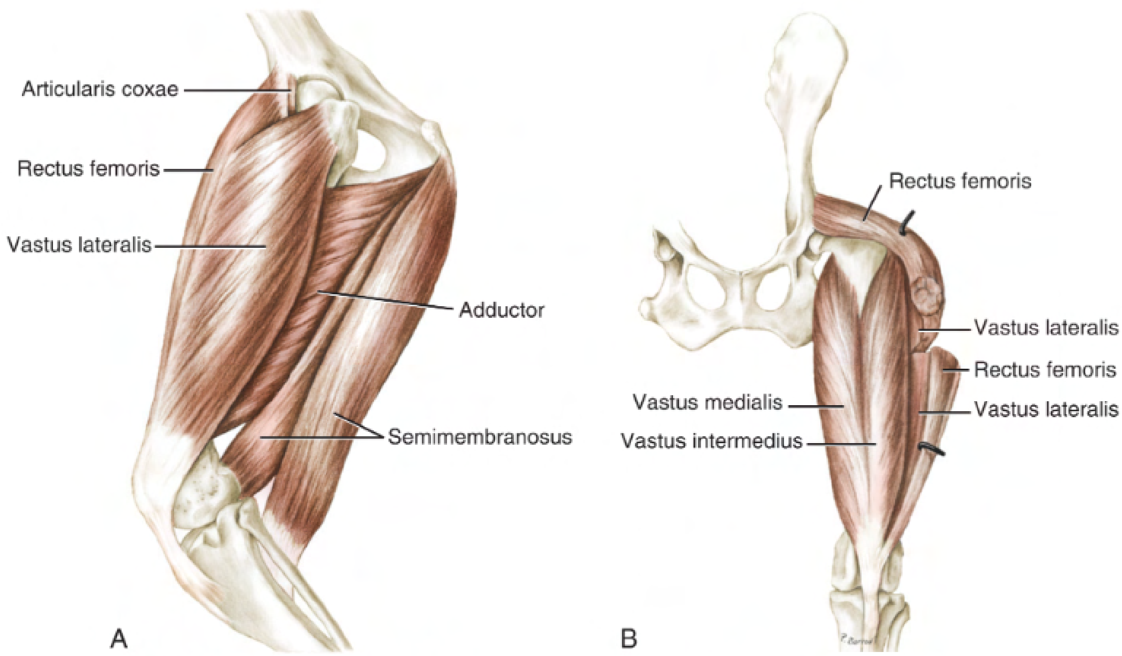


FIGURE 6-79 Muscles of thigh. **A**, Deep muscles, lateral aspect. **B**, Deep muscles, cranial aspect.

Diagram of the Superficial and Deep Gluteal Muscles (Lateral View): (Page 259)

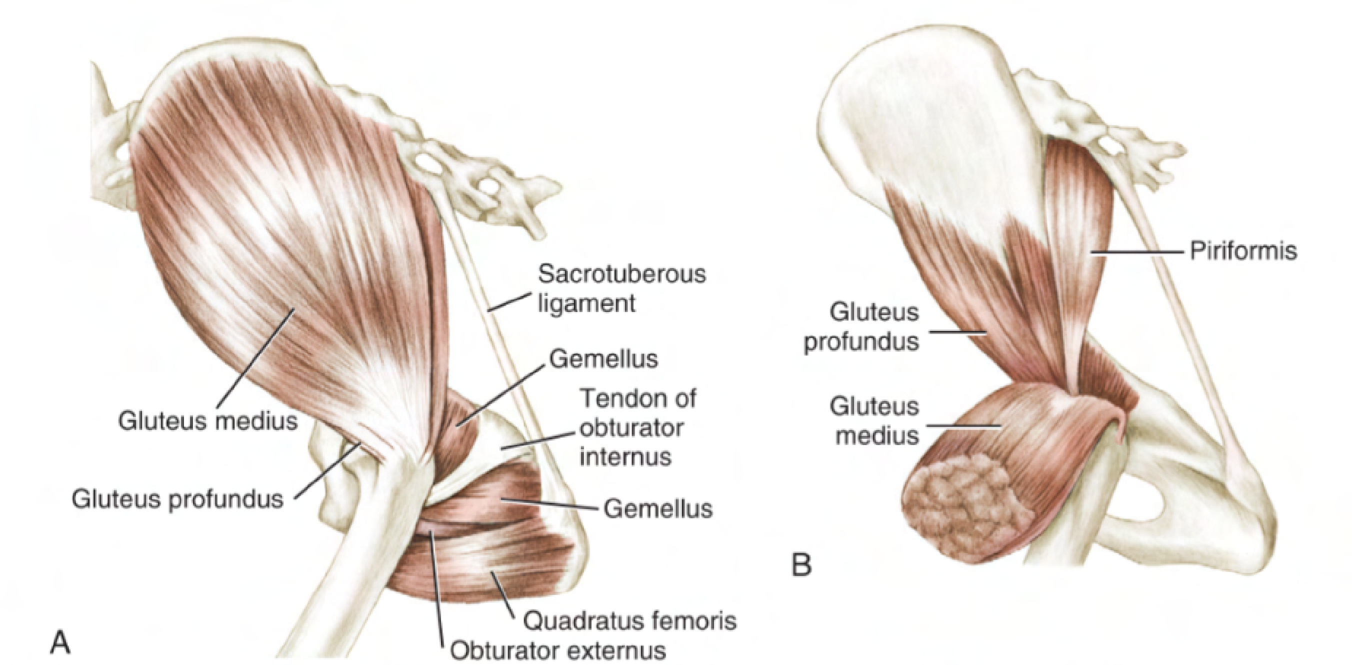


FIGURE 6-75 Muscles of the gluteal region. **A**, Superficial muscles. **B**, Deep dissection.

Diagram of the Muscles of the Canine Hip Joint (Ventral, Ventrolateral, and Dorsal Views): (Page 259+260)

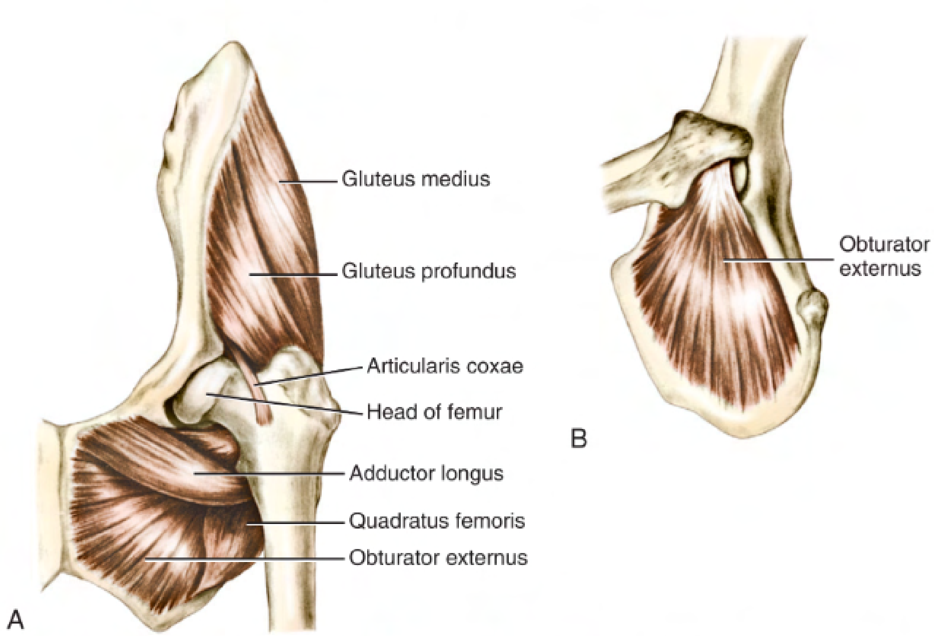


FIGURE 6-76 Muscles of the hip joint. **A**, Ventral aspect. **B**, Obturator externus, ventrolateral aspect.

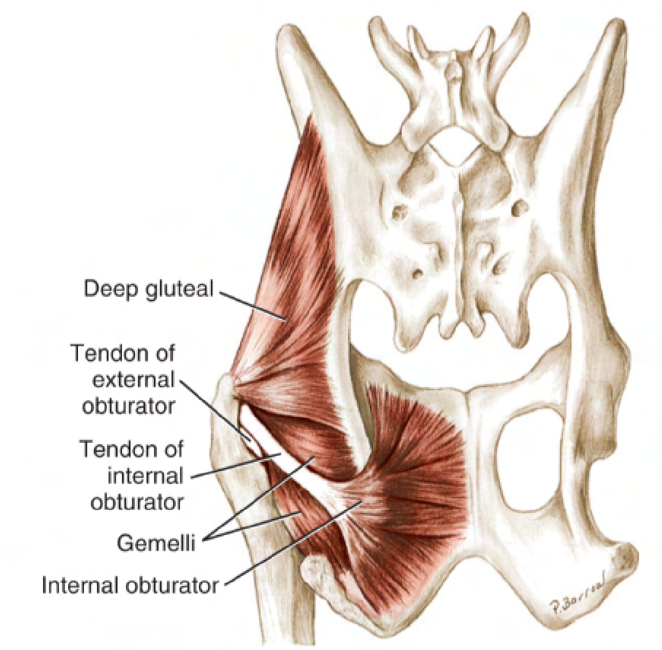


FIGURE 6-77 Muscles of the hip joint, dorsal aspect.

Diagram of the Deep Muscles of the Canine Hindlimb (Lateral View): (Page 266)

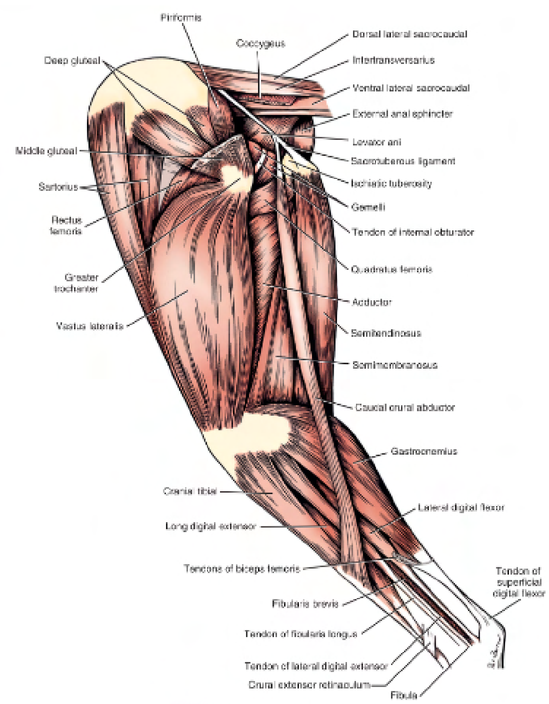


FIGURE 6-82 Deep muscles of pelvic limb, lateral aspect.

Diagram of the Muscles of the Lower Hindlimb (Cranial and Lateral View): (Page 269, 270)

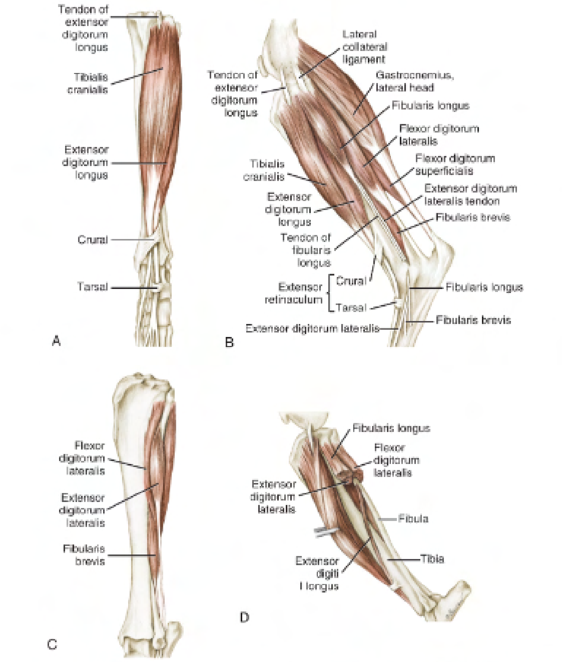


FIGURE 6-85 Muscles of left crus. A, Superficial muscles, cranial aspect. B, Superficial muscles, lateral aspect. C, Deep muscles, cranial lateral aspect. D, Deep muscles, lateral aspect.

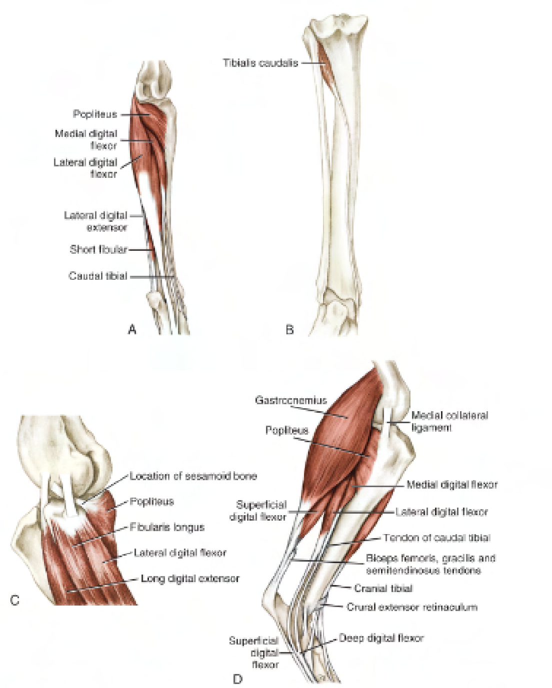


FIGURE 6-86 Muscles of left crus. A, Deep muscles, caudal aspect. B, Tibialis caudalis, caudal aspect. C, Muscles of crus at stifle joint, lateral aspect. D, Muscles of crus, medial aspect.

Citation: H. E. Evans, A. de Lahunta, and J. W. Hermanson, “Chapter 6: The Muscular System,” in *Miller's Anatomy of the Dog*, 4th ed., St. Louis, MO: Elsevier, 2013, pp. 233–276.

Link: See "Miller's Anatomy of a Dog" Page

Conclusions:

After examining the sheer number of muscles there are in the hindlimb of canines, it is still not surprising that veterinary students struggle to learn each muscle's name and function, which makes this project more meaningful and important. I now realize that we will not be able to include all of the muscles on our model (as hinted by our client), which means we will have to decide what muscles are most important. From here, I will begin identifying which muscles we should include in our model.

Action items:

- Continue research
- Determine which limb to model
- Determine which muscles to include in our model

2022/10/12-Canine Muscle Attachment Points in Hindlimb

Cora Williams - Oct 12, 2022, 8

Title: Canine Muscle Attachment Points in Hindlimb

Date: Oct. 12, 2022

Content by: Cora Williams

Present: Cora Williams

Goals:

- Learn about the where the canine muscles in the hindlimb attach to the bones

Content:

Diagram of the Muscle Attachment Points of the Left Half of Pelvis (Lateral View): (Page 255)

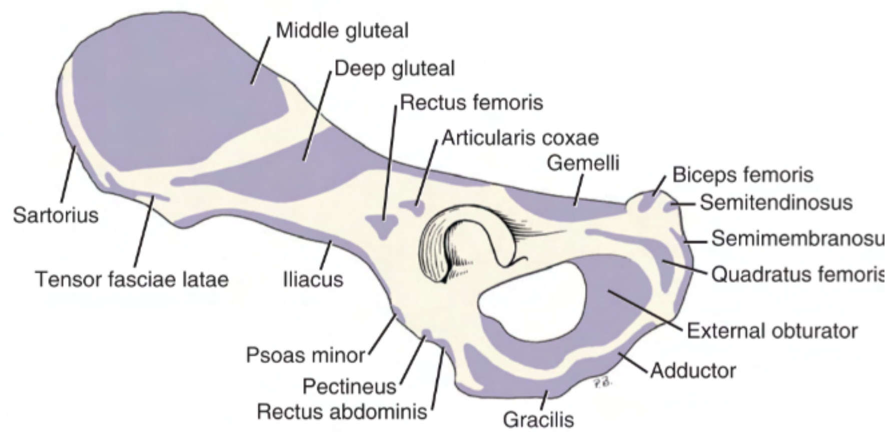


FIGURE 6-69 Left os coxae, showing areas of muscle attachment, lateral aspect.

Diagram of the Muscle Attachment Points of the Left Half of Pelvis (Medial View): (Page 255)

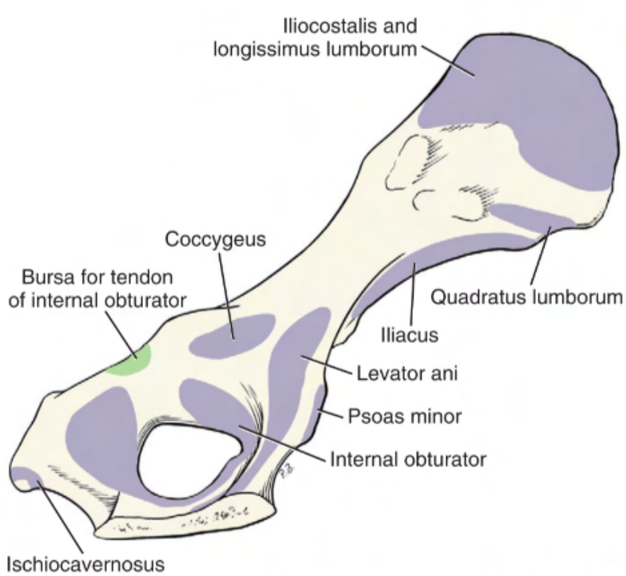


FIGURE 6-70 Left os coxae, showing areas of muscle attachment, medial aspect.

Diagram of the Muscle Attachment Points of the Femur (Caudal, Cranial, and Lateral View): (Page 258)

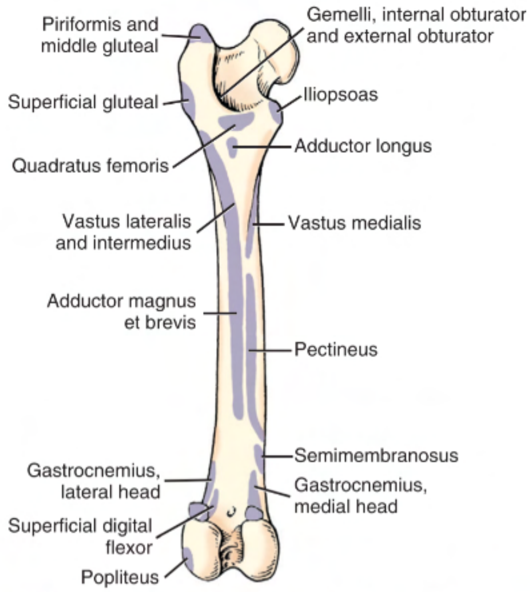


FIGURE 6-72 Left femur, showing areas of muscle attachment, caudal aspect.

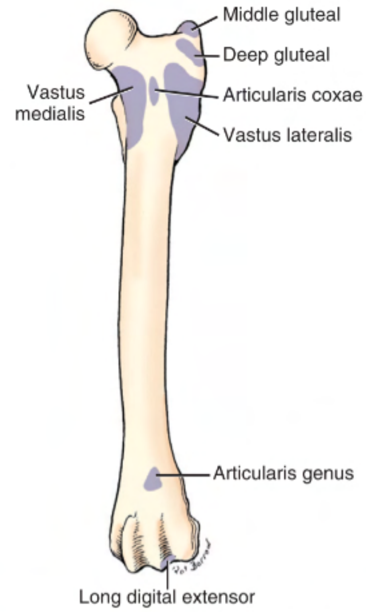


FIGURE 6-74 Left femur, showing areas of muscle attachment, cranial aspect.

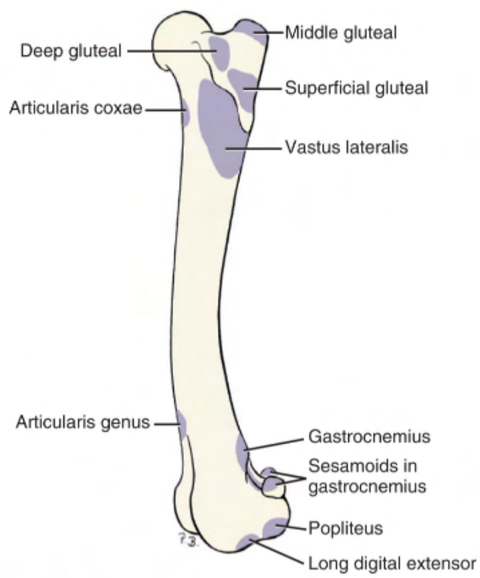


FIGURE 6-73 Left femur, showing areas of muscle attachment, lateral aspect.

Diagram of the Muscle Attachment Points of the Tibia and Fibula (Cranial, Lateral, Caudal, and Medial Views): (Page 265)

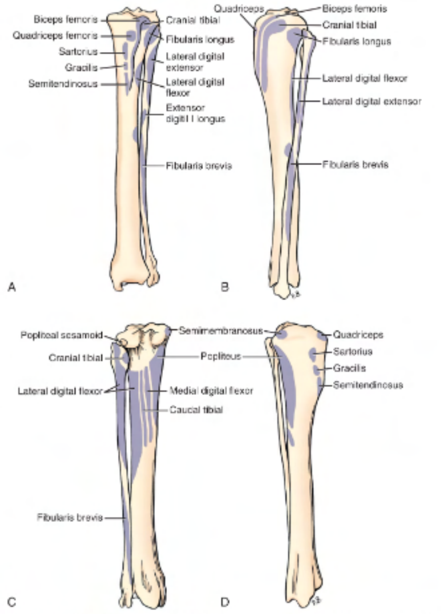


FIGURE 6-81 **A**, Left tibia and fibula, showing areas of muscle attachment, cranial aspect. **B**, Left tibia and fibula, showing areas of muscle attachment, lateral aspect. **C**, Left tibia and fibula, showing areas of muscle attachment, caudal aspect. **D**, Left tibia and fibula, showing areas of muscle attachment, medial aspect.

Diagram of the Muscle Attachment Points of the Left Tarsal and Metatarsal Bones (Dorsal and Plantar View): (Page 275)

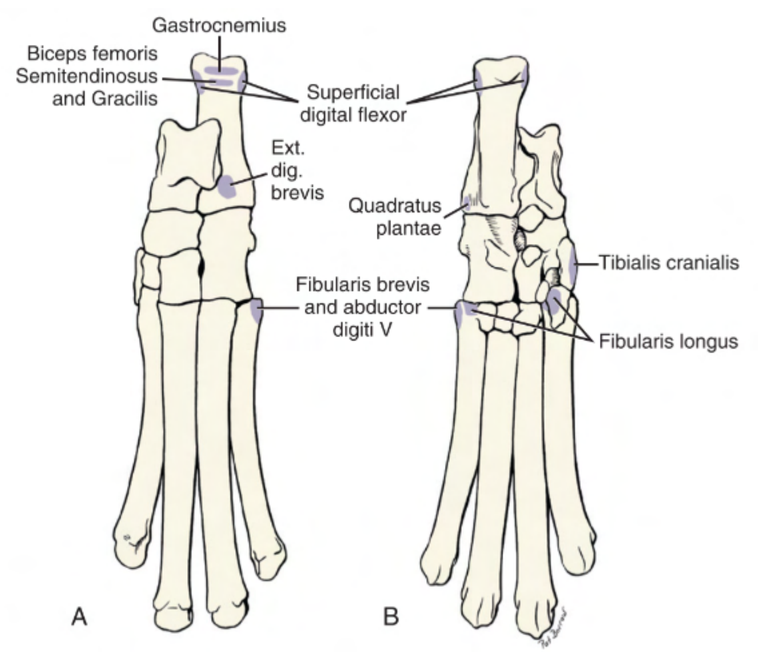


FIGURE 6-90 Left tarsal and metatarsal bones, showing areas of muscle attachment. **A**, Dorsal aspect. **B**, Plantar aspect.

Citation: H. E. Evans, A. de Lahunta, and J. W. Hermanson, "Chapter 6: The Muscular System," in *Miller's Anatomy of the Dog*, 4th ed., St. Louis, MO: Elsevier, 2013, pp. 233–276.

Link: See "Miller's Anatomy of a Dog" Page

Conclusions:

After examining the muscle attachment points in the hindlimb, I realize that there are most likely still too many muscles for us to include on the model. The team will have to determine what mu include. We may need to consult our client or another veterinarian to determine which muscles are most important.

Action items:

- Continue research
- Determine which muscles to include in our model
- Consult with client about what muscles to include

2022/09/25-Anatomy Lab Domestic Canine (Canis lupus familiaris) Anatomy Model

Cora Williams - Oct 12, 2022, 11:00 AM CDT

Title: Anatomy Lab Domestic Canine (Canis lupus familiaris) Anatomy Model

Date: Sept. 25, 2022

Content by: Cora Williams

Present: Cora Williams

Goals:

- Learn about competing anatomy models with muscles

Content:

Product Description: "This Canine Anatomy Model with Removable parts is a comprehensive look at all the features of the average canine. Though not life-size, this model includes 10 removable organs and parts, including a 2-part canine heart, liver, and lung. Additionally, this highly-detailed anatomical model includes multiple views of a canine: on one side, you can see a normal view of a dog, the other side includes the musculature and skeletal features. By dissecting into two separate halves for study, this model allows veterinarians, zoologists, students, teachers, or anyone else to easily identify multiple aspects of the domestic dog. The model's external features are highly detailed and mounted on a display base."

Cost: $365.00

Warranty: 1 year

FAQs:

- What kind of dog is this?
    - "The internal composition is based on an average domestic dog, but it kind of looks like a tiny German Shepherd, in our opinion."
- Can this be removed from the base?
    - "This is not intended to be removed from the base. The base makes the model stand upright."
- Are the pieces held together by screws? Does this require assembly?
    - "Each removable part of this model is held together by magnets and requires a basic understanding of canine anatomy assembly."

Product Dimension: 16.5 in. x 6 in. x 12.5 in.

Product Weight: 4.6 lbs.

Height of Base: 0.75 in.

Number of Removable Parts: 10

Images:

Citation: “Anatomy Lab Domestic Canine (Canis lupus familiaris) Anatomy Model,” *Anatomy Warehouse*. [Online]. Available: https://anatomywarehouse.com/anatomy-lab-domestic-canine-canis-lupus-familiaris-anatomy-model-a-109171. [Accessed: 25-Sep-2022].

Link: https://anatomywarehouse.com/anatomy-lab-domestic-canine-canis-lupus-familiaris-anatomy-model-a-109171

Conclusions:

There are other anatomical models on the market that include muscles, however, they are not detachable. The muscles included in this model also are not detailed enough to be able to tell each individual muscle apart, especially in the limbs, which is where extension and flexion are most present.

Action items:

- Continue research

2022/10/26-Modifying Neodymium Magnets

Cora Williams - Dec 10, 2022, 2:59 PM CST

Title: Modifying Neodymium Magnets

Date: Oct. 26, 2022

Content by: Cora Williams

Present: Cora Williams

Goals:

- Determine if our neodymium magnets can be altered in any way

Content:

- While modifying magnets "is possible under the very best circumstances, it's extremely difficult to perform correctly. If one isn't careful, a powerful magnet will quickly crumble or lose its magnetic field"
- What's Not Possible With Modifications
  - "Neodymium magnets are by far the strongest in terms of magnetic pull"
  - "The problem: they don't react well to drilling, welding, or soldering"
  - "Neodymium magnets bascially start as a powder that is pressed into molds by hydraulics and then sintered, they are then heated almost to melting point"
  - "Because the powder never melts together, the final product is extremely strong, but also very brittle"
  - "As a result, neodymium magnets don't react well to drilling or cutting"
  - "Instead of reacting like a normal piece of metal, these magnets are likely to crumble or break off -- especially once the magnet's casing is damaged"
  - "The dust produced during machining, drilling, or cutting can be explosive, so extra precautions must be take to ensure modifications are performed safely"
  - "In addition, neodymium magnets don't react will to hot temperatures; depending on their design and composition, they begin to lose their magnetism at around 80 degrees Celcius"
  - "Consequently, heating through soldering or welding can quickly ruin a perfectly good magnet, often with no way to get the original magnetic strength back"

Citation: “Modifying Magnets: What's Possible With Cutting, Drilling, Welding, and Soldering,” *Apex Magnets*, 24-Oct-2017. [Online]. Available: https://www.apexmagnets.com/news-how-tos/modifying-magnets-whats-possible-cutting-drilling-welding-soldering/. [Accessed: 26-Oct-2022].

Link: https://www.apexmagnets.com/news-how-tos/modifying-magnets-whats-possible-cutting-drilling-welding-soldering/

Conclusions:

Based on this information, it does not appear that we will be able to modify our purchased magnets without compromising their magnetism and creating a potential safety hazard (via the explosive powder). This information also states that heat can affect the magnetic strength of neodymium magnets, which may explain why we have seen a decrease in attachment strength after the magnets have been hot glued. More research is needed to determine if hot glue is hot enough to affect the magnet's strength.

Action items:

- Look into other potential attachment mechanisms
- Determine if hot glue is hot enough to demagnetise neodymium magnets

2022/10/26-Hot Glue Gun Temperatures

Cora Williams - Dec 14, 2022, 12:24 PM CST

Title: Hot Glue Gun Temperatures

Date: Oct. 26, 2022

Content by: Cora Williams

Present: Cora Williams

Goals:

- Determine hot glue is hot enough to demagnetise neodymium magnets

Content:

- What's the Difference Between High-Temperature and Low-Temperature Hot Melt?
    - High temperature hot glue guns applied melted glue at temperatures between 375 and 400 degrees F
    - Low temperature hot glue guns apply melted glue at temperatures between 200 and 250 degrees F

Citation: "High Temp Hot Melt vs. Low Temp Hot Melt," *Hotmelt.com*, 18-Dec-2019. [Online]. Available: https://www.hotmelt.com/blogs/blog/high-temp-hot-melt-vs-low-temp-hot-melt. [Accessed: 26-Oct-2022].

Link: https://www.hotmelt.com/blogs/blog/high-temp-hot-melt-vs-low-temp-hot-melt

Conclusions:

Based on this information, it does appear that hot glue guns, both low and high temperature ones, are hot enough to modify the strength of neodymium magnets. This means that we will not be able to use hot glue to adhere the magnets to the bones or muscles. More research is needed to determine alternative adhesives.

Action items:

- Look into other potential attachment mechanisms
- Research alternate adhesives

2022/09/26-Muscle Attachment Mechanism Design Individual Brainstorming

Cora Williams - Oct 12, 2022, 9:13 AM CDT

Title: Muscle Attachment Mechanism Design Individual Brainstorming

Date: Sept. 26, 2022

Content by: Cora Williams

Present: Cora Williams

Goals:

- Brainstorm potential muscle attachment mechanisms

Content:

Potential Muscle Attachment Mechanisms

- Hooks
    - J hooks (previously done by client)
        - Pro: confirmed to work, easy to obtain, easy to attach to bone
        - Con: bulky, doesn't accurately represent muscle attachment point
    - I hooks
        - Pro: easy to obtain, easy to attach to bone
        - Con: bulky, doesn't accurately represent muscle attachment point
    - Peg hooks
        - Have a hole cut into the muscle, which would then be stretched over the peg on the bone to secure it
        - Pro: easy to use
        - Con: difficult to fabricate, easy to break, difficult to replace
- Magnets
    - Pro: easy to use, easy to obtain, easy to attach to bone
    - Con: May be too strong or too weak to hold muscle during flexion and extension, need to manipulate to ensure it accurately represent muscle attachment point
- Velcro
    - Pro: easy to use, easy to obtain, easy to attach to bone
    - Con: wears out fast, may be difficult to remore muscle
- Clip
    - Have a clip (thinking a binder clip or laundry clip) glued to the bone that then holds the muscle when clipped in
    - Pro: easy to use, easy to obtain, easy to attach to bone
    - Con: really bulky and ugly

Citation: N/A

Link: N/A

Conclusions:

Four potential muscle attachment mechanisms are hooks, magnets, velcro, and clips. Each design has its pros and cons, so we will have to work through a design matrix to determine which one will work best.

Action items:

- Continue research
- Attend design brainstorming and matrix meeting
- Determine which muscle attachment mechanism to include in our model
- Justify why we chose that muscle attachment mechanism

2022/09/26-Muscle Material Design Individual Brainstorming

Cora Williams - Oct 12, 2022, 9:20 AM CDT

Title: Muscle Material Design Individual Brainstorming

Date: Sept. 26, 2022

Content by: Cora Williams

Present: Cora Williams

Goals:

- Brainstorm potential muscle materials

Content:

Potential Muscle Materials

- Sewing Elastic (previously done by client)
  - Pro: low cost, easy to obtain, easy to work with, stretches easily
  - Con: doesn't show muscle shape, wears out fast
- Exercise Resistance Band (or Latex)
  - Pro: low cost, easy to obtain, easy to work with, durable, can show muscle shape, stretches easily
  - Con: might have catastrophic failure
- Fabric (Spandex)
  - Pro: low cost, easy to obtain, easy to work with, durable, can show muscle shape, stretches easily
  - Con: more time consuming to fabricate
- Molded Silicone
  - Pro: can show muscle shape
  - Con: difficult to obtain, tedious to work with, time consuming to fabricate, may not stretch enough

Citation: N/A

Link: N/A

Conclusions:

Four potential muscle materials are sewing elastic, exercise resistance bands, fabric, and silicone. Each design has its pros and cons, so we will have to work through a design matrix to determine which one will work best.

Action items:

- Continue research
- Attend design brainstorming and matrix meeting
- Determine which muscle material to use for our model muscles
- Justify why we chose that muscle material

2022/09/17: "Dog Leg Anatomy in Human Terms"

Maggie LaRose - Sep 17, 2022, 2:33 PM CDT

Title: "Dog Leg Anatomy in Human Terms"

Date: 09/17/2022

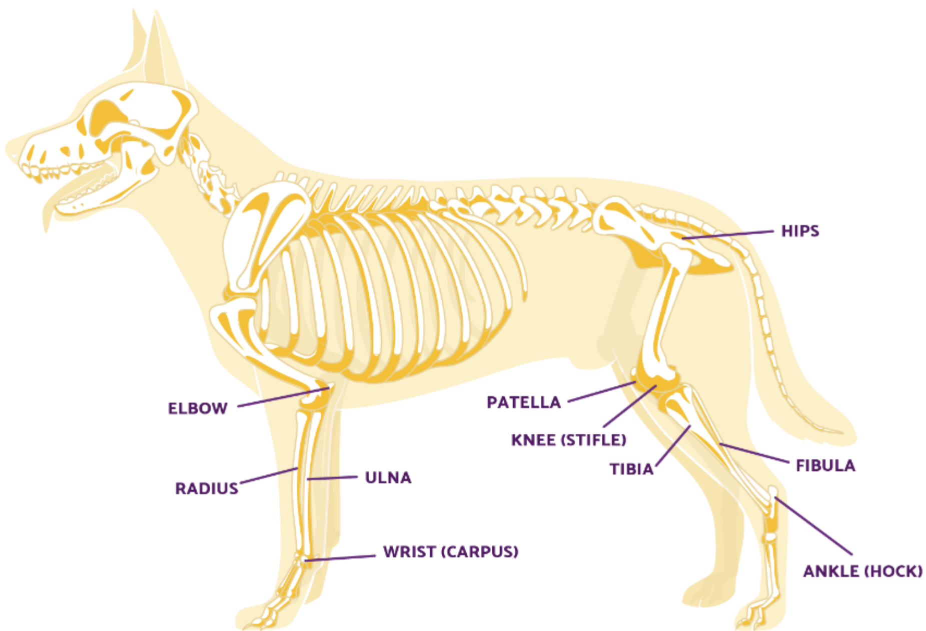
Content By: Maggie LaRose

Present: N/A

Goals: Gain a colloquial understanding of basic skeletal components of the front an hind dog leg to aid in group's decision in model focus.

Content:

- the technical term for the dog "knee" is the stifle joint, connects femur (thigh bone) to tibia and fibula and patella (knee cap)
- dogs do not have an ACL but a CCL (cranial cruciate ligament), a stifle ligament
- dog "ankle" is called a hock and connects shin to paw bones
- the forelegs contain an elbow joint, which contain radius, ulna, and carpus (wrist) bones, similar in name to humans



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Search Term:

Citation: "Dog leg anatomy in human speak," *Ortho Dog*, 15-Feb-2021. [Online]. Available: https://orthodog.com/article/dog-leg-anatomy/. [Accessed: 17-Sep-2022].

Link: https://orthodog.com/article/dog-leg-anatomy/

Conclusion: From now on, seek more academic sources that provide technical terms for bones and also contain more detail in the functions and movements of joints as well as the anatomy of fore/hind leg muscles.

2022/09/23: "Miller's Anatomy of the Dog"

Maggie LaRose - Oct 11, 2022, 10:31 PM CDT

Title: Miller's Anatomy of the Dog

Date: 09/23/2022 - 10/11/2022

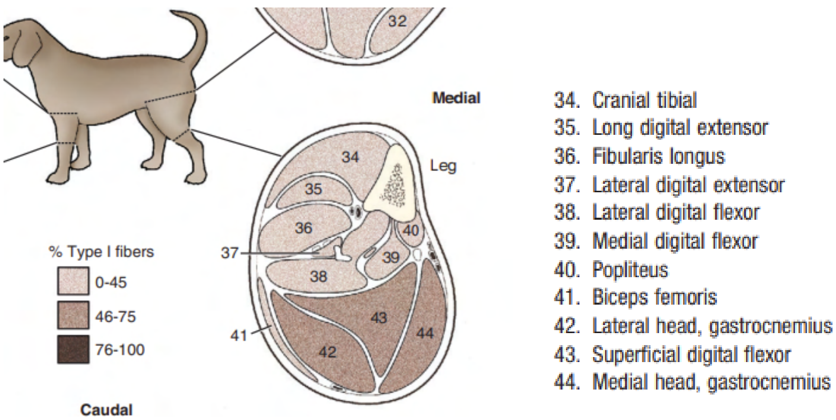
Content By: Maggie LaRose

Present: N/A

Goals: Gather detailed and medical-based terminology of the dog muscular and skeletal systems, specifically the hind leg.

Content:

muscles of concern:



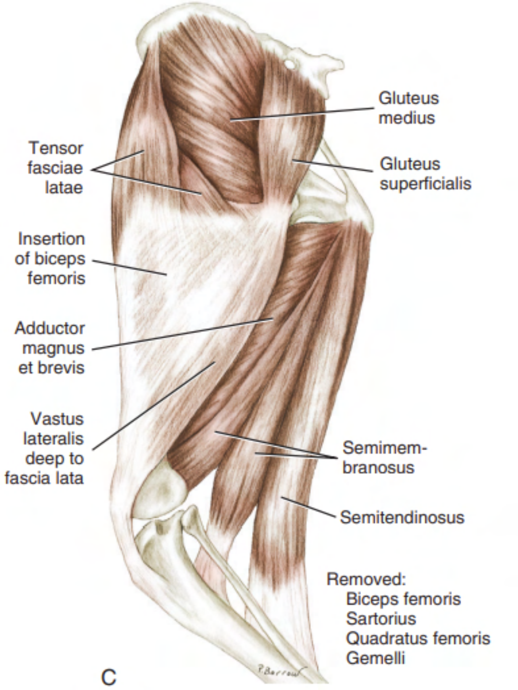
- the muscles of the thigh act primarily on the stifle, the femorotibial joint

- muscles of the thigh are designated as to their cranial, caudal, and medial positions

- caudal - biceps, semitendinosus, and hamstring

- cranial - quadriceps

medial - gracilis, pectineus, adductores, and sartorius caudalis



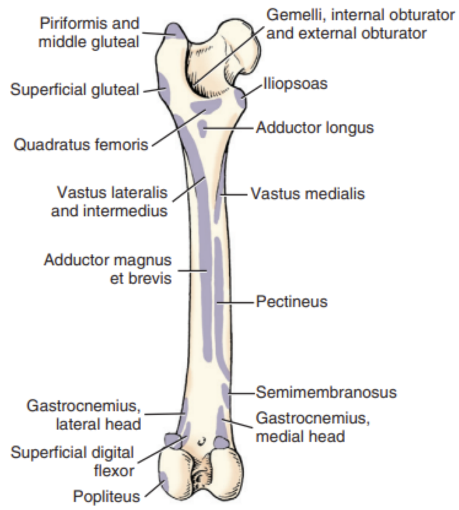


FIGURE 6-72 Left femur, showing areas of muscle attachment, caudal aspect.

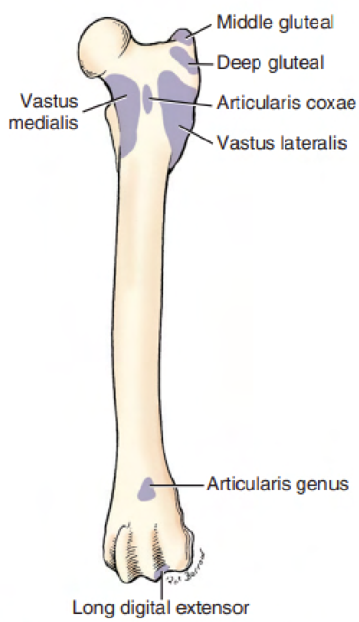


FIGURE 6-74 Left femur, showing areas of muscle attachment, cranial aspect.

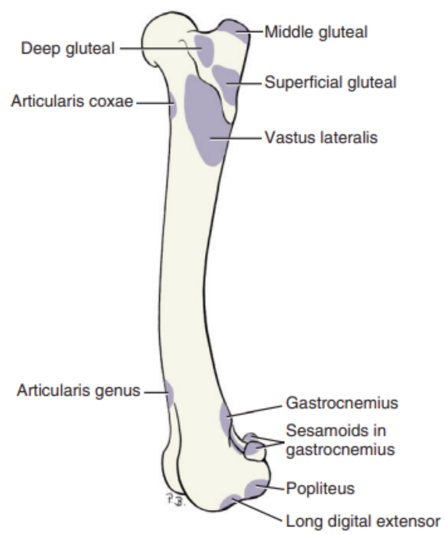


FIGURE 6-73 Left femur, showing areas of muscle attachment, lateral aspect.

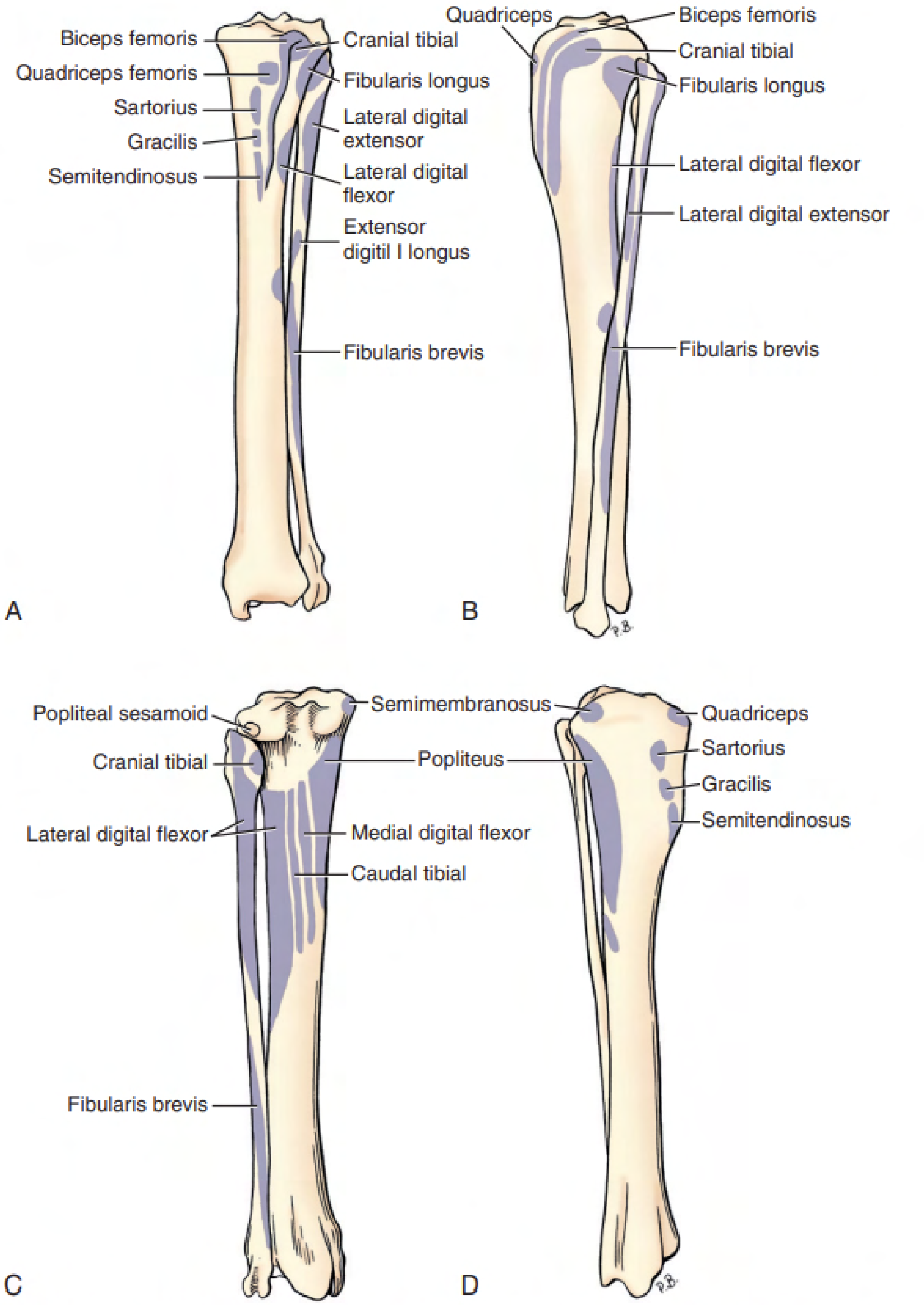


FIGURE 6-81 **A**, Left tibia and fibula, showing areas of muscle attachment, cranial aspect. **B**, Left tibia and fibula, showing areas of muscle attachment, lateral aspect. **C**, Left tibia and fibula, showing areas of muscle attachment, caudal aspect. **D**, Left tibia and fibula, showing areas of muscle attachment, medial aspect.

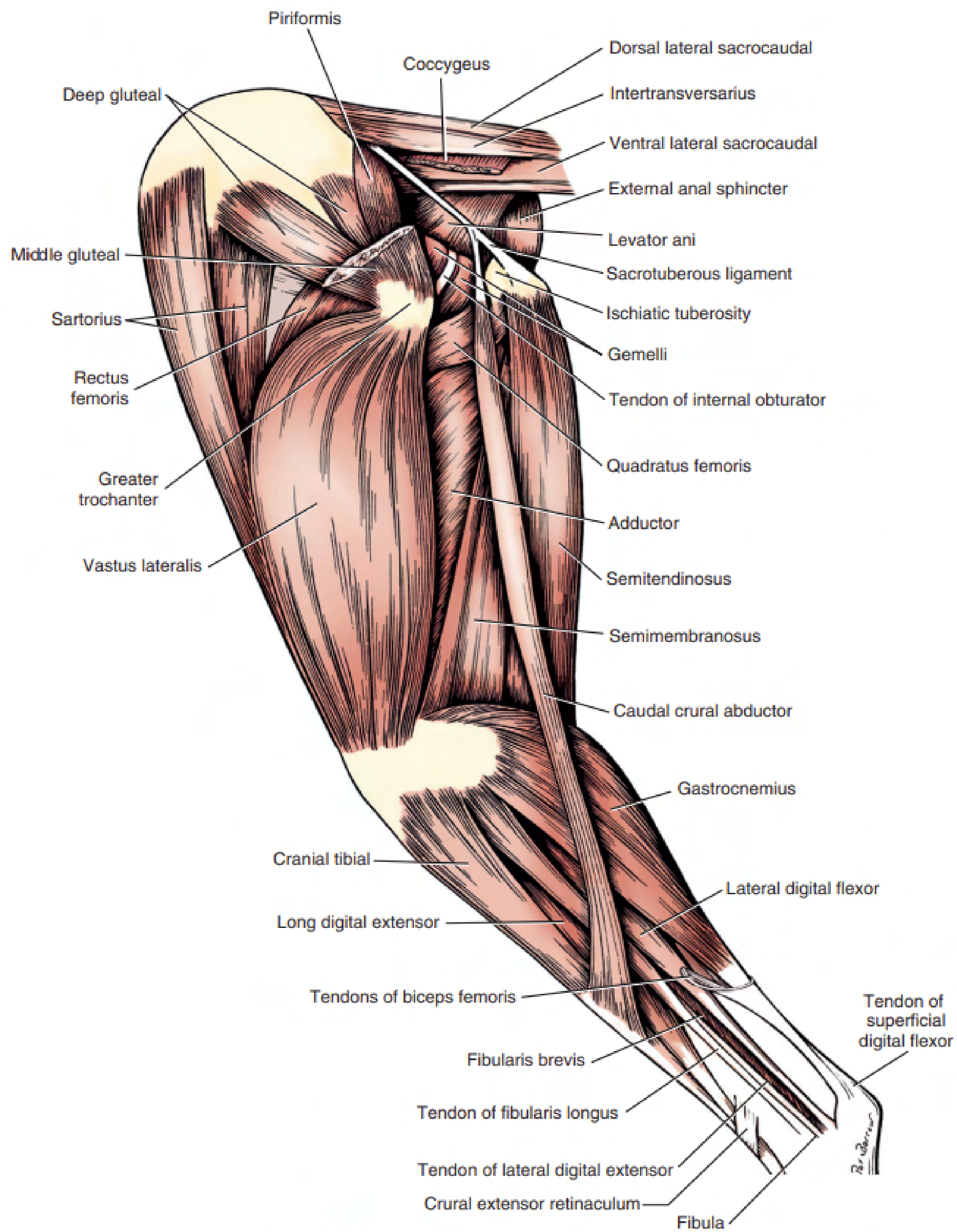


FIGURE 6-82 Deep muscles of pelvic limb, lateral aspect.

bones of concern:

- bones of the leg (humerus and femur) are composed of compact bone

- developed in direct ratio to the stress of which the bone is subjected

- attains the greatest uniform thickness where the circumference of the bone is least, maximum thickness o the compact bone is found in the humerus and femur

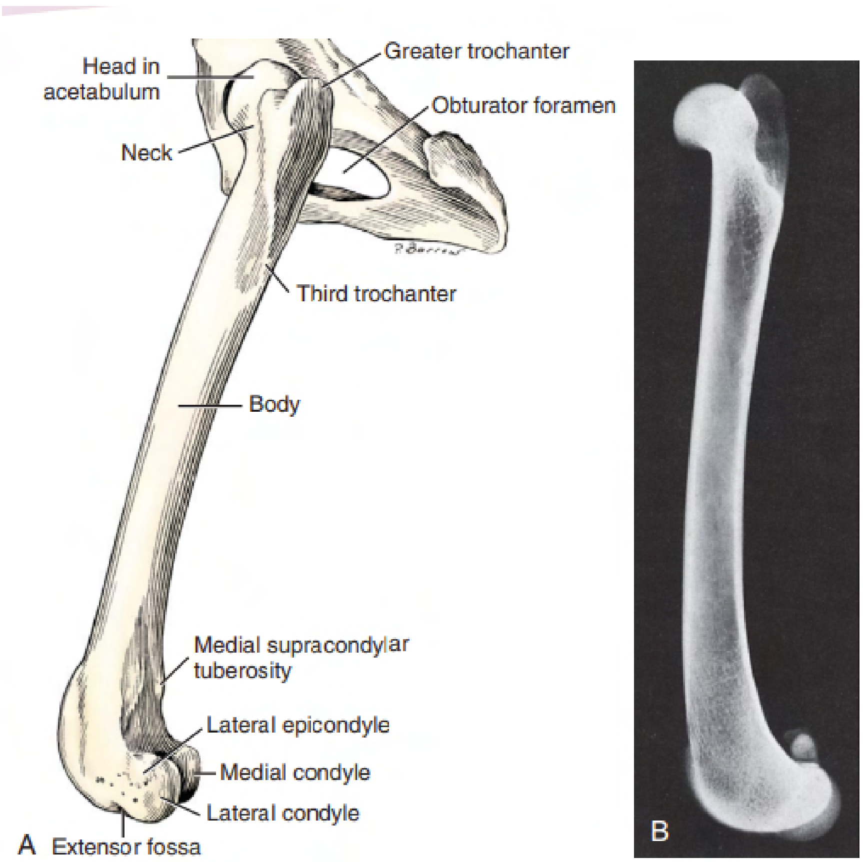
function of bones:

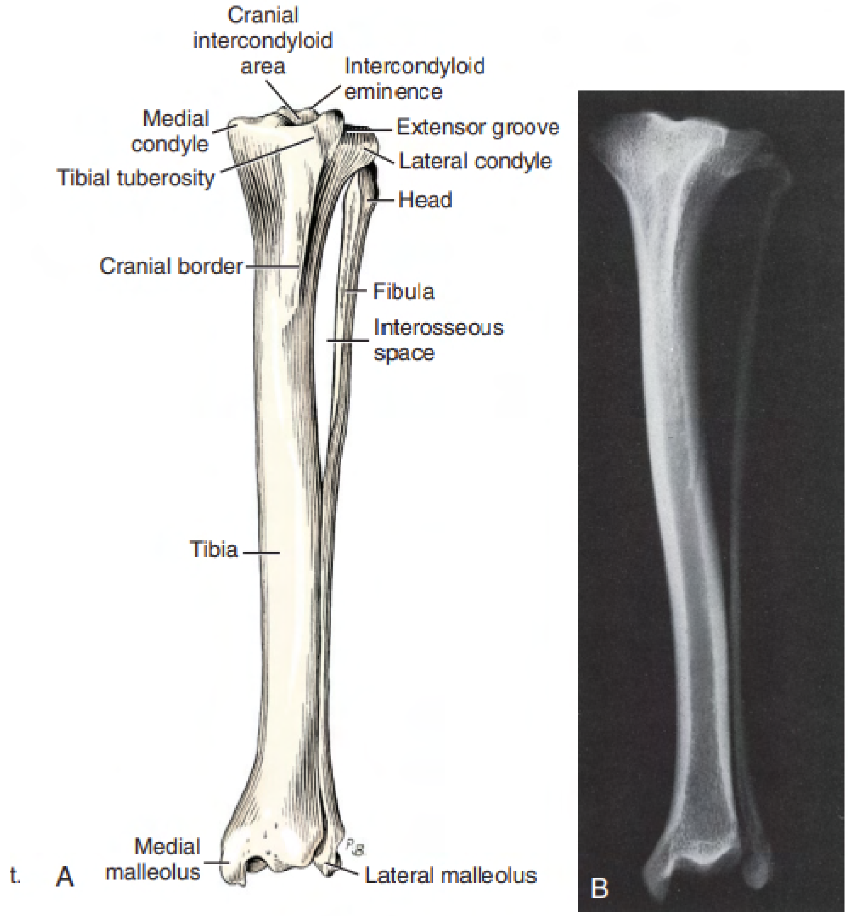
- serve as first, second, and third class levers. nearly all muscles act at a mechanical disadvantage, speed at which weight travels is in direct proportion to the shortness of the force arm and is determined by the distance of the insertion of the muscle from the joint, or fulcrum

- each pelvic limb consists of its half of the pelvic girdle (ilium, ischium, pubis, and acetabular bone)

- thigh represented by the femur and the sesamoids associated with the stifle, the crus, or leg, consisting of the tibia and fibula

- hind paw or pes includes the tarsal bones, metatarsals, and digits consisting of three phalanges in each, and the sesamoid bones associates with the phalanges





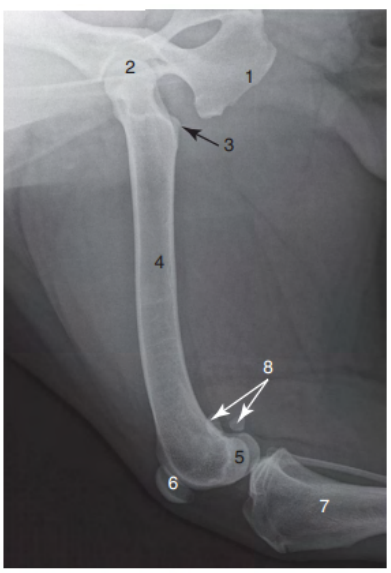
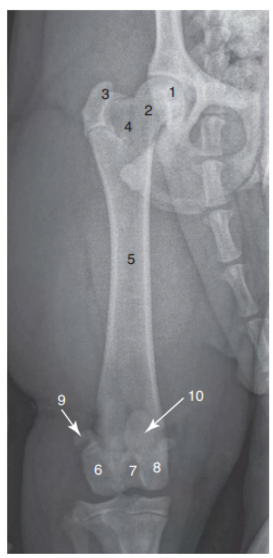


FIGURE 4-130 Lateral radiograph of the femur:

1. Ischiatic tuberosity
2. Femoral head
3. Lesser trochanter
4. Body of femur
5. Femoral condyles
6. Patella
7. Tibia
8. Sesamoid bones in medial and lateral heads of gastrocnemius muscle



GURE 4-131 Craniocaudal radiograph of the femur.

1. Femoral head
2. Femoral neck
3. Greater trochanter
4. Trochanteric fossa
5. Body of femur
6. Lateral condyle
7. Intercondylar fossa
8. Medial condyle
9. Lateral gastrocnemius sesamoid bone
10. Patella

FIGURE 4-136 Lateral radiograph of the stifle:

1. Femoral metaphysis
2. Distal femoral physis
3. Intercondylar fossa
4. Femoral condyles
5. Trochlea
6. Patella
7. Tibial condyles
8. Intercondylar eminence
9. Tibial tuberosity
10. Cranial border of tibia
11. Fibula
12. Sesamoid bones in medial and lateral heads of gastrocnemius muscle
13. Popliteus sesamoid bone

FIGURE 4-146 Lateral radiograph of the tarsus:

1. Calcaneus
2. Talus
3. Central and fourth tarsal bones
4. First to fourth tarsal bones
5. Tibial cochlea
6. Metatarsal bones (bases)
7. Tarsocrural joint
8. Proximal intertarsal joint
9. Distal intertarsal joint
10. Tarsometatarsal joint

Citation: M. E. Miller, H. E. Evans, and A. D. Lahunta, *Miller's anatomy of the dog*. St. Louis, Mo: Saunders, 2013.

Conclusion:

2022/10/14 - Comparison of Muscle Sizes Across Dog Breeds

Maggie LaRose - Oct 20, 2022, 2:33 PM CDT

Title: Comparison of the large muscle group widths of the pelvic limb in seven breeds of dogs

Date: 10/14/2022

Content by: Maggie LaRose

Present: N/A

Goals: Figure out main muscles on dog hindleg and how the muscle thickness/size varies across dog breeds.

Content:

Table 2. Comparisons of the muscles widths (mm = millimetre) and ratios between the breeds

	German shepherd (*n* = 25)	Golden retriever (*n* = 23)	Labrador retriever (*n* = 23)	Belgian Malinois (*n* = 20)	Rottweiler (*n* = 16)	Boxer (*n* = 10)	Doberman pinscher (*n* = 9)	*p*<
QW (mm)	41.4 ± 5.00	42.1 ± 4.77	44.0 ± 5.52	41.2 ± 4.98	44.2 ± 5.33	44.6 ± 3.58	44.1 ± 7.34	NS
HW (mm)	87.6 ± 7.31^{fg}	83.6 ± 10.2^{cdf}	88.6 ± 9.50^{f}	74.4 ± 7.05^{a}	90.9 ± 10.0^{df}	85.6 ± 9.19^{abcdf}	75.2 ± 9.19^{abcg}	0.001
GW (mm)	52.8 ± 3.05^{ef}	47.1 ± 3.73^{ab}	50.0 ± 4.92^{bdef}	48.6 ± 3.00^{acdg}	51.5 ± 4.29^{efg}	54.0 ± 2.79^{f}	49.0 ± 3.31^{bce}	0.001
QW:HW	0.47 ± 0.05^{e}	0.51 ± 0.04^{e}	0.50 ± 0.04^{e}	0.56 ± 0.06^{ac}	0.49 ± 0.04^{de}	0.52 ± 0.04^{bcde}	0.59 ± 0.05^{ab}	0.001
GW:QW	1.29 ± 0.13^{cdef}	1.13 ± 0.10^{ab}	1.15 ± 0.09^{ab}	1.19 ± 0.11^{be}	1.18 ± 0.12^{bf}	1.22 ± 0.06^{bc}	1.14 ± 0.18^{bd}	0.001
GW:HW	0.60 ± 0.04^{bc}	0.57 ± 0.05^{b}	0.57 ± 0.04^{b}	0.66 ± 0.04^{ade}	0.57 ± 0.06^{bf}	0.64 ± 0.06^{bde}	0.66 ± 0.06^{cef}	0.001

Quadriceps width (QW), hamstring width (HW), gastrocnemius width (GW). Mean ± standard deviation. Different superscript letters in the same line are given where significant differences ($p < 0.05$) were detected with post hoc comparisons among breeds by ANOVA.

- more medium sized dog, focus on belgian malinois, boxer, or doberman?

Citation & Link: https://onlinelibrary.wiley.com/doi/10.1111/ahe.12362

http://vanat.cvm.umn.edu/carnLabs/Lab06/Lab06.html

Conclusions/action items: Possibly figure out a dog breed to focus on so we can use more exact dimensions when creating muscle patterns for fabrication?

2022/09/26 Using Dragon Skin Liquid Rubber to Mimic Muscle

Maggie LaRose - Oct 11, 2022, 4:29 PM

Title: Dragon Skin Liquid Rubber for Muscle Material

Date: 09/26/2022

Content By: Maggie LaRose

Present: N/A

Content:

characteristics/applications of dragon skin:

Pros	Cons
elastic qualities that allow the silicone to stretch multiple times its size and rebound without deformation	Require use of vacuum to eliminate air bubbles during curing
versatile in that it can take any form/ shape of muscle, customizable	Would need to make molds to pour mix into
	expensive, and don't know exactly consistency of liquid rubber and whethe would be the right consistency to mimic muscle

Conclusions/Action Items:

Links: https://www.smooth-on.com/product-line/dragon-skin/?pk_campaign=dynamicsilicone&pk_kwd=&gclid=CjwKCAjwm8WZBhBUEiwA178UnEDEHwZ9cHNOyHQVysXTYgQS3JHyl_MAVChTzm5egEdafIy4xBgzNhoCmrMQAvD

https://www.smooth-on.com/products/dragon-skin-20/

2022/09/28 Mold making techniques

Maggie LaRose - Se

Title: Mold Making Techniques with Household materials (for silicone rubber muscle option)

Date: 9/28/2022

Content By: Maggie LaRose

Present: N/A

Content:

Dragon Skin:	Mold Making:
- "superior physical properties and flexibility: - used for medical prosthetics and cushioning applications - Dragon Skin 10,20,30 very durable and stretchy, can stretch to multiple times its size without tearing or deformation - high tear strength and easy to color - certified skin safe and non-toxic - no scale necessary for measurements and low viscosity	- requires dish soap (glycerin in dish soap accelerates the cure proc acts as a catalyst), 100% silicone, caulking gun - place silicone via caulking gun into soapy water bowl and then pla glob of silicone, let set

Links/Citations:

Official Dragon Skin Website:

https://www.smooth-on.com/product-line/dragon-skin/?pk_campaign=dynamicsilicone&pk_kwd=&gclid=CjwKCAjwm8WZBhBUEiwA178UnEDEHwZ9cHNOyHQVysXTYgQS3JHyl_MAVChTzm5egEdafIy4xBgzNl

Silicone mold making kit on Amazon:

https://www.amazon.com/Silicone-Molds-Making-Kit-Liquid-Translucent-Silicone-Casting/dp/B08LY9VM79/ref=sr_1_1_sspa?keywords=silicone%2Bmold%2Bmaking%2Bkit&qid=1664393657&qu=eyJxc2MiOiI1LjYzIiwicXNhIjoiNS4xMyIsInFzcCI6IjQuODgifQ%3D%3D&sr=8-1-spon

Making 100% better caulk molds:

https://martha.net/2018/05/how-to-make-better-100-silicone-caulk-molds/

World's Easiest Silicone Molds:

https://www.instructables.com/Worlds-easiest-silicone-mold/

Conclusions/Action Items:

Dragon skin/pourable silicone rubber should be considered as a muscle option for the model due to its high elastic performance and durability. The more ch its fabrication process, i.e, the mold-making and curing process, should be considered when decided between this among other options.

2022/09/26-09/30 Green Permit Training

Maggie LaRose - Oct 11, 2022, 4:28 PM CDT

Title: Green Permit Training Documentation (Completed)

Date: 9/26/2022 - 9/30/2022

Content By: Maggie LaRose

Present: N/A

Completed On: 9/30/2022

Medium Dog

Emily HUTSELL - Oct 11, 2022, 10:07 PM CDT

Title: Medium Dog

Date: October 11, 2022

Content by: Emily Hutsell

Present: N/A

Goals: To discover the approximate size of a medium sized dog.

Website 1: Your Purebred Puppy

Link: https://www.yourpurebredpuppy.com/dogbreeds/index-medium-dog-breeds.html

Citation: "Dog Breed Reviews: Medium Dog Breeds," Your Purebred Puppy. https://www.yourpurebredpuppy.com/dogbreeds/index-medium-dog-breeds.html (accessed October 11th, 2022).

This website is by Michele Welton who has worked as a dog breed advisor, obedience instructor, canine psychologist, and veterinary technician. She also wrote many books on animals. She defines medium sized dogs as 18-22 inches at the shoulder. This means our model should be approximately that high. Additionally, she defines medium sized dogs to weigh between 40 and 60 pounds, although this won't be necessary information for our model.

Website 2: Dog Sized

Link: https://dogsized.com/how-big-is-a-medium-sized-dog/

Citation: "How Big is a Medium Sized Dog," Dog Sized. https://dogsized.com/how-big-is-a-medium-sized-dog/ (accessed October 11th, 2022).

This website disagrees slightly with the previous website. This one says that a medium sized dog can be anywhere from 12-24 inches from the ground to shoulder. This is measurement goes six inches smaller and two inches bigger. For our model we need to consider how easy it will be for small groups to use the model, so a larger size, like 18-24 inches might be best. However, we also need to consider how expensive 3D printing will be, so we may need to choose to make the model only 18-19 inches tall.

Conclusion: The average medium sized dog could be anywhere from 12-24 inches, but our model should be 18-20 inches tall.

Purpose of Gluteal Muscles

Emily HUTSELL - Dec 13, 2022, 10:35 PM CST

Title: Purpose of Gluteal Muscle

Date: December 10th, 2022

Content by: Emily Hutsell

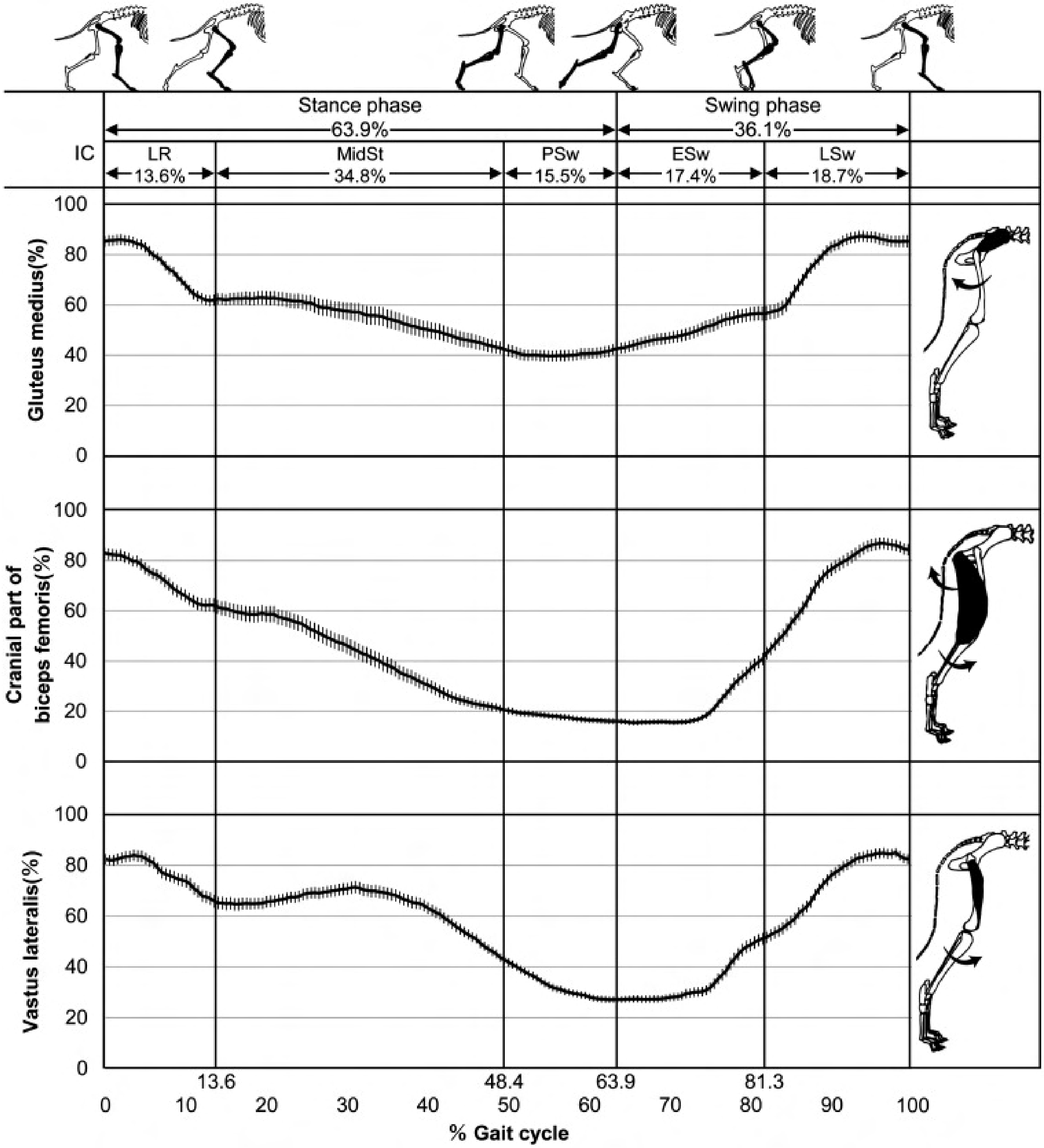
Present: N/A

Goals: To discover the purpose of the Gluteal Muscles in Dogs.

Title: Yoshikawa K, Tsubakishita S, Sano T, Ino T, Miyasaka T, Kitazawa T. Functional assessment of the gluteus medius, cranial part of the biceps femoris, and vastus lateralis in Beagle dogs based on a novel gait phase classification. J Vet Med Sci. 2021 Jan 14;83(1):116-124. doi: 10.1292/jvms.20-0127. Epub 2020 Nov 23. PMID: 33229819; PMCID: PMC7870396.

Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7870396/

Author:



The Gluteus Medius muscle is used while walking, particularly in the Loading Response (LR) stage and the Early to Late Swing (ESw and LSw). This muscle extends and contracts in order to stabilize the bones while the contralateral hindlimb is being lifted as well as when the attached limb is being swung.

Title: Muscles dogs use during exercise

Link: https://www.thecaninefitnesscentre.co.uk/health/muscles-dogs-use-during-exercise/#:~:text=Gluteal%20muscles%20help%20a%20dog,tarsus%20features%20of%20the%20body.

Author: The Canine Fitness Center

The Hindlimb area has 7 major muscles including, the gluteal muscles, bicep femoris, semitendinosus, membranous, quadriceps femoris, cranial tibial muscles, and Achilles tendon. These control and support the movement of the hip muscles and joints. In particular, the Gluteal muscles extend and move the hip joint away from the body. These muslces can be activated by almost any movement a dog makes, particularly in swimming, running, and long walks.

Purpose of Gastrocnemius

Emily HUTSELL - Dec 14, 2022, 4:25 PM CST

Title: Purpose of Gastrocnemius

Date: December 10th, 2022

Content by: Emily Hutsell

Present: N/A

Goals: To discover the purpose of the Gastrocnemius in Dogs.

Link: Lideo L, Milan R. Ultrasound monitoring of shortwave diathermic treatment of gastrocnemius strain in a dog. J Ultrasound. 2013 Oct 24;16(4):231-4. doi: 10.1007/s40477-013-0044-7. PMID: 24432180; PMCID: PMC3846949.

This muscle extends the tarsus and flexes the knee during movement. If the gastrocnemius breaks, the dog's hind limb will appear lame and in a plantigrade stance. This could be because the quadricep is mulling the limb forward and the gastrocnemius is not able to counteract the action of the quad like it normally would, making them walk with a limp. This is important when understanding how muscles interact with each other and create stability and motion. In the future, we really need to focus on making the quadricep so we can show what happens when something damages the gastrocnemius. When talking with the vet students they talked a lot about what happens to dogs when this muscle is broken.

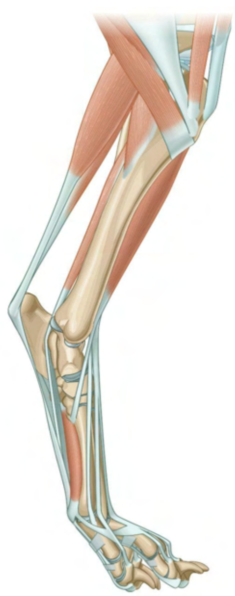
Title: Gastrocnemius Muscle

Link: https://petmassage.com/gastrocnemius-muscle/

Author: Linda Hilger

This article describes the gastrocnemius as one of the many muscles that make up the Achilles tendon. This article says the specific purpose of this muscle is to keep the heel off of the floor, when this muscle and / or the SDF is broken, the heel is unable to be kept off the floor resulting in the plantigrade stance the previous article mentioned. While the hindlimb retraction is initiated by the middle gluteal muscle, the flexion of the paw is due to this gastrocnemius and the deep flexor.

Link: https://www.imaios.com/en/vet-anatomy/anatomical-structure/gastrocnemius-muscle-11078084892



Link: https://thecatsite.com/media/cat-plantigrade-stance-diabetic-neuropathy2-jpg.265737/

Purpose of the Adductor

Emily HUTSELL - Dec 14, 2022, 4:38 PM CST

Title: Purpose of the Adductor

Date: December 10th, 2022

Content by: Emily Hutsell

Present: N/A

Goals: To discover the purpose of the Adductor in Dogs.

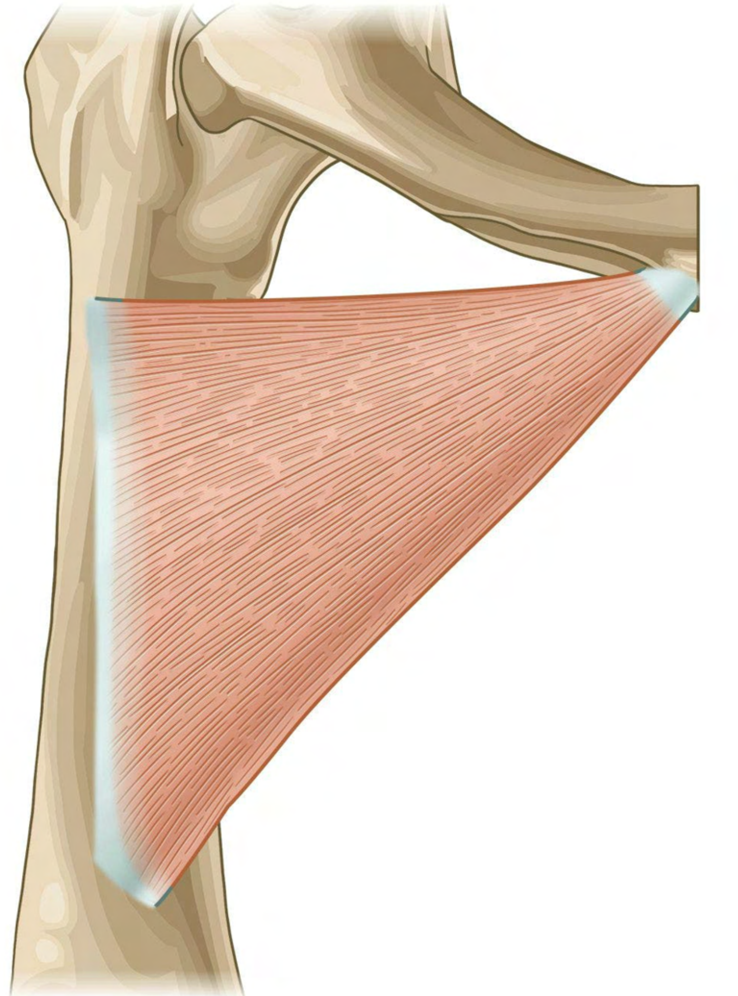
Title: FORELIMB AND HINDLIMB ADDUCTION

Link: http://martialarfs.com/blog/forelimb-and-hindlimb-adduction/#:~:text=For%20nonlinear%20sports%20like%20agility,with%20minimal%20wiggle%20or%20wobble.

Author: Jeris Pugh

This article describes the function of the adductor as being mostly for stability, when the dog is running forward the muscle works to minimize the wobble and keep the limb moving in the correct direction. The adductor helps dogs change direction and stabilize themselves while moving in various directions. Dr. Gunderson, our client, noted that this muscle is what stops dogs from "splaying out" over the floor while trying to walk, especially on slippery floors where their paws are more likely to slip. This muscle counteracts the gluteal Medius a little, but it would be better to demonstrate its effect if the model was of a full dog a off the stand, when it is being fully supported by the stand it is difficult to show how important this muscle is.

Link: https://www.imaios.com/en/vet-anatomy/dog/dog-myology?slice=517&structureId=3166&isolate=true



Axis Scientific

Emily HUTSELL - Oct 11, 2022, 10:34 PM CDT

Title: Axis Scientific

Date: Ongoing (September 20th-October 9th)

Content by: Emily Hutsell

Present: N/A

Goals: Understand the types of models created by competitors.

Competing Designs:

Company: Axis Scientific

Model 1: Articulated Complete Dog Skeleton

Link: https://anatomywarehouse.com/axis-scientific-large-canine-flexible-articulation-on-base-a-108846

Citation: "Axis Scientific Large Canine - Flexible Articulation on Base," Anatomy Warehouse. https://anatomywarehouse.com/axis-scientific-large-canine-flexible-articulation-on-base-a-108846 (accessed Sep.20, 2022).

Explanation:

$400 . A very detailed depiction of a complete dog skeleton. However, it doesn't have muscles despite being articulated. This is a model of an entire dog; our model will just be a section. The model is 20 inches tall and 42 inches from nose to tail.

Model 2: Disarticulated Dog Skeleton

Link: https://anatomywarehouse.com/axis-scientific-disarticulated-dog-skeleton-a-109159

Citation: "Axis Scientific Disarticulated Dog Skeleton," *Anatomy Warehouse*. https://anatomywarehouse.com/axis-scientific-disarticulated-dog-skeleton-a-109159 (accessed Sep.20, 2022).

Explanation:

$200 . A very detailed depiction of a complete dog skeleton. However, this mode is not articulated so it is just a pile of bones. Our model will be assembled to look like a canine hindlimb and will have muscles that you can attach and detach. There are 321 bones total included in this kit. Our dog model will just be one hindlimb and so there will be fewer bones involved. The product is 4 lbs.

Model 3: Articulated Hindlimb with Foot

Link: https://anatomywarehouse.com/axis-scientific-canine-hindlimb-with-foot-a-109194

Citation: "Axis Scientific Canine Hindlimb with Foot," *Anatomy Warehouse*. https://anatomywarehouse.com/axis-scientific-canine-hindlimb-with-foot-a-109194 (accessed Sep.20, 2022).

Explanation:

$72 . This model contains a very detailed depiction of the hindlimb section of a dog's skeleton including: femur, rotula, stifle joint, tibia, hock, fibula, tarsus, metatarsus, phalanges. It also comes with a 3 year warranty. This is the exact area that we intended to create a model for; however, this model doesn't have any muscle attachments or indication of where muscles attach. This is going to be the key difference between this model and our model. Our model will focus on showing muscle attachments. We want our model to have a similar level of detail. Other features of this mode are that it is the size of a large beagle or a small Labrador, as explained by the company. The leg is about 16.25 in. x 5.5 in. x 1.5 in. According to their website... "Because it's about 16 inches long, that's how we determined it's based on an average medium dog, probably sized somewhere between a beagle and lab." The model weighs .25 lbs.

Conclusion: Axis Scientific creates an number of high-quality models of dog anatomy, however, they all lack muscles and some of them are not even articulated. As for cost, the are middle of the range.

Anatomy Lab

Emily HUTSELL - Oct 11, 2022, 10:37 PM CDT

Title: Anatomy Lab

Date: September 29th

Content by: Emily Hutsell

Present: N/A

Goals: Understand the types of models created by competitors.

Competing Designs:

Company: Anatomy Lab

Model 1: Anatomy Lab Canine Skeleton - Fixed Articulation on Base

Link: https://anatomywarehouse.com/anatomy-lab-canine-skeleton-fixed-articulation-on-base-a-108697

Citation: "Anatomy Lab Canine Skeleton - Fixed Articulation on Base", *Anatomy Warehouse.* https://anatomywarehouse.com/anatomy-lab-canine-skeleton-fixed-articulation-on-base-a-108697 (accessed Sep.29, 2022)

Explanation:

$230 . Cheaper than Axis Scientific's Articulated Skeleton with Base. The sculpt is of similar quality and the base has informational material attached. Unfortunately, this model lacks muscles and doesn't even have any indication of where they would attach. Our model would have muscles that flex are contract to demonstrate movement.

Model 2: Anatomy Lab Domestic Canine

Link: https://anatomywarehouse.com/anatomy-lab-domestic-canine-canis-lupus-familiaris-anatomy-model-a-109171

Citation: "Anatomy Lab Domestic Canine (Canis lupus familiaris)", *Anatomy Warehouse. https://anatomywarehouse.com/anatomy-lab-domestic-canine-canis-lupus-familiaris-anatomy-model-a-109171* (accessed Sep.29, 2022)

Explanation:

$312 . This model shows many different layers of a dog's body. Showing organs, skin, and muscles- all in great detail. However, this model is not articulated therefore it would be difficult to demonstrate how muscles affect movement. Our model will not contain organs as they are not relevant to what we want to teach students; our model will also be articulated.

Conclusion: Anatomy Lab has a variety of dog models, one that focuses on muscles and organs and the other than focuses on bones. Both are lacking something that our model will have.

4D Master

Emily HUTSELL - Oct 11, 2022, 10:38 PM CDT

Title: 4D Master

Date: September 19th

Content by: Emily Hutsell

Present: N/A

Goals: Understand the types of models created by competitors.

Competing Designs:

Company: 4D Master

Model 1:

Link: https://www.rainbowresource.com/product/025530/4D-Dog-Skin-Model.html?

Citation: “4D Dog Skin Model,” Rainbow Resource. https://www.rainbowresource.com/product/025530/4D-Dog-Skin-Model.html? (accessed Sep.19, 2022).

Explanation:

$26.95 . This model is very cheap compared to other models; however it is not life sized. It is very small and lacks details. The model is meant to be for children 8 years and older as opposed to first year anatomy students. In addition, because of the size it is not suitable for groups of 2-5 students. In addition, the model is not articulated even though it does show the skeleton and the muscles. Our model will be the same size as a medium sized dog and it will be articulated with muscles and bones. This model has both a Husky and a Golden Retriever version.

Conclusion:

4D Master has many cheap models available. They appear to be directed towards younger audiences and are small enough to display on shelves.

Client's Design

Emily HUTSELL - Oct 11, 2022, 10:40 PM CDT

Title: Client's Design

Date: September 15th

Content by: Emily Hutsell

Present: N/A

Goals: Understand the types of models created by competitors.

Competing Designs:

Company: Client's Design

Model 1:

Link: N/A

Citation: N/A

Explanation:

The client's model is our strongest competitor. They started developing it to use to teach their first-year anatomy students; however, they didn't like how the muscles were turning out and so they stopped. The bone skeleton is detailed and the region of muscle attachment is painted on with a color code to facilitate learning. The muscles themselves are just single pieces of elastic and connect to at most two locations in a particular muscle attachment region. Ideally, the muscles should connect to the entire region of attachment (i.e. the entire yellow region) they should also have a 3D form the resembles real dog muscles'. The attachment point were little hooks that the muscles attached onto; the client also mentioned that they didn't love how obtrusive the hook design was and said they might like it to be less apparent.

Conclusions:

Our client has put a lot of effort into developing a high quality model of how muscles control movement; however there are a few key areas that our model will improve upon, like the shape of muscles and their attachment points.

Spandex

Emily HUTSELL - Oct 11, 2022, 10:32 PM CDT

Title: Spandex

Date: September 23, 2022

Content by: Emily Hutsell

Present: N/A

Goals: To understand more about Spandex.

Website 1: Refiber Designs

Link: https://refiberdesigns.com/blog/the-why-and-how-of-stretch-fabrics

Citation: “The How and Why of Stretch Fabric,” Refiber Deigns. https://refiberdesigns.com/blog/the-why-and-how-of-stretch-fabrics (accessed September 23, 2022).

2 main aspects of stretchy fabric: 1. ability to extend in length without breaking. 2. ability to return back to its original state. Spandex tends to retain its shape when stretched, but knit fabrics won't. Spandex can be blended with other fabrics in order to improve stretch and comfort. The way it expands is by having the long fibers stretch out then returns to its natural shape determined by how the short fibers are.

Website 1: Silver Bobbin

Link: https://silverbobbin.com/lycra-vs-spandex-vs-elastane/

Citation: “Lycra vs Spandex vs Elastane,” Silver Bobbin. https://silverbobbin.com/lycra-vs-spandex-vs-elastane/ (accessed September 23, 2022).

Lycra, elastane, and spandex are all the same material. It was first created by German Researcher DuPont who decided to call it Lycra to market it better. Neither elastane nor spandex are trademarked. Spandex has more strength and stretch than rubber and it can outlast most organic fabrics. The only fiber that is more durable is other plastics. Clothes usually contains less than 10% of spandex, but elastane on its own can stretch 5-8 times it original length. Blends containing spandex are less stretchy.

Conclusion:

Spandex is very durable and will be able to return to its original shape even after being stretched many times which will be important for our project. In addition, it is very stretchy and so even blends should be able to stretch far enough for the muscles.

Silicone

Emily HUTSELL - Dec 14, 2022, 5:09 PM CST

Title: Silicone

Date: September 23, 2022

Content by: Emily Hutsell

Present: N/A

Goals: To understand more about Silicone.

Due to time and cost we have deiced to go with either Eco Flex 10 or 50; this is also the silicone Dr. Gunderson had on hand and so we decided it would be the best silicone to make the muscles out of. However which silicone will be the best for future work needs to be though about.

Website 1: EcoFlex 00-10

Link: https://www.smooth-on.com/products/ecoflex-00-10/

This silicone is one of the softest this company offers; with a hardness of 00-10. This means that the material will be easy to stretch and won't put as much pressure of the attachment points. However, this also comes with many downsides. For instance, this silicone only has a tensile strength of 120 psi, which means it is far more prone to tearing. This will significantly reduce the longevity of the product and reduce the worth. The goal of our project is to make an accurate and durable product. The cure time is also 4 hours which is longer than other silicones.

Website 1: EcoFlex 00-50

Link: https://www.smooth-on.com/products/ecoflex-00-50/

This is the silicone is the one we used for our current prototype. It is durable, cures in 3 hours, and is translucent. This is an excellent choice, however the hardness does make it somewhat harder to stretch; many of the comments left by the veterinary students was that the muscles took a little too much force. The force required to stretch them also impacts the magnetic attachments as it requires them to be stronger. The muscles would detach from the bone regularly. This does have a tensile strength of 315 psi, which is over double the 00-10.

Conclusion:

In the future it might be best to test with the 00-20 or 00-30 to see how much of a difference the hardness and tensile strength makes.

Definitions of Material Science Terms

Emily HUTSELL - Dec 14, 2022, 5:29 PM CST

Title: Definitions of Material Science Terms

Date: December 10th, 2022

Content by: Emily Hutsell

Present: N/A

Goals: To understand more about Material Science Terminology used by Silicone Websites.

Website 1: https://moldeddimensions.com/blog/defining-tensile-strength-elongation-and-modulus-for-rubber-and-cast-polyurethane-materials/

Tensile Strength

"Tensile strength is usually measured as the amount of force in pounds per square inch (psi) or megapascals (MPa) required to pull a specimen to the point of material failure. " This is important to know because our muscles will be repeatedly pulled and stretched by students and some students may over stretch the muscles for fun and so we should be aware of how much force the muscles will be able to handle and compare it with how much force the average human can apply while pulling something.

"Ultimate elongation is the percentage change in length from original to rupture." This is important to know because we plan on making all the muscles be slightly shorter than they would be if the dog was standing normally; this would make the model be in constant tension and we need to make sure that the elongation required to stretch the muscle to its full length won't be longer than the ultimate elongation.

"Modulus is the force at a specific elongation value, ie 100% or 300% elongation... In general, higher durometer materials have a higher modulus." This is important in case a website doesn't list its material durometer stat; if we have the modulus then we can still estimate how strong or soft the material is.

Magnet Lock for Cabinets

Emily HUTSELL - Dec 14, 2022, 6:14 PM CST

Title: Magnet Locks for Cabinets

Date: December 11th, 2022

Content by: Emily Hutsell

Present: N/A

Goals: To find new attachment mechanisms.

Title: Skyla Homes Magnetic Multi-Purpose Locks

Link: https://www.amazon.com/Skyla-Homes-Magnetic-Proofing-Multi-Purpose/dp/B01AW3XLBE

This product is something recommended by a person who tested our product. This product has a lot of strength and most likely would be able to withstand all the forces that the muscles being stretched exert on the attachments, but they are not malleable enough to fit on the attachment points. These locks are recommended for use on a flat surface whereas our bones are a very organic shape with little flat surfaces. In addition, these locks can work well though two inches of wood, and that would mean we could place them inside the bones like we were originally planning to do with the neodymium magnets. however, these locks are too large to be placed inside the bones as the bones are very small and thin, we couldn't even insert magnetic tape. Another concern, is that the attachment points are too small for these large locks to attach. In conclusion, this idea seemed like it could be very useful, but it doesn't seem like it will work in practicality. We could attempt to mimic the locking mechanism on a smaller scale, but that may still take up too much room.

Pin

Emily HUTSELL - Dec 14, 2022, 8:40 PM CST

Title: Pin

Date: December 11th, 2022

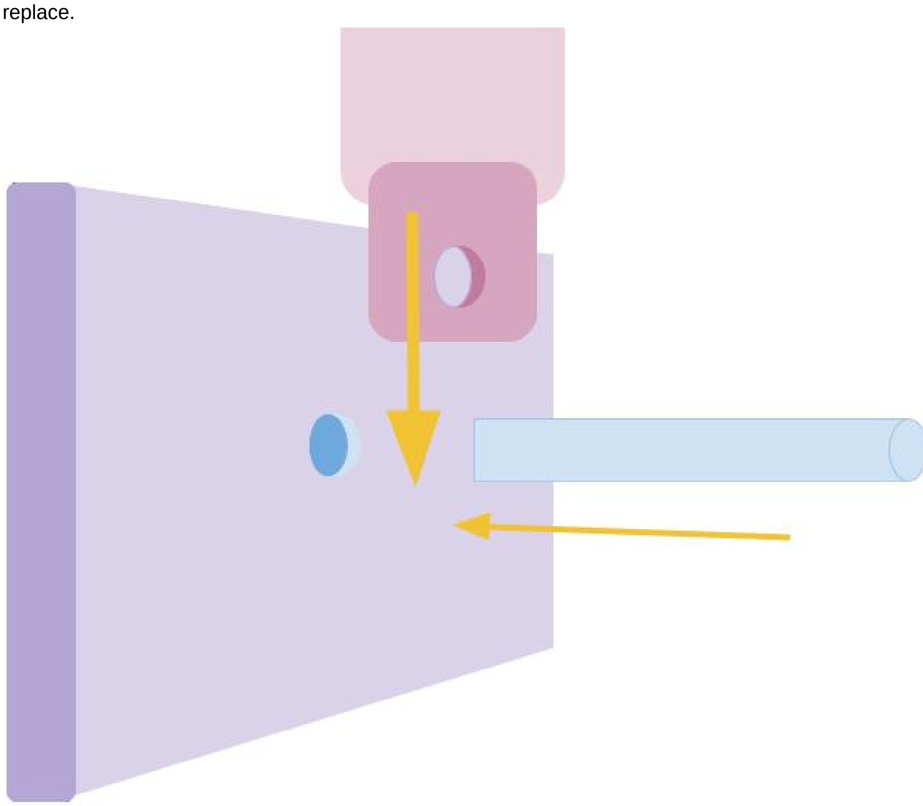
Content by: Emily Hutsell

Present: N/A

Goals: To find a new attachment mechanism

Title: Pin design

I thought that instead of using magnetic force to hold the muscles to the bones it would be better to use a physical lock to hold everything in place; this way we wouldn't have to worry about finding the sweet spot between being able to remove the magnet and the magnet falling off too easily. I attached a Jpeg of my idea. There would be a 3D Printed or molded piece of plastic or clay with a pin sized hole in it and the muscle would have a similar piece. You would be able to slide the pin through the hole and have it lock in place while the muscle is stretched. The pin would be attached by a thin thread to the muscle. Some of the downsides to this would be, the pin being so small it is lost or easily broken. In addition, the small pin may be difficult for some people to hold and poke through the equivalently small hole. But the benefits include, not having to worry about magnets or magnets losing strength; if the pin is made from a sewing needle then they would be easy to replace.



2014/11/03-Entry guidelines

John Puccinelli - Sep 05, 2016, 1:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity, subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

Title: Descriptive title (i.e. Client Meeting)

Date: 9/5/2016

Content by: The one person who wrote the content

Present: Names of those present if more than just you (not necessary for individual work)

Goals: Establish clear goals for all text entries (meetings, individual work, etc.).

Content:

Contains clear and organized notes (also includes any references used)

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.

2014/11/03-Template

Zach Spears - Oct 03, 2022, 12:11 PM CDT

Title:

Date:

Content by:

Present:

Goals:

Content:

Citation & Link:

Conclusions/action items: