Structural and Mechanical Function of Canine Forelimb

Advisor
Dr. Christa Wille
Client
Dr. McLean Gunderson
The Vets
Kaden Kafar (Co-leader)
Colin Fessenden (Co-leader/BSAC)
Samantha Kahr (Communicator)
Dan Altschuler (BWIG)
Jake Allen (BPAG)
Matt Sheridan (BWIG)

Overview

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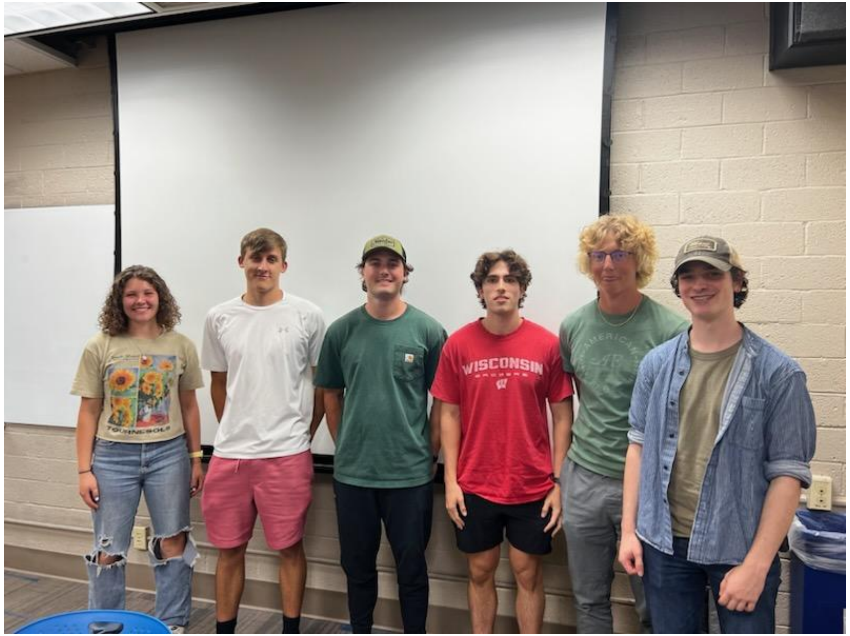


Figure 1: Team Picture

Client Description

- Dr. McLean Gunderson
    - UW School of Veterinary Medicine
    - Department of Comparative Biosciences
        - Lecturer for Veterinary Anatomy

Figure 2: Veterinary School Crest [1]

Problem Statement

Create realistic models of the forelimb of a canine's musculature to replicate muscle and bone interactions of the joint. The models should be easily removable and resistant to wear as training models for veterinary students to learn the mechanics of the important joints in the animal.

Background

- First year veterinary students require hands on learning
- Anatomical accuracy issues with purchasable models
  - Muscle insertions and action over joints
- Project from last year was successful, but can be improved
  - More time to include more muscles and to involve tendons

Figure 3: Model from last year [2].

Figure 4: Middle gluteal model from last year [2].

Competing Solutions

Figure 5: Bone model of forelimb of dog [3]

- Vetwho/axis scientific bone model
- Lack of muscles
- $78

Figure 6: Full model of a dog with muscle and organs [4]

- Anatomy warehouse
- Static, no bones, detachable parts
- $365

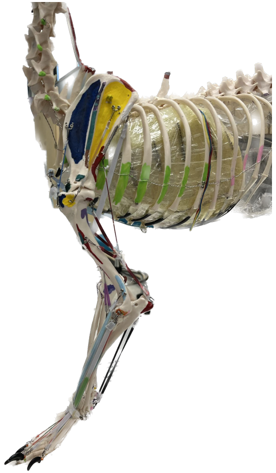


Figure 7: Current model being used in teaching veterinary students

- Current model
- Pin and hooks
- Altered purchased model

Design Specifications

- 3D modeled bones and fabricated muscles to replicate a dog’s forelimb
- Muscles be easily detached and reattached
  - Muscles connected by tendons
- Opposing muscles balance tensile forces
- Easily usable and durable enough to withstand use by approximately 100 first year Veterinary students

Muscle Design 1: Elastic Bands

- Elastic band to mimic muscle
- Attach by bar and hook mechanism
- Does not look like muscles

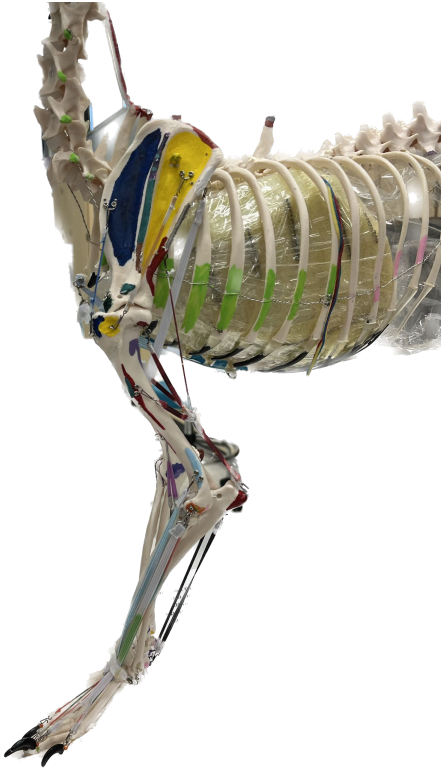


Figure 7: Current model in use using elastic bands

Muscle Design 2: Resin

- Can be molded using 3D printed casts
  - Plastic resin specifically can be used to keep prices down
  - Treated resin prevents heat damage
- Doesn’t deform much after casting
- Resin is easily dyed/colored

Figure 8: 3D printed molds for resin casting

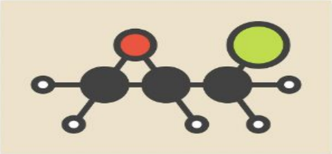
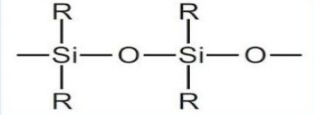
Muscle Design 3: Silicone

- EcoFlex Silicone material
- Versatile and easy to use
- Variability
  - Different solutions (00-10,00-50, etc.)
  - Ability to manipulate different muscle hardness levels

Figure 9: Ecoflex Silicone

Muscle Design Matrix

<u>Table 1:</u> The Design Matrix Ranking each Muscle Design

Design Criteria	Design 1: Elastic Band 		Design 2: Resin 		Design 3: Silicone 	
Ease of Fabrication (20)	5/5	20	5/5	20	4/5	16
Durability (20)	4/5	16	4/5	16	5/5	20
Mechanical Similarity to Muscle (20)	3/5	12	2/5	8	4/5	16
Safety (15)	2/5	6	3/5	9	4/5	12
Appearance (15)	1/5	3	3/5	9	4/5	12
Cost (10)	5/5	10	4/5	8	5/5	10
Total (100)	67/100		70/100		86/100	

Attachment Design 1: Velcro

- Velcro fasteners can be used as a simple and effective attachment
- In shear, they are able to withstand 195N of force while fresh, 182N after 100 uses, and 137N after 500 uses [8]
- Main downsides to a velcro attachment are the unnatural look and the deterioration of the attachment force over time

Figure 10: Velcro Attachment

Attachment Design 2: Magnets

- A 3-D printed component in the shape of the muscle attachment with space for magnets, and a matching piece on the muscle
- Magnets do not wear down over time with use, and different strengths and sizes are available
- Very easy and intuitive to use

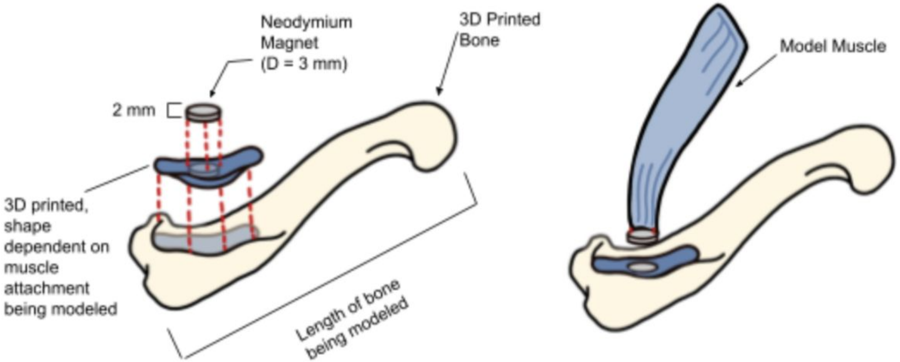


Figure 11: Muscle Attachment [2]

Attachment Design 3: Button Release Pins

- Extremely durable connection
  - Can last years on an actively driven vehicle
- Intuitive to use and substantial feel
- Create clutter in large numbers
  - Possible to shrink design/release pin with force opposed to a button

Figure 12: button release pin

Attachment Design Matrix

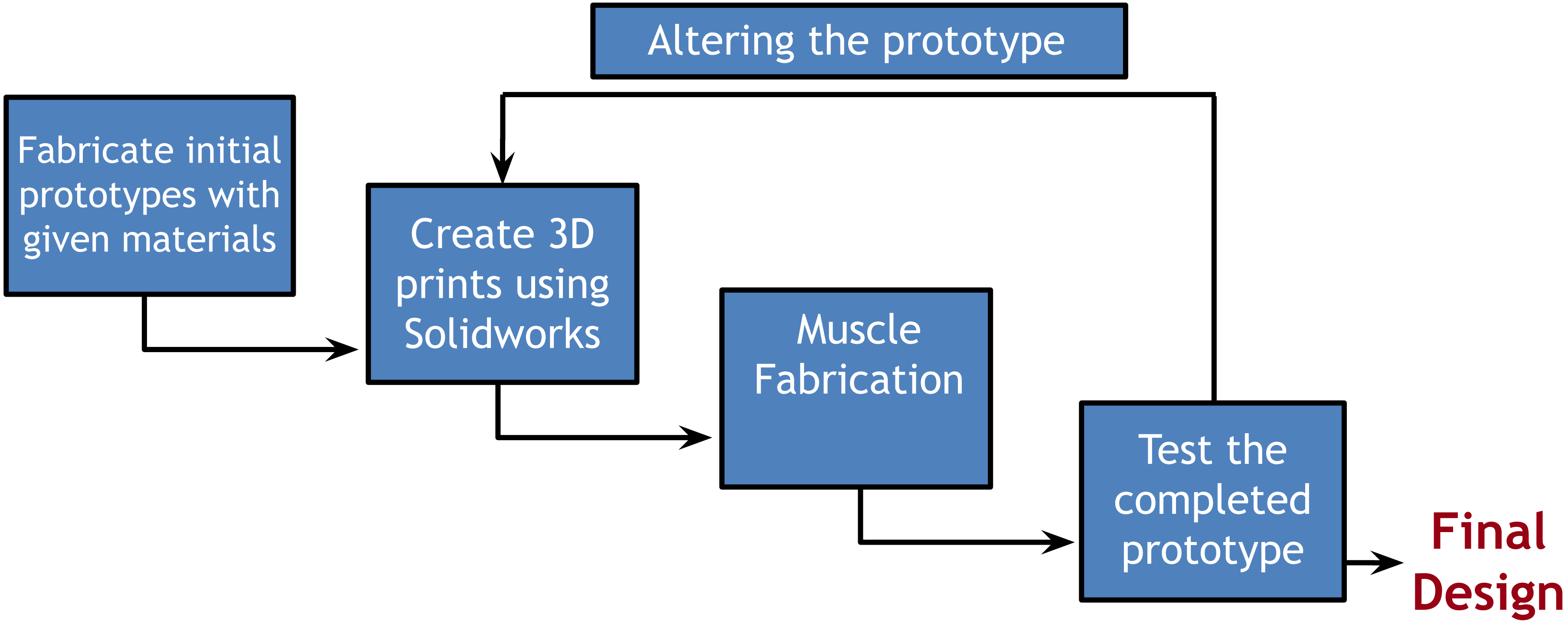
Table 2: The Design Matrix Ranking each attachment Design

Design Criteria	Design 1: Velcro 		Design 2: Magnets 		Design 3: Button Release Pins 	
Attachment Strength (20)	3/5	12	4/5	16	5/5	20
Ease of Fabrication (10)	3/5	6	4/5	8	3/5	6
Durability (20)	2/5	8	5/5	20	5/5	20
Ease of Use (15)	3/5	9	5/5	15	4/5	12
Appearance (15)	3/5	9	4/5	12	2/5	6
Cost (10)	5/5	10	4/5	8	3/5	6
Safety (10)	5/5	10	3/5	6	5/5	10
Total (100)	64/100		85/100		80/100	

Materials + Testing

- Pick materials based on Design Matrix
  - Silicone muscles
  - Magnet attachments
  - Tough PLA for bones (STL files available online)
- Test mechanical properties of muscles
  - Want to be as close to real muscles as possible
- Test magnet attachments to find the best magnet strength

Future Plans



What we’ve learned

- Rule out what doesn’t work first
- Client questions should continue throughout process
- Team communication and planning is key

Acknowledgments

Thank you!

Dr. Christa Wille
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Dr. John Puccinelli

References

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Questions and Comments?