Advisor: Dr. William Murphy
Clients: Dr. McLean Gunderson

DEPARTMENT OF
Biomedical Engineering
UNIVERSITY OF WISCONSIN–MADISON

3D Printed Anatomy Models for Vet Students

Zach Spears (Co-Leader), Lauren Fitzsimmons (Co-Leader), Cora Williams (Communicator), Molly Paras (BSAC), Emily Hutsell (BWIG), and Maggie LaRose (BPAG)

Team Members

From left to right:

Cora Williams (Communicator)
Maggie LaRose (BPAG)
Molly Paras (BSAC)
Lauren Fitzsimmons (Co-Leader)
Zach Spears (Co-Leader)
Emily Hutsell (BWIG)

Advised by Dr. Bill Murphy
Client Dr. McLean Gunderson

Overview

I. Problem Statement/Background
II. Client Information/Requirements
III. Product Design Specifications
IV. Design Options/Design Matrices
V. Final Design and Future Work
VI. Acknowledgements/References

Problem Statement

- First year veterinary students learn anatomy of canines
- Cadavers pose ethical, safety, and monetary concerns [1]
- 3D printing as a viable alternative
  - Cheaper, safer, more durable [2]
- 3D printed model of a right canine hindlimb
  - 3D printed bones
  - Accurate muscle depiction and insertion
  - Realistic muscle flexion and extension

Background

- First year veterinary students benefit from hands-on learning
- 3D animal models for teaching demonstrations and experimental processes
- Many models lack important anatomical characteristics:
  - Joints and ability for movement
  - Accurate muscle insertions and origins
- Cost
  - $2500 for the one pictured

Figure 1. Canine Bone Model [1]

Competing Designs

Figure 2. Axis Scientific Canine Hindlimb with Foot [2]

Figure 3. Anatomy Lab Domestic Canine (*Canis lupus familiaris*) Anatomy Model [3]

Figure 4. Dr. McLean Gunderson's Preliminary Model

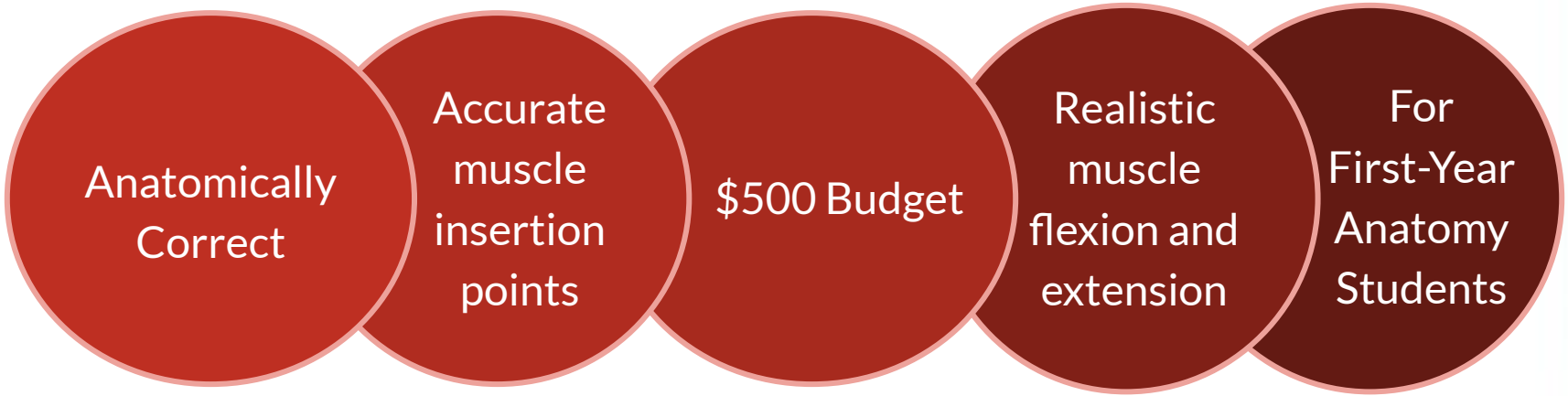
Client Information

Figure 5. Dr. McLean Gunderson [4]

- Dr. McLean Gunderson
- Researcher and Professor
  - Small and Large Animal Anatomy
- Previously:
  - Senior Instructional Specialist for the Department of Surgical Sciences
  - Veterinarian
- Passion for innovation
  - 3D teaching models

Emily Hutsell

Client Requirements

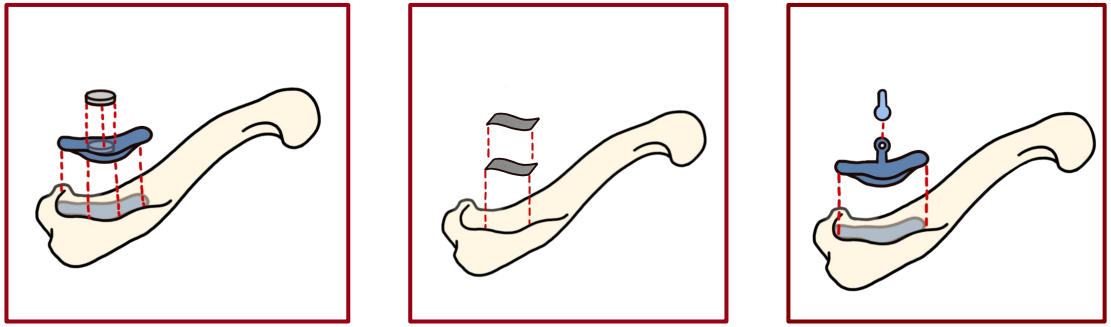


Molly Paras

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

Design Matrix 1: Muscle Attachment Mechanisms



1. 2. 3.

Figure 6. Three Muscle Attachment Mechanisms Design Options

Design 1: Magnets

- 3D printed piece in the shape of actual muscle attachments
  - Magnets in bone and attachment piece

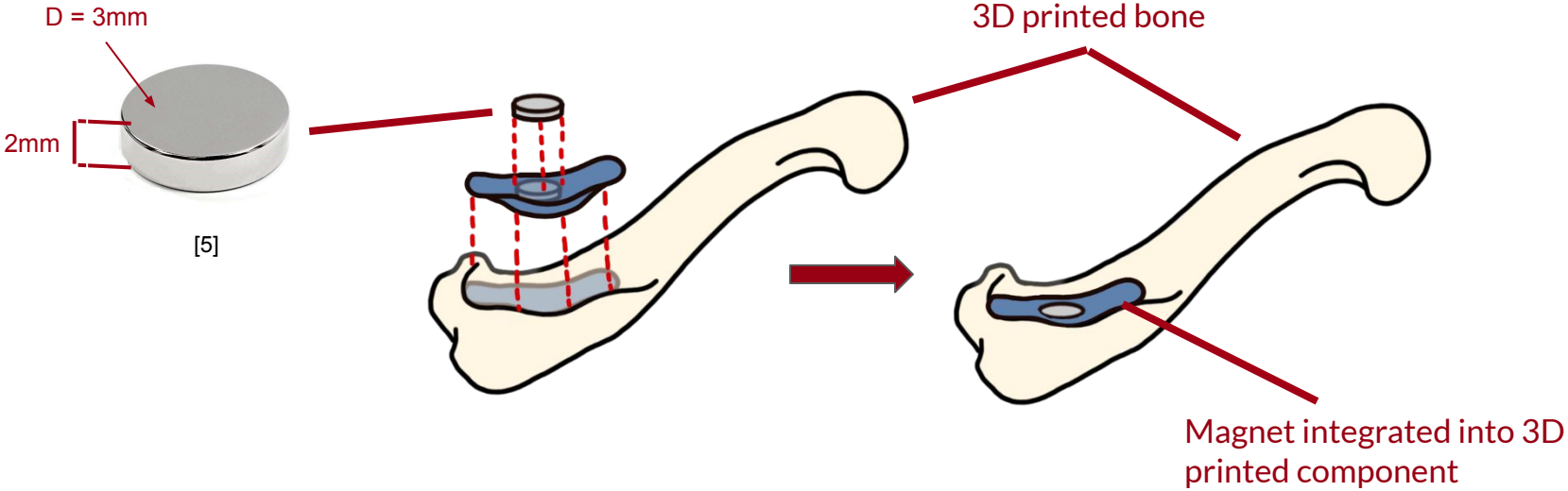


Figure 7. Neodymium Magnet Attachment Mechanism

Design 2: Velcro

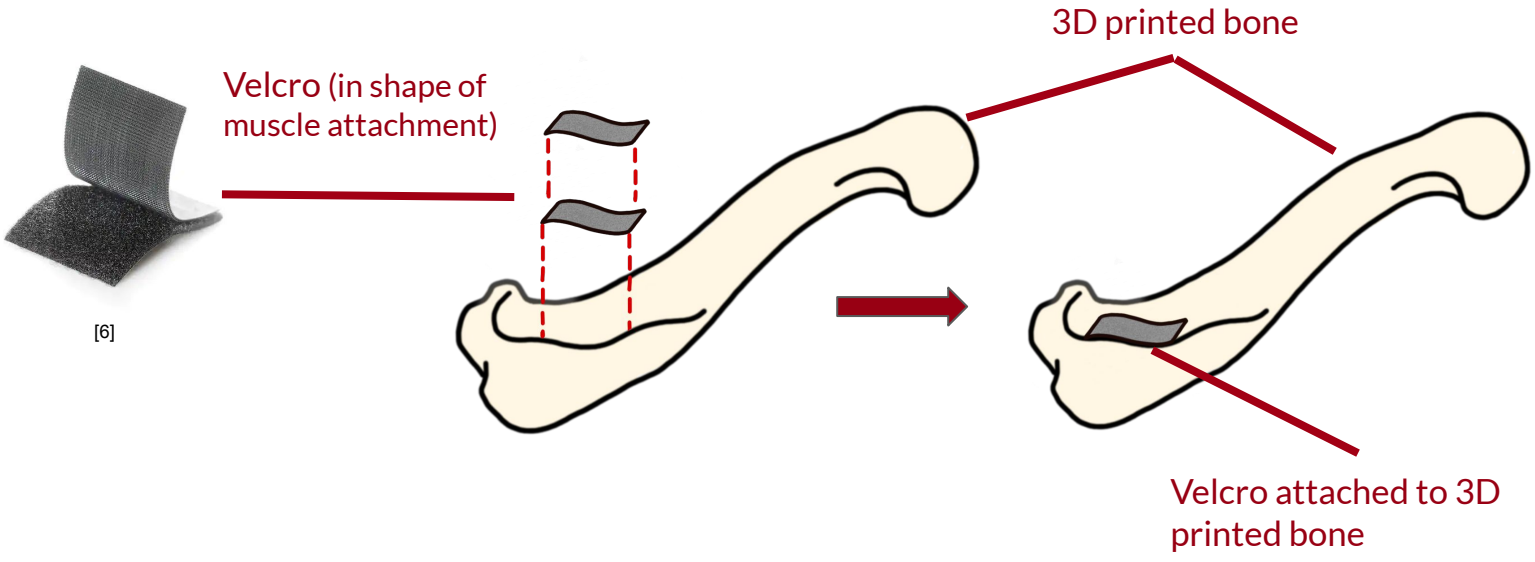


Figure 8. Velcro Strip Attachment Mechanism

Design 3: Hooks

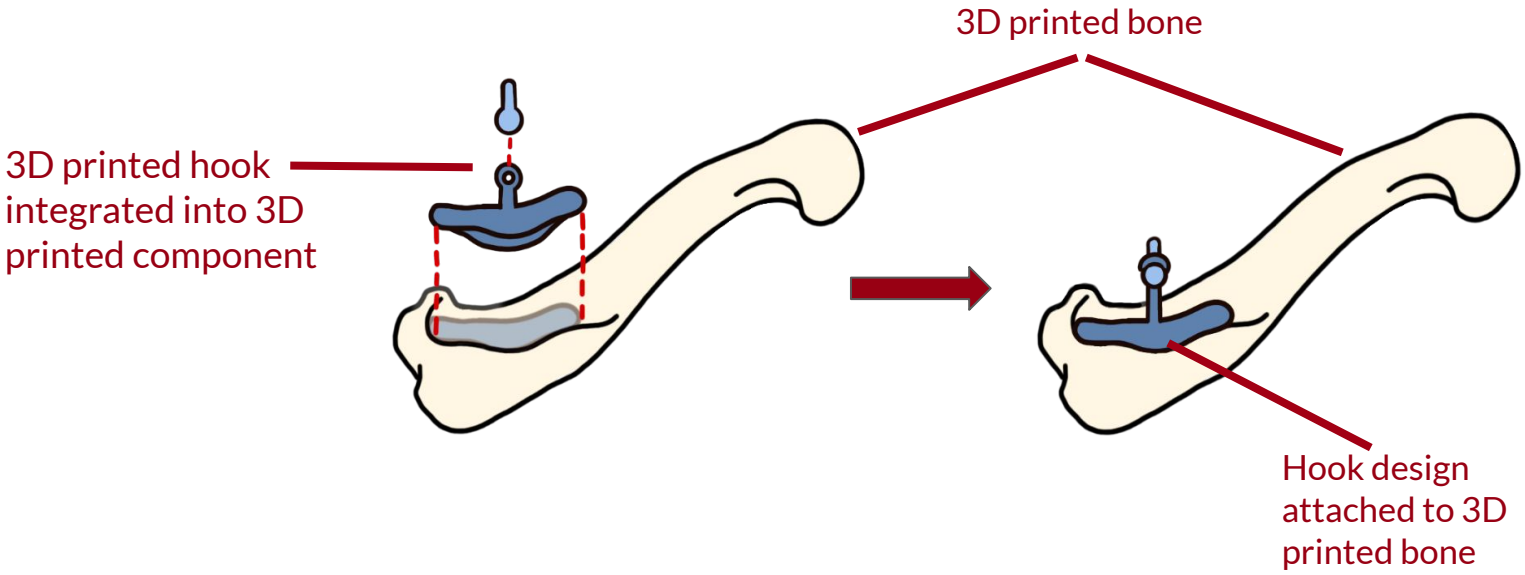


Figure 9. Hook Attachment Mechanism

Design Matrix 1 Criteria

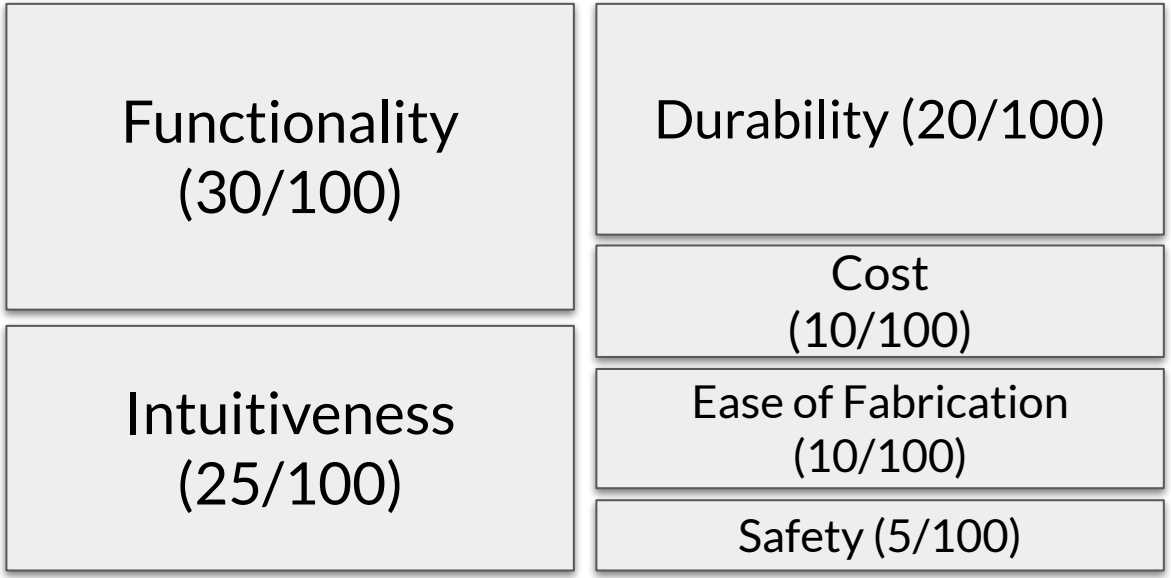
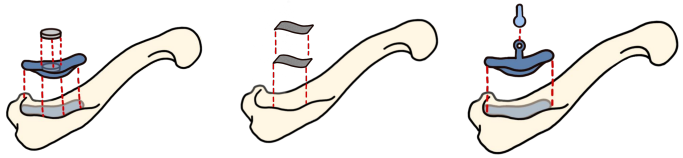


Figure 10. Design Matrix 1 Criteria

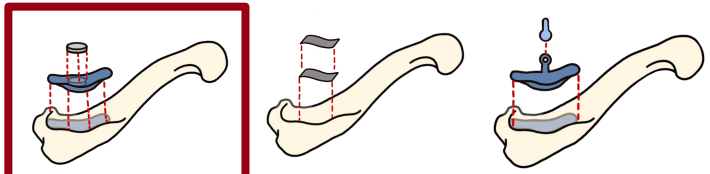
Design Matrix 1



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	

Figure 11. Design Matrix

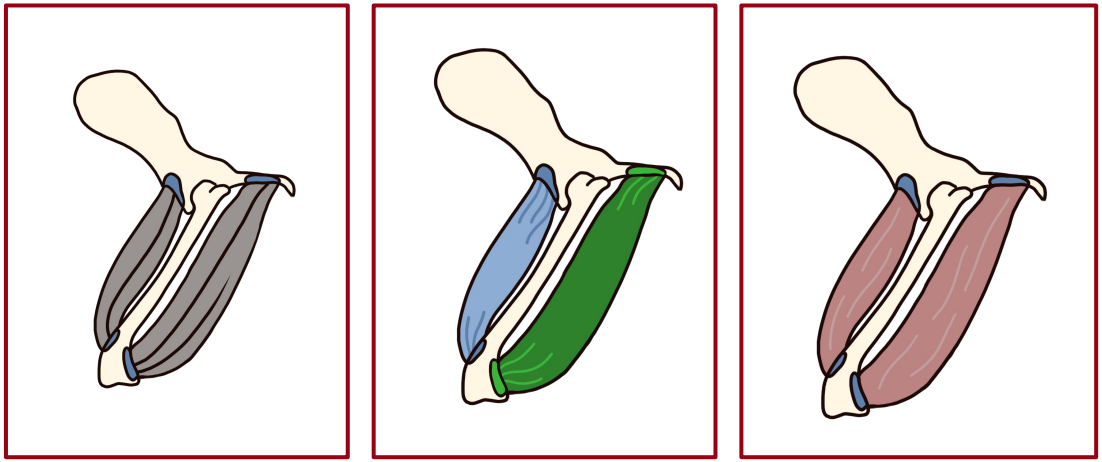
Design Matrix 1



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	

Figure 12. Design Matrix

Design Matrix 2: Muscle Materials



1. 2. 3.

Figure 13. Three Muscle Material Design Options

Design 1: Latex

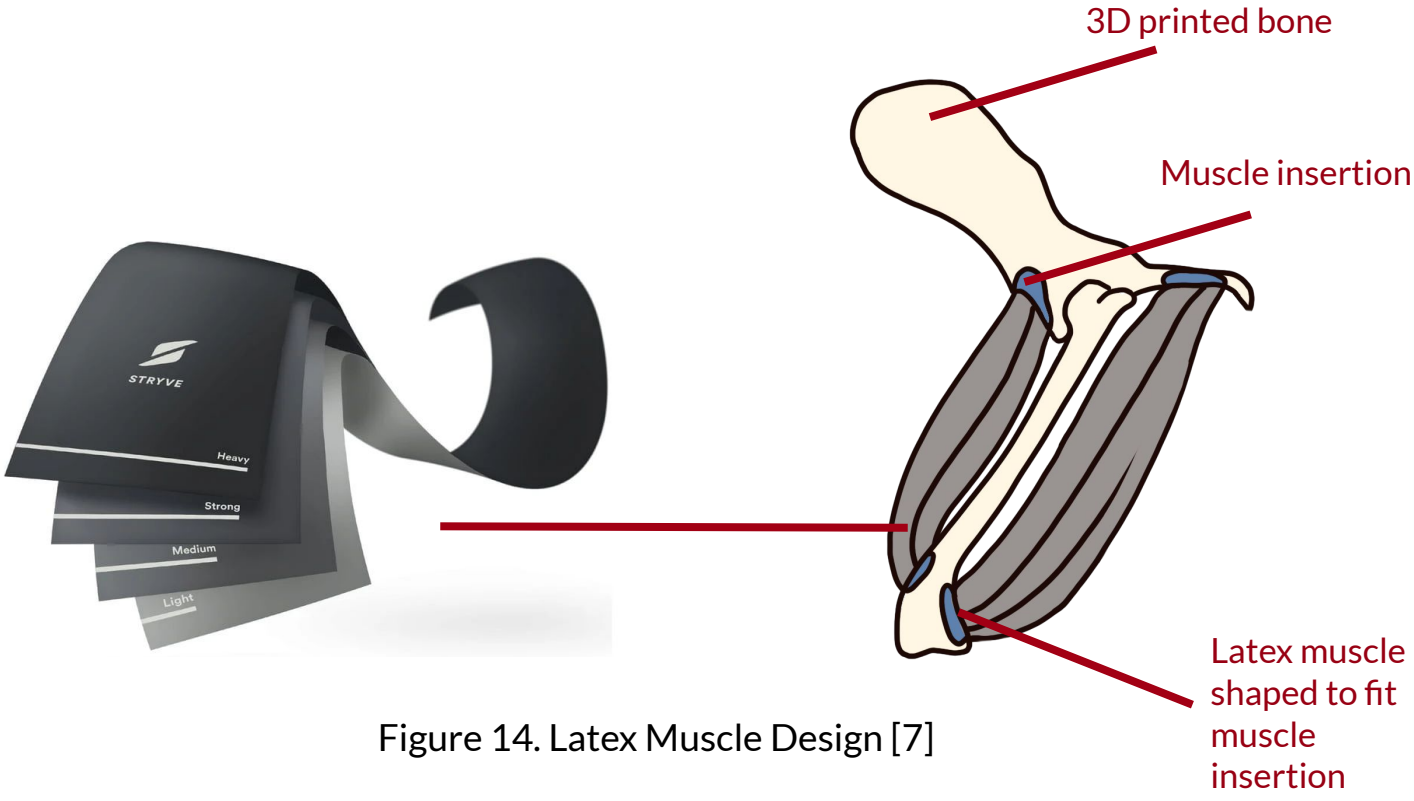


Figure 14. Latex Muscle Design [7]

Design 2: Fabric (Nylon/ Spandex)

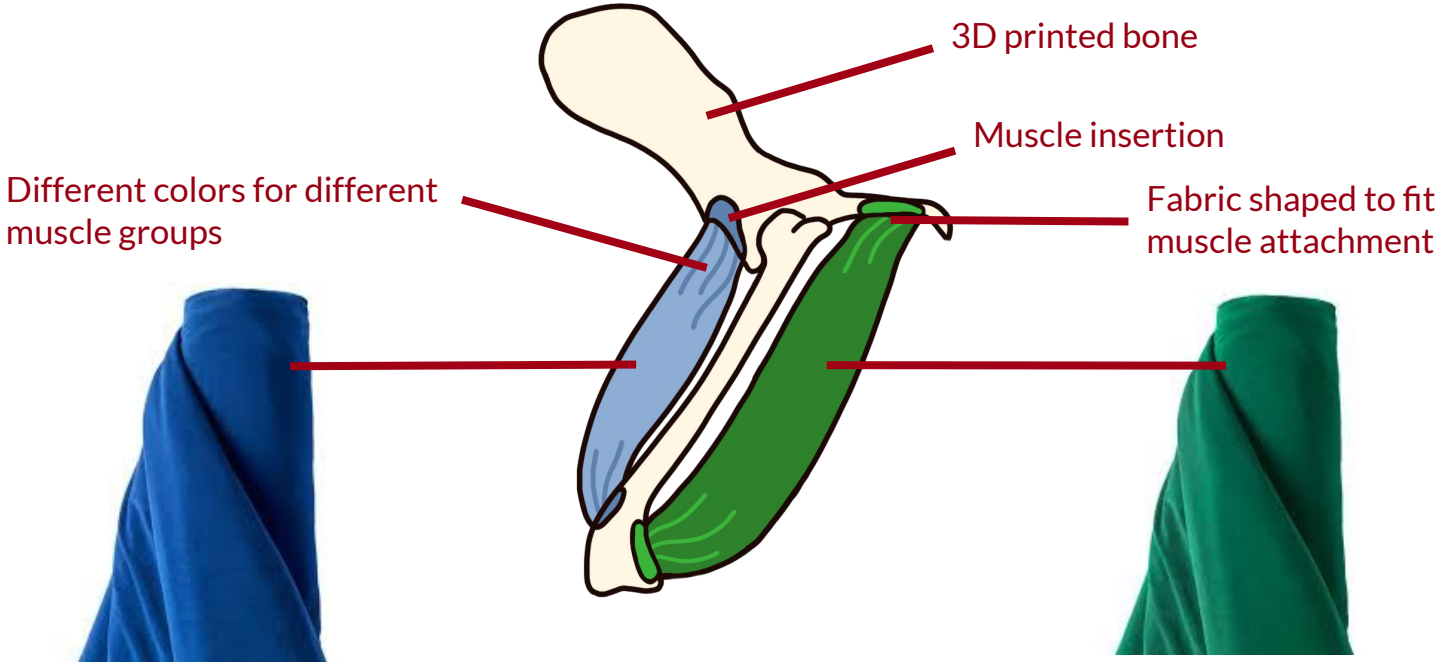
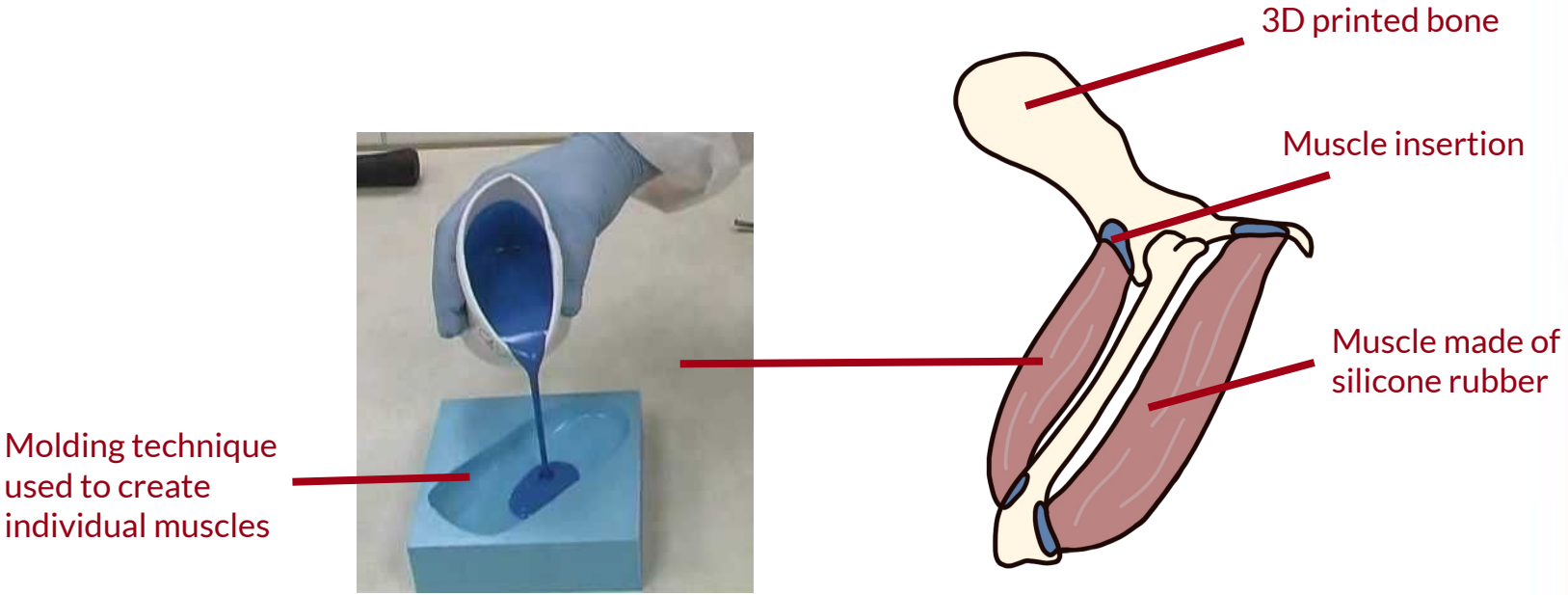


Figure 15. Fabric Muscle Design [8,9]

Design 3: Silicone Rubber (Ecoflex)

- Pour silicone rubber and cure in individual muscle molds



[10] Figure 16. Silicone Rubber Muscle Design

Design Matrix 2 Criteria

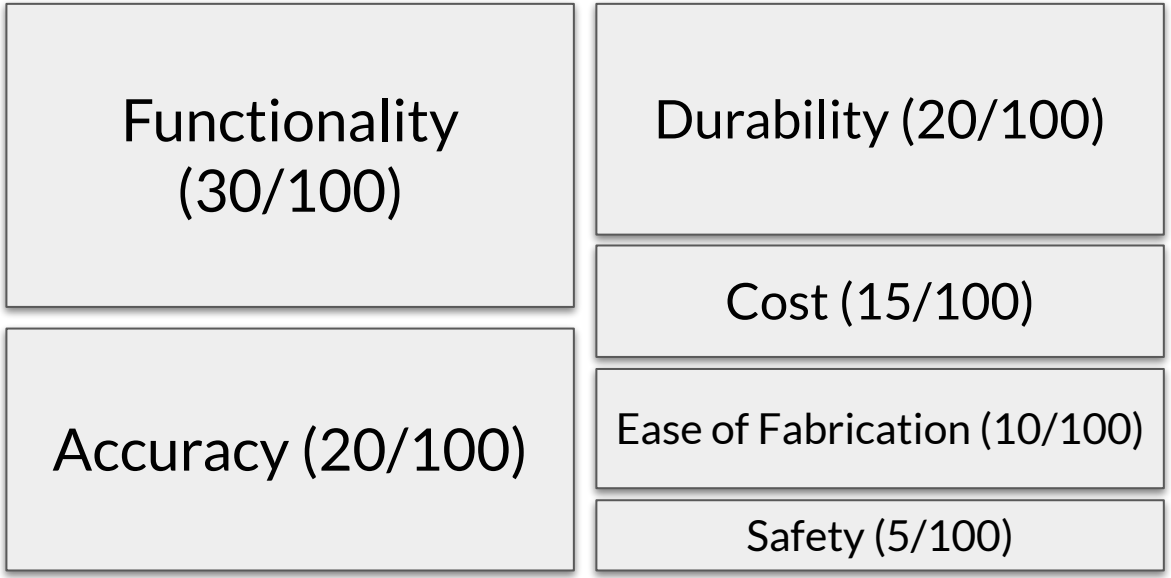
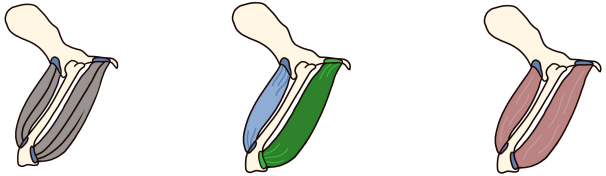


Figure 17. Design Matrix Criteria

Maggie LaRose

Design Matrix 2

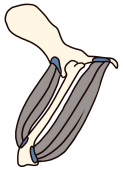
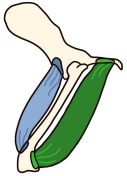
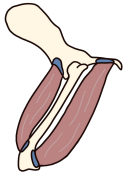


Design		Latex Band		Fabric (Nylon/ Spandex)		Silicone Rubber (Ecoflex)	
Criteria	**Weight**						
Functionality	**30**	3/5	18	4/5	24	2/5	12
Accuracy	**20**	2/5	8	5/5	20	4/5	16
Durability	**20**	4/5	16	5/5	20	4/5	16
Cost	**15**	5/5	15	4/5	12	2/5	6
Ease of Fabrication	**10**	4/5	8	3/5	6	2/5	4
Safety	**5**	4/5	4	2/5	2	5/5	5
Total	**100.0**	69/100		84/100		59/100	

Figure 18. Design Matrix

Maggie LaRose

Design Matrix 2

Design		Latex Band		Fabric (ex. Spandex)		Silicone Rubber (Ecoflex)	
Criteria	Weight						
Functionality	**30**	3/5	18	4/5	24	2/5	12
Accuracy	**20**	2/5	8	5/5	20	4/5	16
Durability	**20**	4/5	16	5/5	20	4/5	16
Cost	**15**	5/5	15	4/5	12	2/5	6
Ease of Fabrication	**10**	4/5	8	3/5	6	2/5	4
Safety	**5**	4/5	4	2/5	2	5/5	5
Total	**100.0**	69/100		84/100		59/100	

Figure 19. Design Matrix

Final Design: Magnet Integrated Fabric Muscle 3D Model

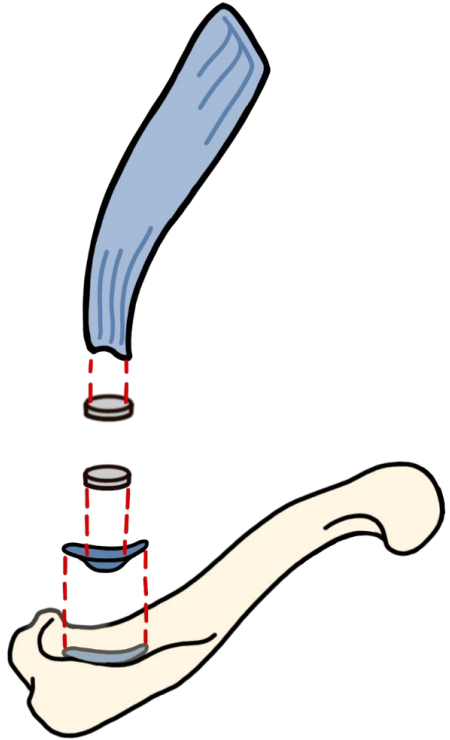


Figure 20. Final Design: Magnet Integrated Fabric Muscle 3D Model

Final Design: Magnet Integrated Fabric Muscle 3D Model

Muscle composed of spandex fabric and sewn according to pre-designed, muscle-specific patterns

Outer neodymium magnet sewn into muscle

Inner neodymium magnet

Inner 3D printed connection

3D printed bone insertion

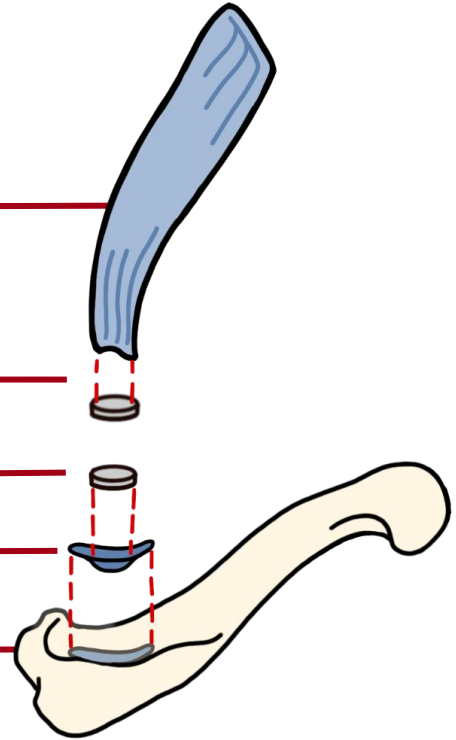


Figure 21. Final Design: Magnet Integrated Fabric Muscle 3D Model

Future Work

Phase 1:	3D scan and print bones
Phase 2:	3D print muscle attachment components
Phase 3:	Design, sew, and fabricate spandex muscle model
Phase 4:	Prototype evaluation and testing

Acknowledgements

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Dr. John Puccinelli & the entire BME Department

DEPARTMENT OF

Biomedical Engineering

UNIVERSITY OF WISCONSIN–MADISON

Questions

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