



DEPARTMENT OF
Biomedical Engineering
UNIVERSITY OF WISCONSIN-MADISON

Elbow Enthusiasts:
Functional Model for Reduction of Pediatric Radial Head Subluxation
October 2, 2026

Team Members

Team Members

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Co-Team Leader & BSAC: [Madeline Kaltman](#)

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Figure 1: Team photo of Functional Model for Reduction Pediatric Radial Head Subluxation



Overview

- Client Description
- Background Material
- Competing Designs
- Product Design Specifications
- Designs
- Design Matrix
- Future Work
- Questions and Challenges



Client Description

- **Client:**

- Carey Wagoner, DO, MHPE
- Pediatric Orthopedic Surgeon
- Assistant Professor (Clinical Health Sciences)

- **Problem Statement:**

- Nursemaid's elbow is common in young children.
- Providers need a safe way to practice reduction techniques.
- Current training models do not realistically simulate pediatric elbow reduction.
- A realistic, reusable model could improve hands on training.



Figure 2: Dr. Carey Wagoner



Background Material



Background Material

- Anatomy
 - Common in ages 1 - 4
 - Caused by being picked up by the hand or wrist
 - Radial head to partially slips out of its normal position relative to the annular ligament [1]
- Supination/Flexion vs Hyperpronation
 - 2 ways to reduce subluxation
 - Hyperpronation is more successful and commonly attempted first [2]
 - Currently no way to teach this

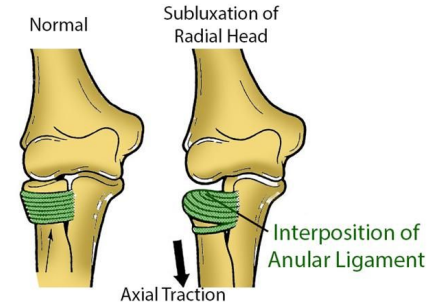


Figure 3: Radial Head Subluxation Diagram [3]

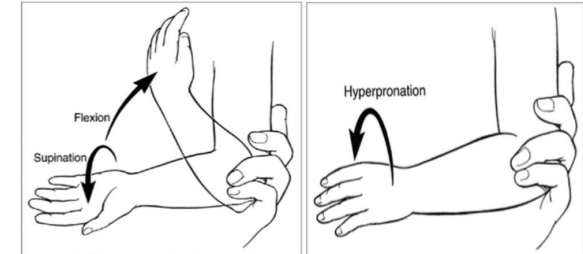


Figure 4: Reduction Techniques [4]



Competing Designs

- The Michigan Elbow
 - Magnetic internal mechanism
 - Low physician ratings for accuracy and feel [5]
 - High ratings for training value
- University of South Florida Elbow Patent
 - 2 magnet mechanism, one repelling, one attracting
 - Built on a stand
 - Fully mobile joints
 - Accurate to both reduction techniques [6]

Speaker: Addie

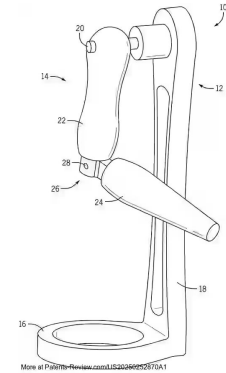


Figure 5: USF Full Model [6]

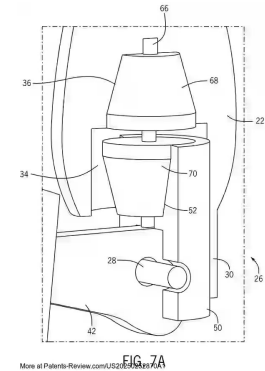


Figure 6: USF Internal Mechanism [6]



Product Design Specifications



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Product Design Specifications

Specifications from the Client:

- **Accuracy and Reliability:**
 - The model should allow for 140° of flexion, 0° to - 10° of hyperextension, 85° for forearm supination, and 60° to 70° for pronation [7]
 - Reduction feedback should occur consistently at the appropriate position
- **Feedback :**
 - “Click” sensation during successful reduction
 - Radial head region to be palpated
 - Easy to transport and store
- **Cost**
 - Project/design budget target: $\leq$ \$300 for development and final prototype.
- **Ergonomics**
 - Represent a 1 to 4-year-old toddler’s arm
 - Extend from the bicep through the wrist
 - Include humerus, radius, and ulna
- **Size and Weight**
 - Arm length should be between 13.8 and 14.11cm, forearm length 12.41, arm circumference between 15.59 and 15.64 cm, and forearm circumference between 15.04 and 15.05 cm [8]
 - No more than 3 pounds.



Designs



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Design 1: Detent Arm

- Advantages:
 - Least moving parts
 - Most available fabrication materials
 - Low cost
- Disadvantages:
 - Resetting mechanism
 - One big piece of equipment

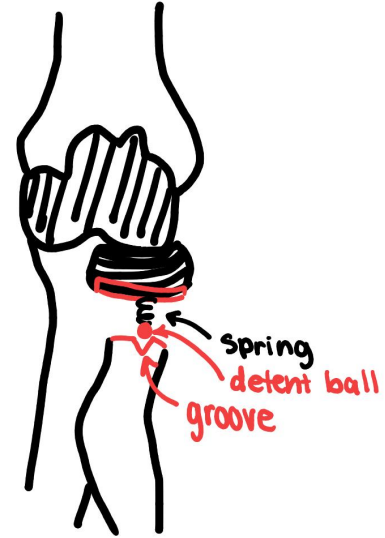


Figure 7: Detent Arm Design, specifically of the mechanism



Design 2: Wind-Up Arm

- Advantages:
 - High reusability
 - High portability
- Disadvantages:
 - Low durability
 - Challenging to fabricate
 - Requires custom gears and a spring

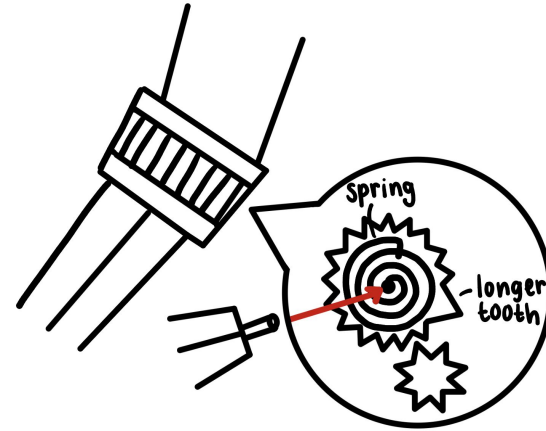


Figure 8: Wind-Up Arm Design



Design 3: Hybrid

- Advantages:
 - Highest accuracy
 - Most important criterion
 - Controlled and repeatable click and use of elastic to mimic ligaments
- Disadvantages:
 - More complex than Design 1 to fabricate
 - Lower durability

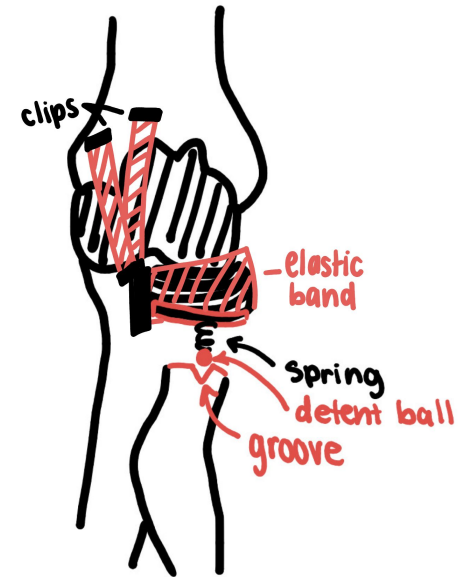


Figure 9: Hybrid Design



Design Matrix



Product Design Matrix

Speaker: Maddie

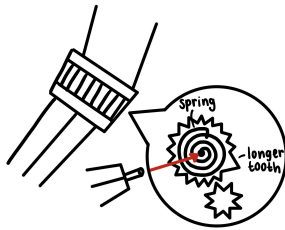
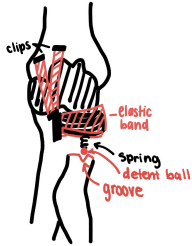
Criteria	Weight	Design 1: Detent Arm		Design 2: Wind-Up Arm		Design 3: Hybrid	
							
Accuracy	35	4/5	28	3/5	21	5/5	35
Reusability	25	4/5	20	5/5	25	4/5	20
Durability	15	4/5	12	2/5	6	3/5	9
Ease Of Fabrication	10	3/5	6	2/5	4	2/5	4
Cost	10	5/5	10	4/5	8	4/5	8
Portability	5	3/5	3	5/5	5	4/5	4
Total:	100	79		69		80	

Table 1: Product Design Matrix



Final Design

Speaker: Maddie

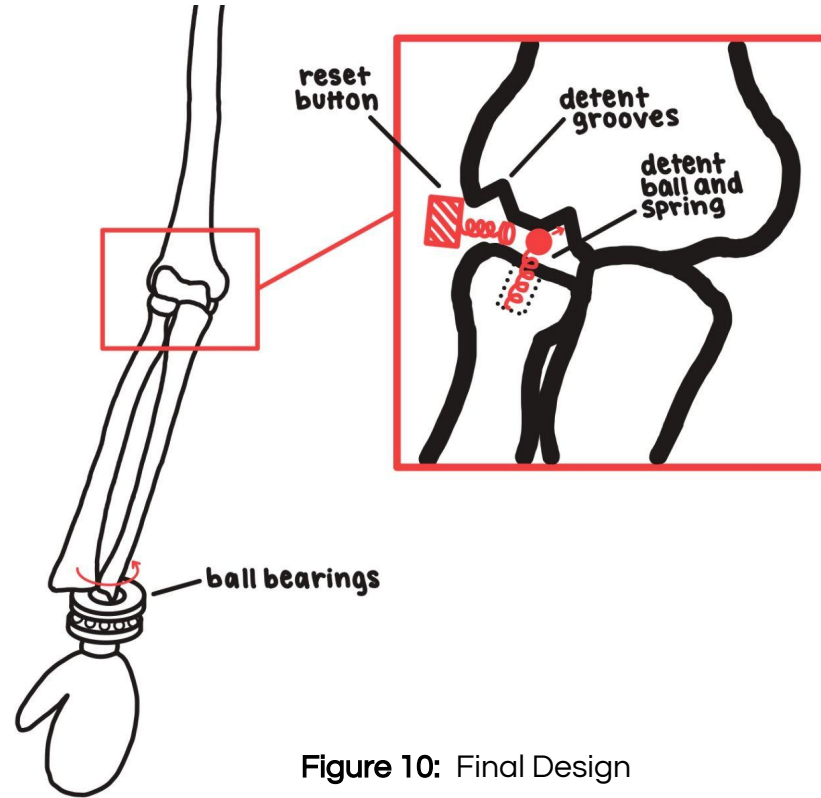


Figure 10: Final Design



Future Work



Challenges

- Accurately simulating the feel of the reduction technique
- Replicating the characteristic “click” at the end of the reduction
- Balancing accuracy with cost and simplicity
- Creating realistic resistance during forearm rotation



Future Work

October



November



December

- Select elbow design to move forward with
- Begin creating prototypes

- Testing the accuracy of the model

- Fabricate final design
- Final deliverables



Acknowledgements

Dr. Carey Wagoner

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References

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- [2] M. Krul, J. C. van der Wouden, L. W. A. van Suijlekom-Smit, and B. W. Koes, "Manipulative interventions for reducing pulled elbow in young children," The Cochrane database of systematic reviews, vol. 1, no. 1. England, p. CD007759, Jan. 18, 2012. doi: 10.1002/14651858.CD007759.pub3.
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- [4] A. Shanes and T. Khowong, "Radial Head Subluxation (Nursemaid's Elbow)," Kwak Talk, Feb. 6, 2025. <https://kwaktalk.org/ortho/2025/2/6/radial-head-subluxation-nursemaids-elbow>
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Questions?

