Model of Pediatric Supracondylar Humerus Fracture

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Abstract

The supracondylar humerus fracture is a common elbow fracture in children. There is a need to practice “Closed Reduction and Percutaneous Pinning,” which is the appropriate procedure for this fracture. The team created a teaching model for this complex procedure by modifying off-the-shelf models. The bone was fractured, holes for pinning were pre-drilled, the envelope was shaved down, and a patch was placed to obscure the holes. To test the model, the team received qualitative evaluations of the simulation from orthopedic residents. Overall the model is a good first prototype, but requires future work to make it more reusable and realistic.

Background and Motivation

Background

- In children the supracondylar area is predisposed to fracture [2]
- The common way to fix Type II & III fractures is the surgical method of closed reduction and percutaneous pinning (CRPP)[3]
- The goal is to minimize neurovascular damage

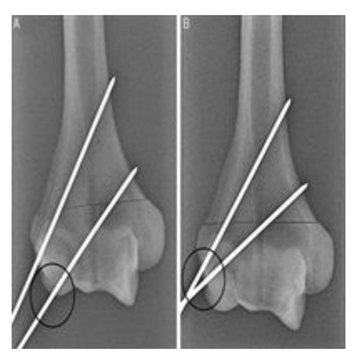

Figure 1: Correct (left) and incorrect (right) pin placement.

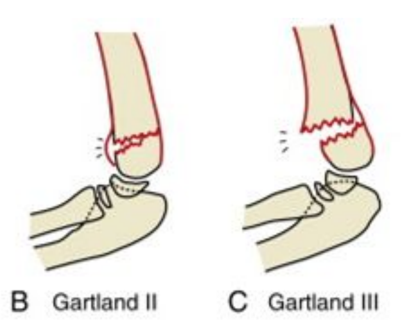

Figure 2: Types 2 and 3 of the Gartland classification for supracondylar humerus fractures.

Motivation

- Supracondylar humerus fractures represent 18% of all pediatric fractures [1]
- Residents need a realistic and reusable model to practice the CRPP surgery

Design Criteria

Criteria	Specification
Functionality	Anatomically accurate
Reusability	Maintains functionality up to 5 years
Appearance	Looks realistic
Ease of Fabrication	Methods are doable under time constraints
Materials	Easily accessible
Cost	Within $250 budget
Safety	Non-flamable

Fabrication & Development

The team decided the most efficient route was to modify an already existing humerus model

Materials

- SawBones pediatric humerus model: *Strong, radiopaque*
- Sawbones pediatric tissue envelope
- Band-aid*: *cheap, replaceable patching method to cover the drilling site*

**The team also considered using putty*

Figure 3: A picture of the sawbones model used.

Figure 4: A picture of the Tissue Envelope used.

Methods

- Fracturing the bone
  - Coping Saw was used for accurate ridge formation
- Drilling pilot holes for proper pin placement
- Cutting patch in the envelope for proper assessment of skill
- Shaving of material in envelope to give model more realistic feel

Figure 5: A bone model with practice cuts the team used for cut testing.

Final Design: Testing and Results

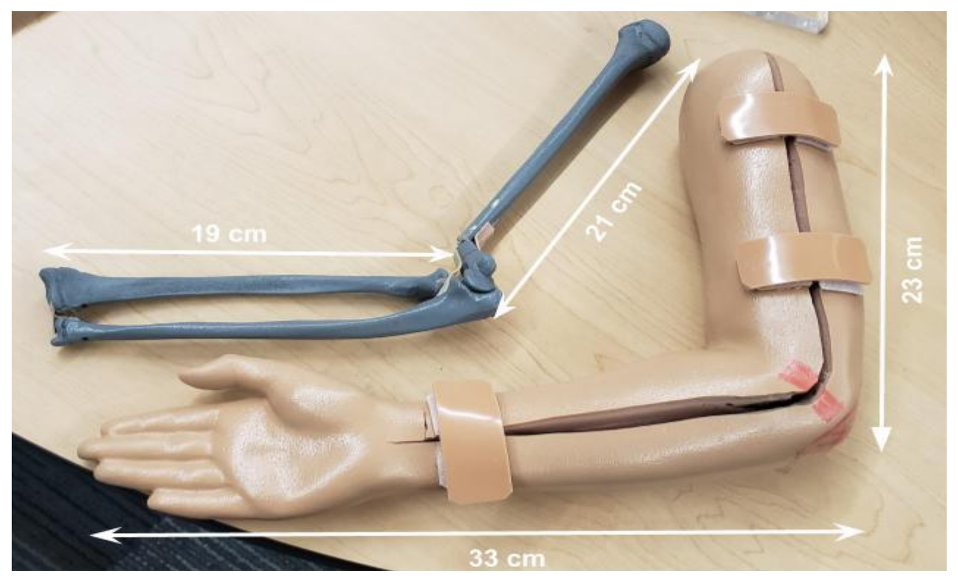

Figure 10: Final Design prototype.

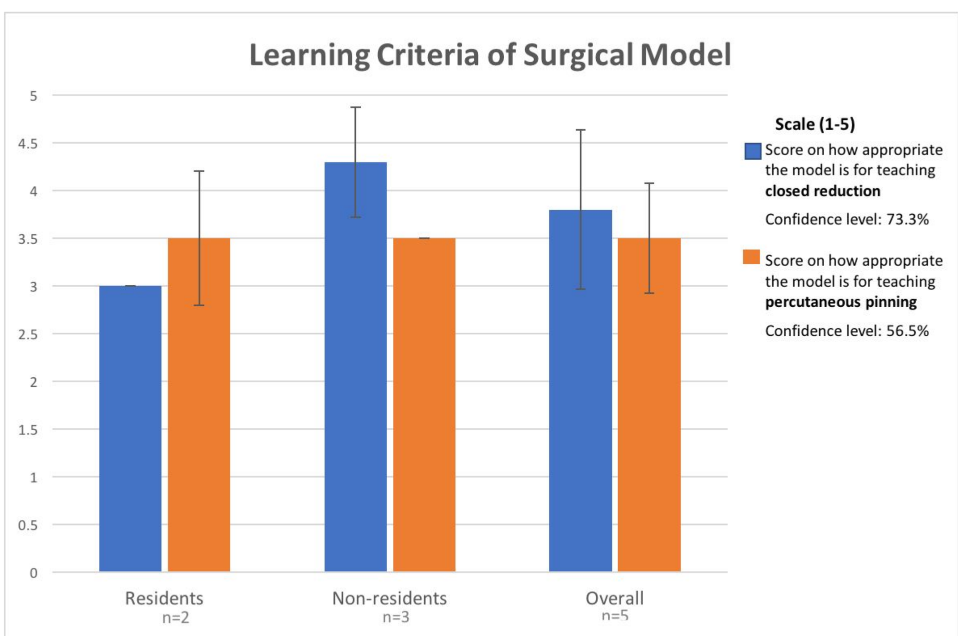

Figure 7. Learning criteria of Surgical Model. Comparison of mean scores for learning criteria of the closed reduction and perctunatenous pinning procedures for distinct population groups.

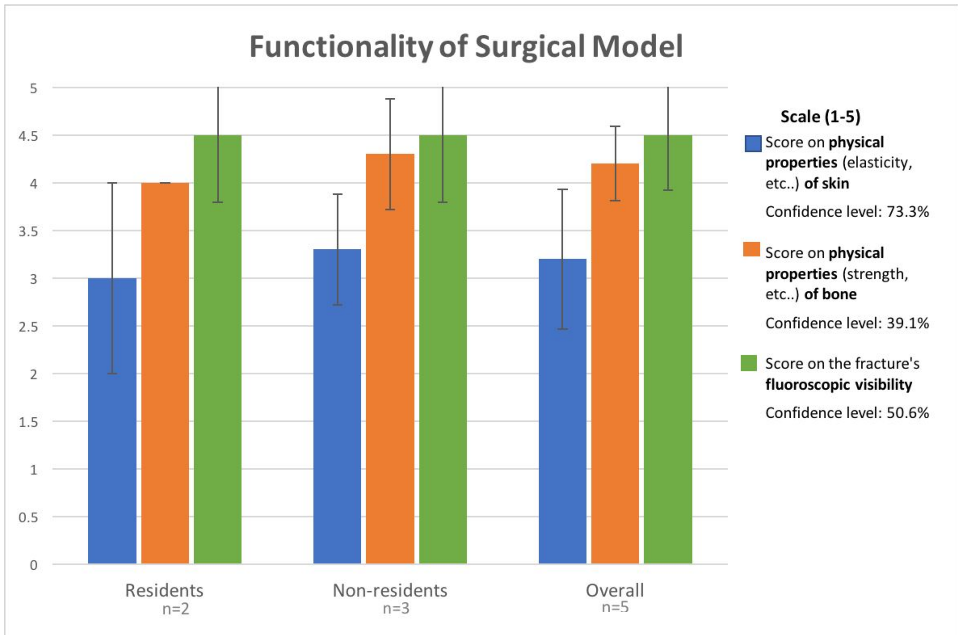

Figure 6. Functionality of Surgical Model. Comparison of mean scores for the functionality skin, bone, and fluoroscopy for distinct population groups.

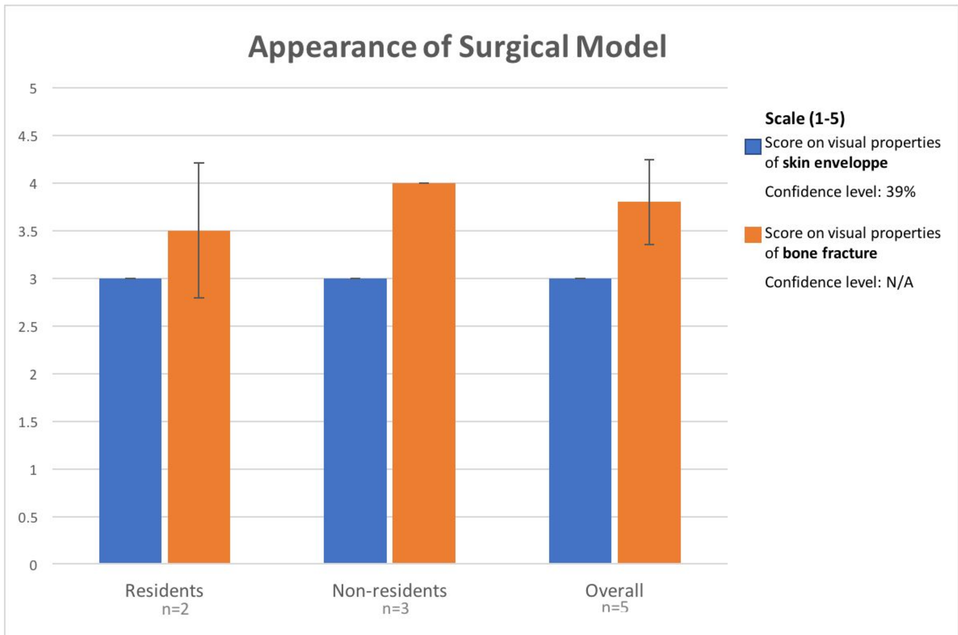

Figure 8. Appearance of Surgical Model. Comparison of mean scores for the appearance of skin and bone for distinct population groups.

Discussion

Model Achievements:

- Excellent fluoroscopic visibility
- Great functionality of bone
- Good teaching method for closed reduction
- Low-cost and reusable

Model Issues:

- Rubber periosteum was too weak
- Elbow joint was too stiff
- Foam was too thick
- Fracture location was too high

Design Evaluation:

- Senior medical staff were more generous in their scoring of the model
- The client is overall satisfied with this first prototype

Future Work

Tissue Envelope

- Utilize self healing material for patch site
- Increase flexibility of the elbow joint and add neurovascular anatomical details

Bone

- Add sensor in model to prevent damage to the bone
- Move fracture site proximal to the elbow

Design Process

- Increase sample size and duration of testing
- Consider 3D printing options

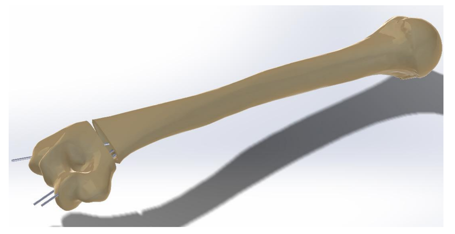

Figure 9. 3D CAD model of a pediatric supracondylar humerus fracture.

Acknowledgements

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References

- [1] Kim, T. and Sponseller, P. (2019). *Pediatric Supracondylar Humerus Fractures*. [online] Available at: https://www.jhandsurg.org/article/S0363-5023(14)00985-X/fulltext [Accessed 7 Oct. 2019].
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- [3] C. Vuillermin, C. May, and J. Kasser, “Closed Reduction and Percutaneous Pinning of Pediatric Supracondylar Humeral Fractures,” *Jbjs Essential Surgical Techniques*. [Online]. Available: https://insights.ovid.com/crossref?an=01709766-201808020-00002. [Accessed: 09-Oct-2019].