Pressure Monitoring During Cast Application for a Distal Radius Fracture

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Overview

- Introduction
  - Client
  - Problem Statement
  - Background
    - Current Methods and Models
- Pressure Sensor Selection
- Attachment Method Selection
- Future Work
- Acknowledgements & References

Client Description

- Dr. Matthew Halanski
  - Pediatric orthopedic surgeon at UW Hospital & Clinics
  - Research interest in safe immobilization and fracture reduction

Matthew Halanski, MD
http://www.thehartwellfoundation.com/2012/2012_Investigators.shtml

Problem Statement

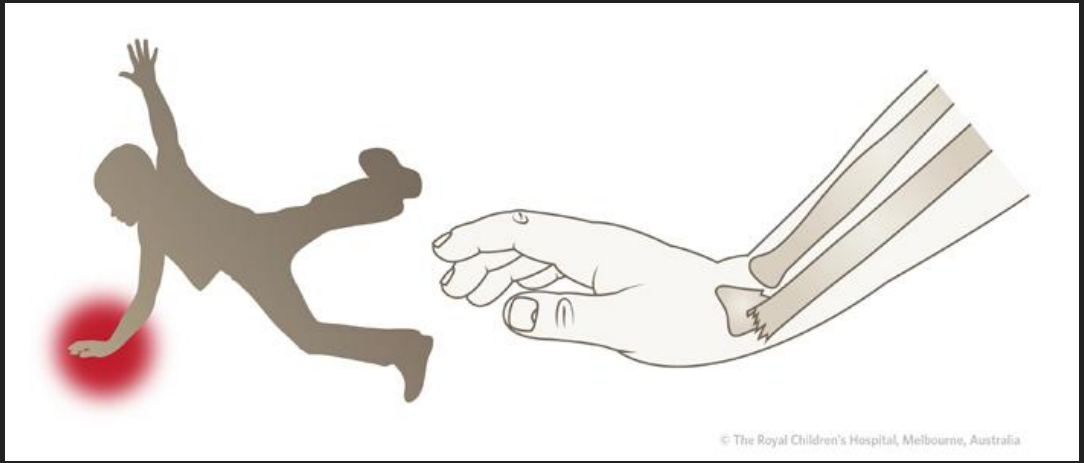
Casting is becoming a lost art in medicine, yet many children and adults need casts applied. While this appears to be a benign treatment, complications are known to exist in the placement and removal of these devices. Typically medical students and residents learn these techniques by trial and error. There is currently no method to sense pressures being applied as the bone is being set, or to sense the general pressure of the overall cast once applied.

Design Specifications

- Removable
- Ability to record pressure over time
- Real-time visible feedback of pressure change
- Sleek with limited protrusions
- Withstand casting procedures
- Expenses must be under $1,000

The Distal Radius Fracture

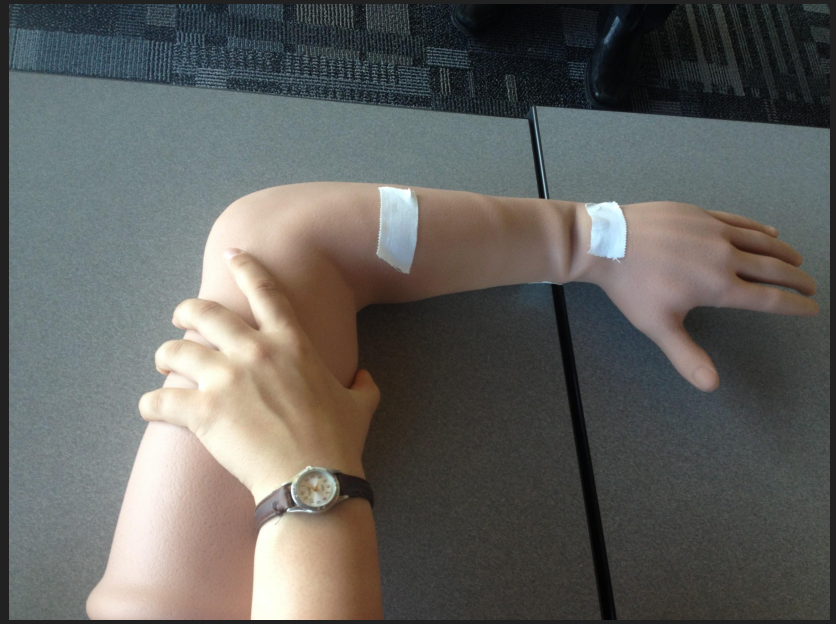
- Most commonly broken bone in the arm
- 40% of all pediatric fractures occur on the forearm [1]
- 75% of pediatric forearm fractures are distal [2]



www.orthospinenews.com

Current Teaching Methods

- Trial and error
- Shadowing
- Sawbones Arm Model



Common Injuries

- Cast saw burns
- Skin abrasions and infection
- Improper bone healing

Cast saw burns
(courtesy of Dr. Halanski)

Past BME Design Work

- Spring 2013: BME 402
  - Forearm fracture simulator
    - applied force, temperature at skin surface

- Spring 2014: BME 402
  - pediatric fracture model
    - temperature, surface pressure, bone alignment

Previous Fracture Model
BME 402 Spring 2014

FlexiForce Sensors

- Piezoresistive
- No resistance change when flexed
- Up to 445N
- 21.59cm length
- 9.53mm sensing area

FlexiForce Sensor
www.tekscan.com

Conductive Thread

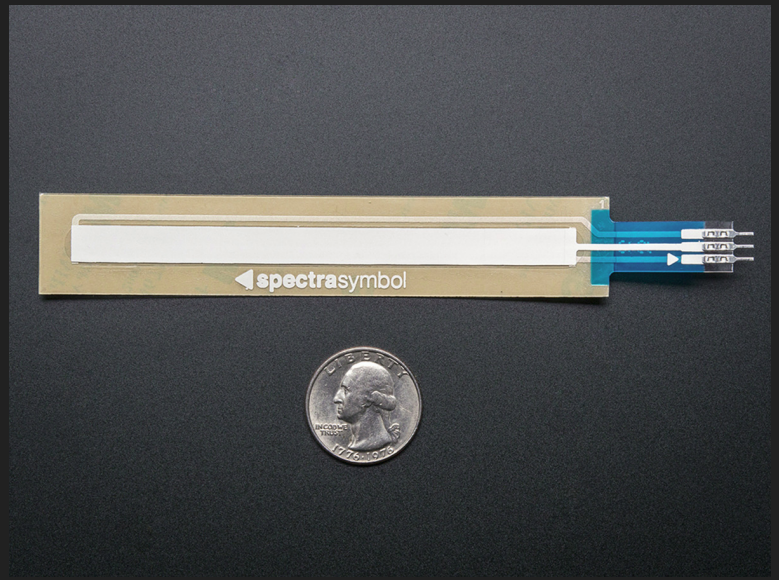
- Carries a current
- Come in various resistances
- Can be used to create a circuit

Sewn conductive thread circuit attached to LilyPad Arduino

https://jrockdigitalart.wordpress.com/

Softpot Membrane Potentiometer

- Resistance range of 100Ω-10000Ω
- 215.86mm
- 4,064mm^2 sensing area
- Adhesive backing



Softpot Membrane Potentiometer
www.adafruit.com

Pressure Sensor Design Matrix

Pressure Sensors	Flexiforce	Conductive Thread	SoftPot Membrane Potentiometer
Feel (25)	(4/5) 20	(3/5) 15	(4/5) 20
Feasibility (20)	(4/5) 16	(3/5) 12	(4/5) 16
Sensitivity (15)	(5/5) 15	(5/5) 15	(4/5) 10
Durability (10)	(4/5) 8	(4/5) 8	(4/5) 8
Safety (10)	(5/5) 10	(5/5) 10	(5/5) 10
Fit (10)	(4/5) 8	(5/5) 10	(3/5) 6
Accuracy (5)	(4/5) 4	(2/5) 2	(3/5) 3
Cost (5)	(3/5) 3	(5/5) 5	(4/5) 4
Total: 100	84/100	77/100	77/100

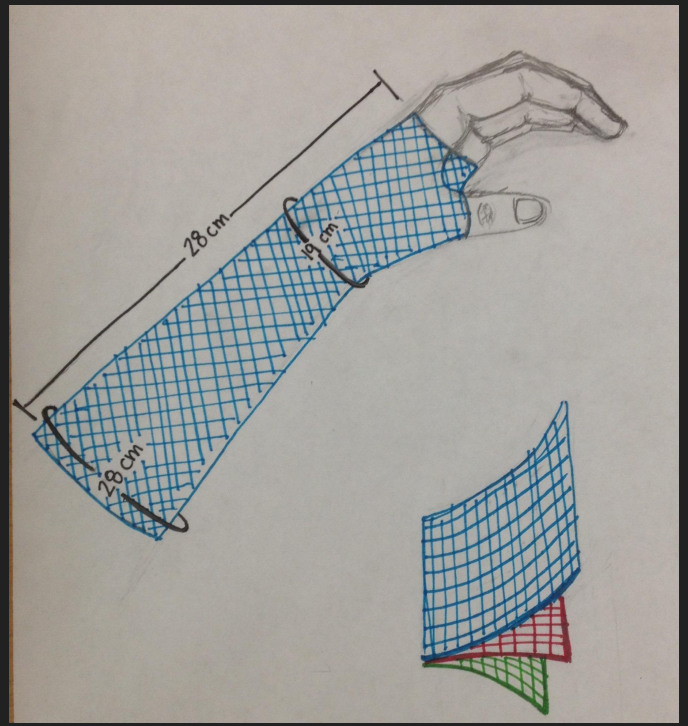
Compression Sleeve - Intact vs. Velcro

- Considerations
  - Fit
  - Ease of removability

Professional Edema Sleeve
www.pattersonmedical.com

Custom Sleeve - Intact vs Velcro

- Same considerations as compression style
- Customizable- fit and fabric
- More material variety
    - spandex, lycra blend
    - neoprene
    - piezoresistive fabric and conductive thread

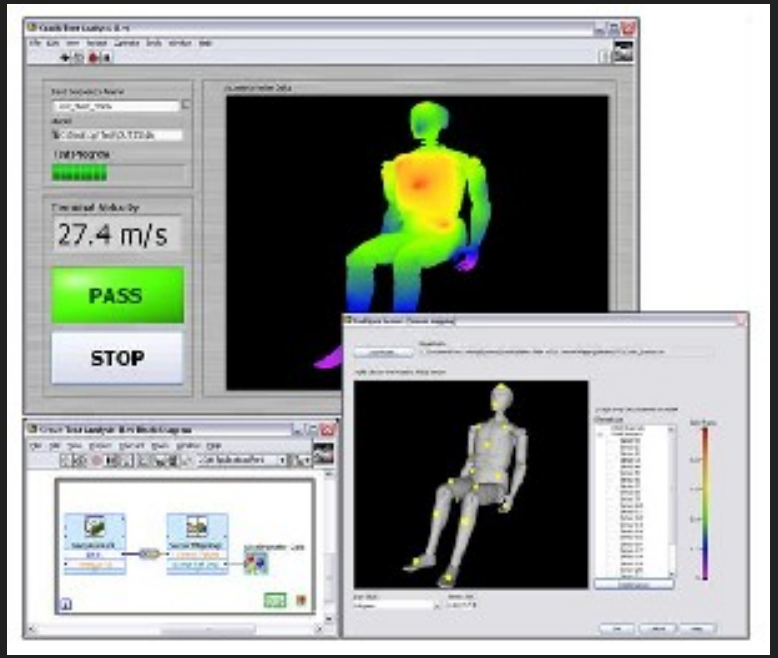


Method of Attachment Design Matrix

Method of attachment	Compression Sleeve	Compression Sleeve - Velcro	Complete Custom Sleeve	Custom Sleeve - Velcro
Functionality (25)	(2/5) 10	(4/5) 20	(3/5) 15	(4/5) 20
Bulkiness (20)	(5/5) 20	(4/5) 16	(4/5) 16	(4/5) 16
Removability (20)	(3/5) 12	(5/5) 20	(3/5)	(5/5) 20
Feasibility (15)	(5/5) 15	(4/5) 12	(2/5) 6	(3/5) 9
Durability (10)	(4/5) 8	(4/5) 8	(3/5) 6	(3/5) 6
Safety (5)	(5/5) 5	(5/5) 5	(5/5) 5	(5/5) 5
Cost (5)	(5/5) 5	(5/5) 5	(4/5) 4	(4/5) 4
Aesthetics (5)	(5/5) 5	(5/5) 5	(4/5) 4	(4/5) 4
Total: 100	80/100	91/100	68/100	84/100

LabVIEW Live Feedback

- 3D Sensor Mapping Express VI
- Import user-defined CAD model
- Assign sensors
- Map DAQ channel data directly onto model



LabVIEW 3D Sensor Mapping Express VI http://www.ni.com/white-paper/7335/en/#toc2

Future Work

- LabVIEW
- Circuit design
- Sleeve fabrication
    - Waterproofing

Acknowledgments

Client: Dr. Halanski

Advisor: Dr. Puccinelli

Questions?

References

[1] Biomed Central. (October, 2010 30). *Pattern of fractures across pediatric age groups: analysis of individual and lifestyle factors.* Retrieved from http://www.biomedcentral.com/1471-2458/10/656

[2] Wright, M. (July, 2010 16). *Forearm injuries and fractures.* Retrieved from http://patient.info/doctor/forearm-injuries-and-fractures