Development of an Upper Extremity Fracture Model

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Outline

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Casting & Instruction

- Cast immobilization has become a lost art
  - Casting overlooked by newer treatment options and surgical techniques
- Most young physicians learn casting techniques through trial and error
  - Patient at increased risk of injury
  - Often lack of follow-up with patient to know if any complication or loss of reduction has occurred [1]

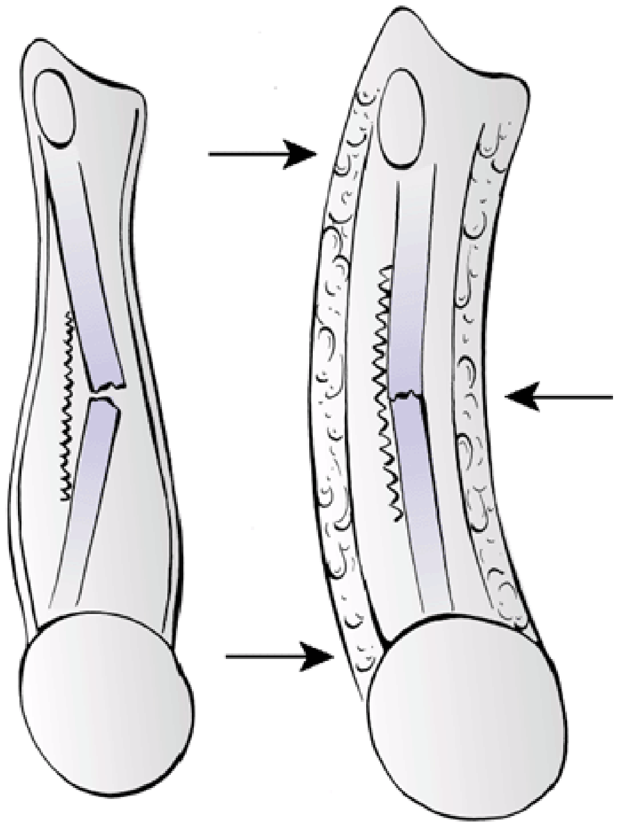
Occurrence of Pediatric Fractures

- 40% of fractures among all ages of children involve the forearm
- Greenstick fractures are the most common distal radial and ulnar fracture
  - Bone bends and only partially breaks [1]

Pictures courtesy of client [2].

Casting Process

- Assess the fracture via x-ray
- Determine the best treatment option
- If casting, use 3-point molding to reduce fracture
- Maintain pressure and apply casting material, commonly plaster or fiberglass [1]



Picture courtesy of client [2].

Casting Complications

- Casting assumed to be “safe” treatment
- #1 cause of litigation
  - ~35% claims paid avg. of $120,000 each
- Application: burns, irritation
  - Rigid tourniquet if too tight
  - Loss of reduction if too loose
- Removal: saw burns [1]

Picture courtesy of client [2].

Current Model

- PVC pipes
- Copper coating on simulated forearm
- Temperature loggers on cast saw blade
- Doesn’t monitor alignment, applied force, or temperature of skin surface

Picture courtesy of Hope Marshall [3].

Problem Statement

- Construct distal radial and ulnar fracture simulator that provides immediate feedback to the user and monitors:
  - Fracture reduction
  - Force applied during 3-point molding
  - Temperature of skin surface
- Motivation
  - Teach proper techniques of cast application, reduction, immobilization, and cast removal

Design Criteria

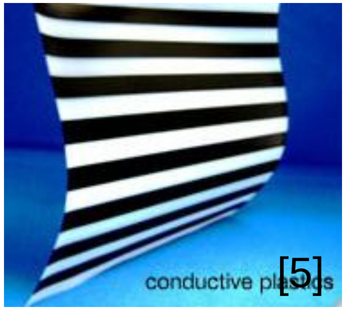
- 7” from elbow to wrist
- Reusable device
- Easy for one person to transport
- Measures and displays skin temperature
- Measures and displays pressures applied to the arm in real-time
- Clearly indicates successful fracture reduction

  -Angulation no more than 15°

  -Translation no more than 2mm

Design Matrix – Pressure Sensors

[4]



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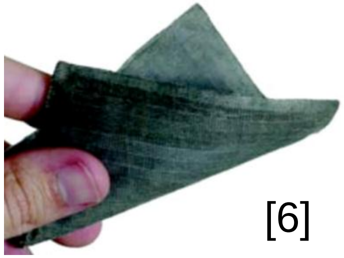
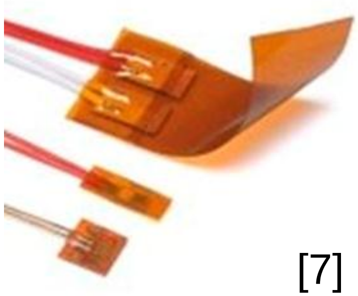


[6]

	Weight	TekScan (Individual Sensors)	Zebra Sensor (SensorTech)	Tactile Sensor (Pressure Profile)
Cost	20%	5	3	1
Compatibility	15%	1	4	4
Precision	30%	3	3	5
Resolution	25%	1	2	5
Ease of Use	10%	1	4	4
TOTAL:	100%	2.4	3	3.95

Design Matrix – Temperature Sensors



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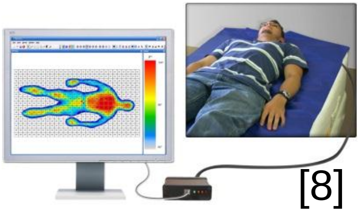

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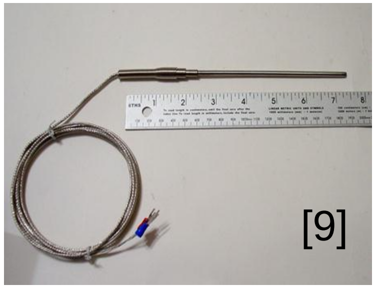
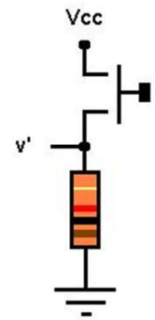


[9]

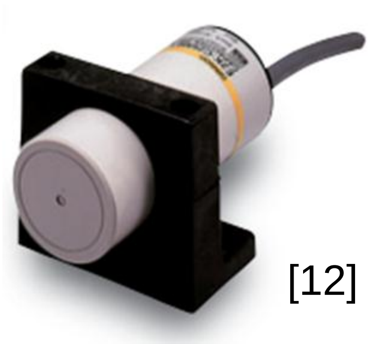
	Weight	Thermal Ribbon Thermistors	Temperature Mapping	Thermocouple
Cost	35%	3	1	5
Compatibility	10%	2	4	2
Precision	10%	4	4	3
Resolution	25%	3	5	3
Ease of Use	20%	2	4	2
TOTAL:	100%	2.8	3.2	3.4

Design Matrix – Alignment Sensors

[10]



[11]



[12]

	Weight	Optical Sensor	Complete Circuit/Button	Capacitive Sensor
Cost	15%	1	5	2
Compatibility	20%	3	5	3
Precision	30%	2	2	4
Ease of Use	35%	3	5	3
AVERAGE:	100%	2.40	4.10	3.15

Additional Elements

- Chain metal sleeve to protect sensors
- Skin – Low Molecular Weight PDMS
- Soft tissue – PlatSil Gel-10 (Polytek Development Corp., Easton, PA) or High Molecular Weight PDMS
- Bone – acrylic, PVC, or Hydroxyapatite

Final Design

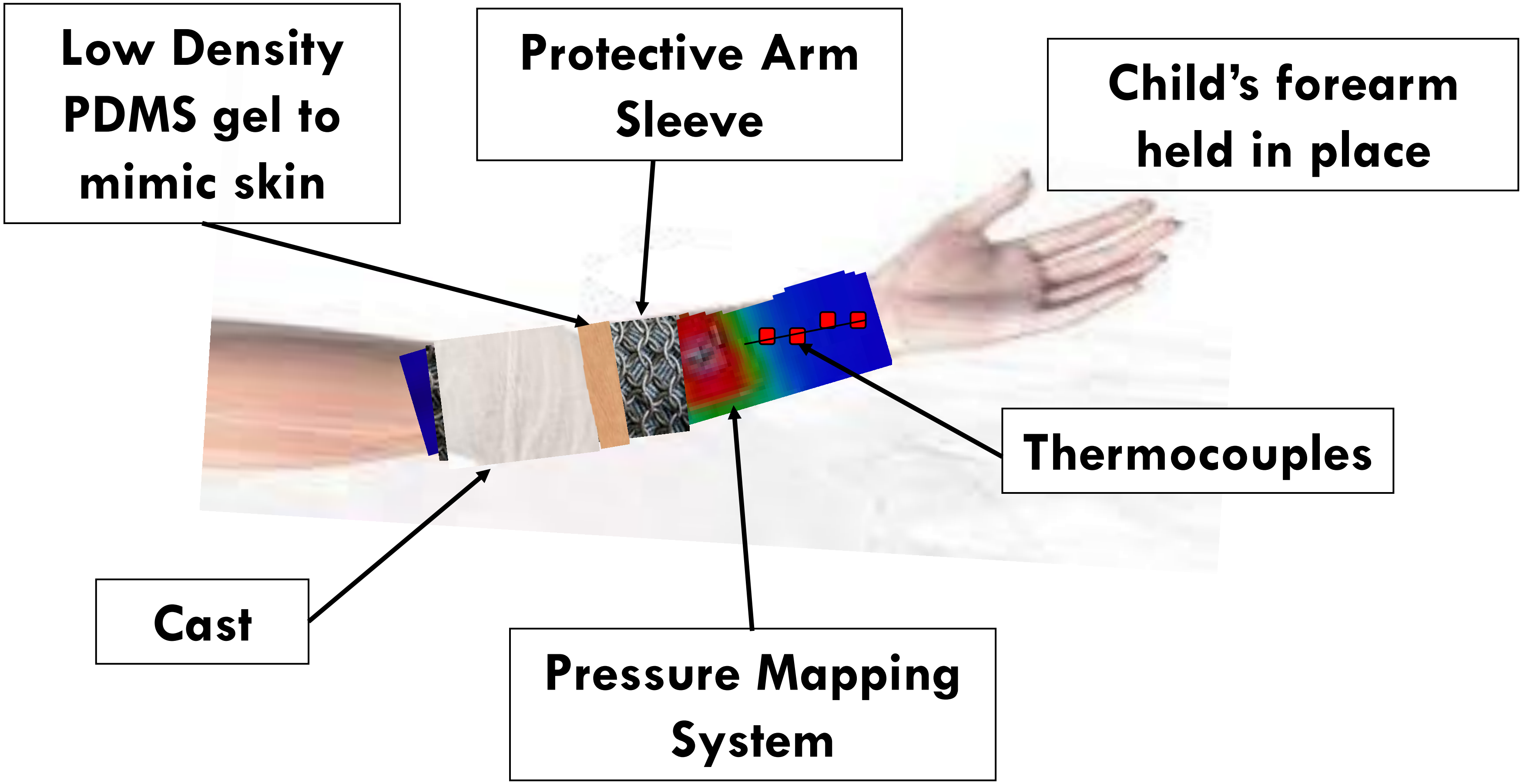


Diagram courtesy of Hope Marshall [3].

Final Design (cont.)

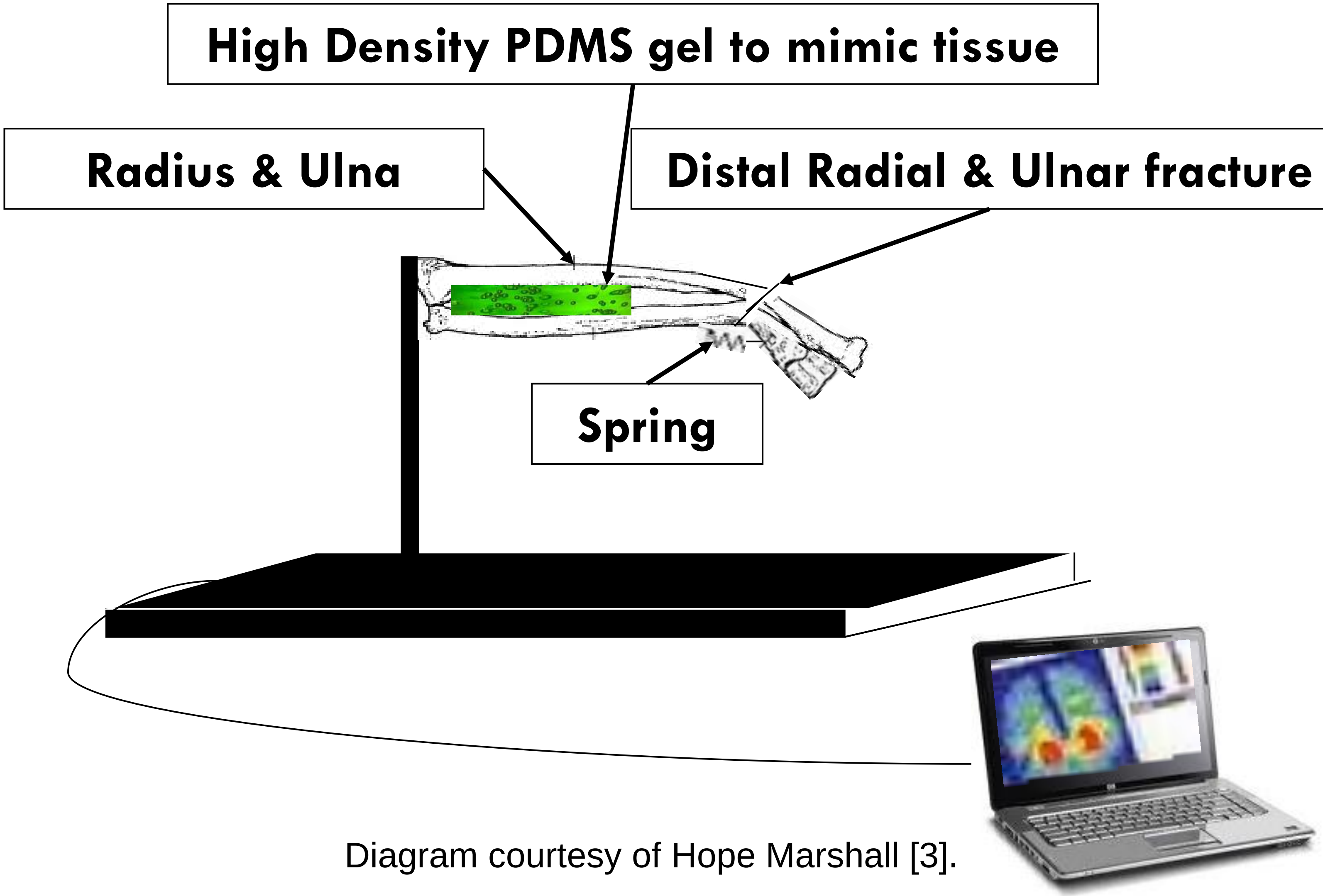


Diagram courtesy of Hope Marshall [3].

Future Work

- Perform compatibility testing for sensors & materials
- Cast pediatric forearm
- Construct model
- Create user interface
- Collect data from professionals with extensive casting experience, compare to real fracture

Acknowledgements

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- Dr. Matthew Halanski (client)
- Professor Thomas Yen (advisor)

References

[1] Halanski M, Noonan KJ. Cast and splint immobilization: complications. *J Am Acad Orthop Surg* 2008 January;16(1):30-40.

[2] Photos. Dr. Matthew Halanski.

[3] Photos & Diagrams. Hope Marshall.

[4] TekScan (Individual Sensors). Photo. www.tekscan.com

[5] Zebra Sensor (SensorTech). Photo. www.sensortechcrop.com

[6] Tactile Sensor (Pressure Profile). Photo. www.pressureprofile.com

[7] Thermal Ribbon Thermistors. Photo. www.directindustry.com

[8] Temperature Mapping. Photo. www.sensorprod.com

[9] Thermocouple. Photo. www.auberins.com

[10] Optical Sensor. Photo. http://dc190.4shared.com/doc/Fo4NuAQE/preview.html

[11] Complete Circuit. Photo. www.acroname.com

[12] Capacitive Sensor. Photo. www.ia.omron.com

Questions?