Forearm Fracture Model

Max Schultz (Team Leader)
Taylor Moehling (Communicator)
Luke Haug (BWIG)
Colin Dunn (BSAC)

Outline

- Client
- Problem Statement
- Background
- Existing Products/Procedures
- Design Specifications
- Design Matrix
- Final Design
- Future Work
- Acknowledgements

Client

Dr. Matt Halanski

Orthopedic Surgeon

Clinical Medicine

Orthopedic Research

Associate Professor

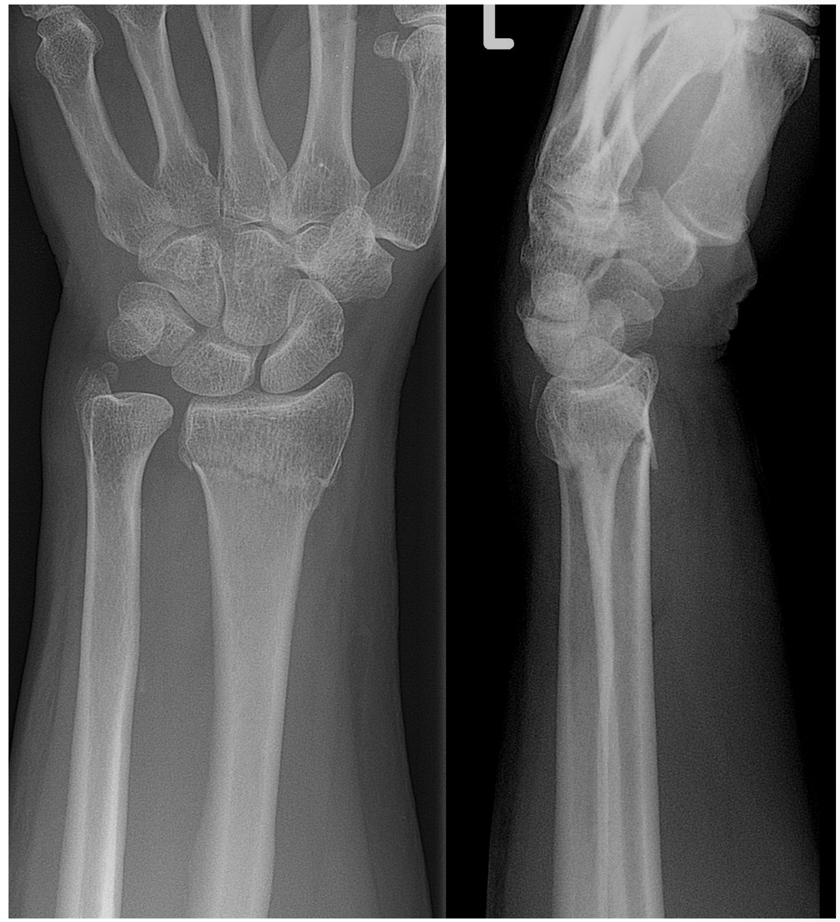
School of Medicine and Public Health
UNIVERSITY OF WISCONSIN-MADISON

Problem Statement

To develop a pediatric forearm fracture model that provides temperature, skin surface pressure, and bone alignment feedback for use by medical school residents in order to practice and learn safe, effective casting techniques.

Background

- 75% pediatric forearm fractures are distal
- Both bones or only radius
- Caused by fall on outstretched hand
- May include wrist fracture
- Proximal fragment in neutral or slight supination
- Weight of hand with pronator quadratus pronates distal fragment



Distal forearm fracture
http://en.wikipedia.org/wiki/Distal_radius_fracture

Background

Volar Angulation
http://www.learningradiology.com/archives05/COW%20157-Galeazzi%20Fx/galeazzicorrect.htm

- When completely broken, bones shorten, angulate, and rotate within surrounding membrane and muscle attachments
- Angulation
  - Volar
  - Dorsal
  - Toward or away from interosseous space
- Axis of rotation from distal ulnar head to proximal radial head

Background

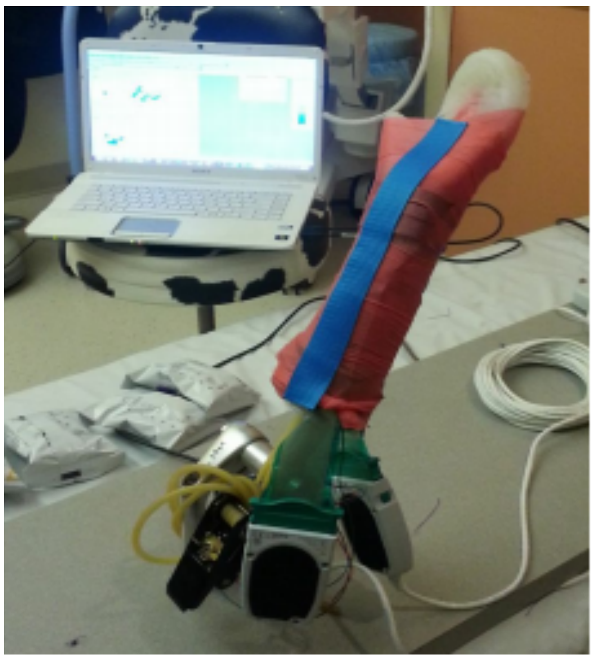
Fracture Types:

- Growth plate fracture (Physeal fracture)
- Torus fracture
- Metaphyseal fracture
- Greenstick fracture
- Galeazzi fracture
- Monteggia fracture

Greenstick Fracture
http://www.imageinterpretation.co.uk/wrist.html

Existing Products/Procedures

- Teaching tools not commercially available
- BME 402 Team Spring 2013
- Residents currently learn casting in situ with instructions from experienced orthopedic surgeon

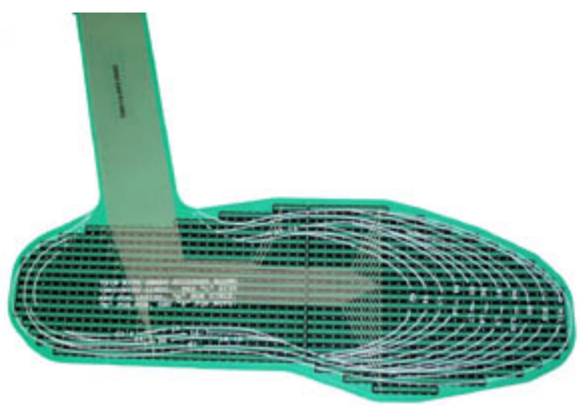


Final product in Spring 2013

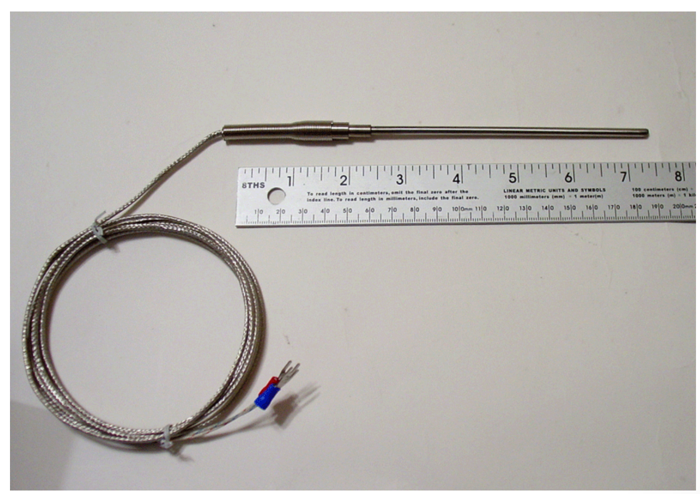
Client's previous forearm model

BME 402 Team Spring 2013

- Radius and ulna represented as one piece
- Strain gage potentiometers measure fracture angle
- Tekscan Foot Pressure Mapping system
- Thermocouple for temperature sensing
- Platsil Gel-10 tissue representation
- Latex surgical tubing to create fracture/resistance



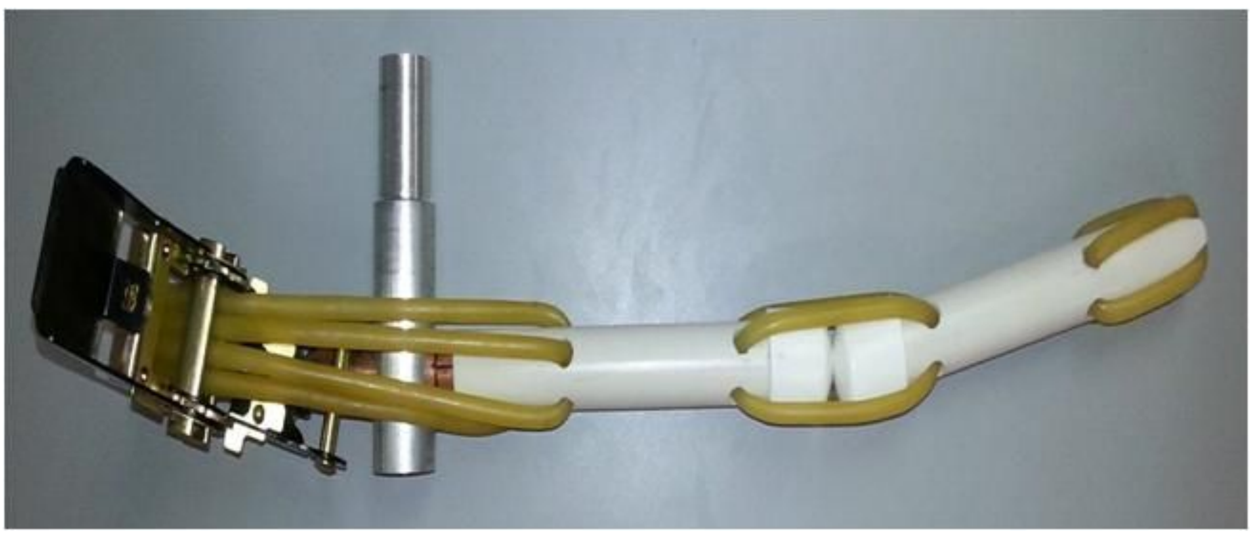
Tekscan Foot Pressure Mapping System
http://www.prweb.com/releases/2009/09/prweb2886554.htm



Thermocouple
http://www.auberins.com/index.php?main_page=index&cPath=20_3

Problems with Existing Design

- Fracture location
- Not user friendly
- Poor accuracy in 3D for alignment
- Poor modular resistance for bone realignment
- No protection for hardware



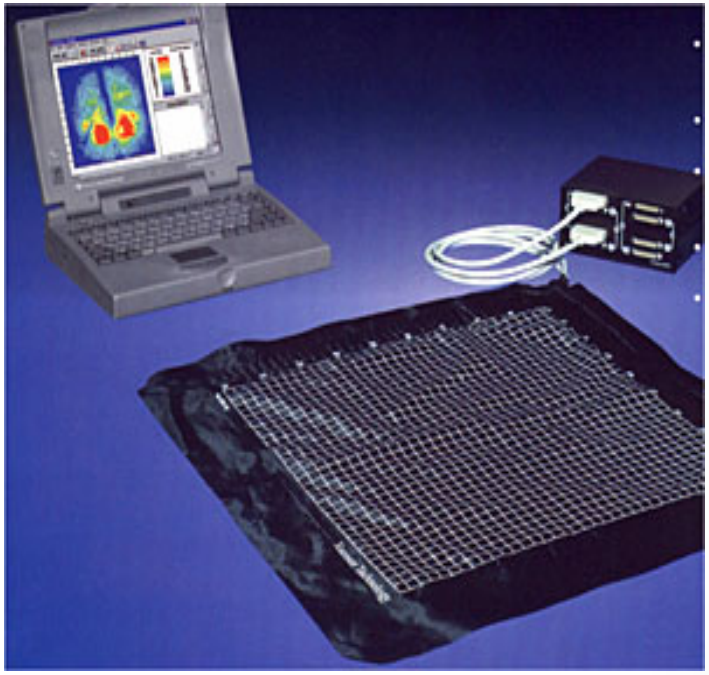
Bone alignment after Spring 2013. Fracture in the middle, not at the distal end of the arm. Use of bands to create resistance.

Design Specifications

- Create distal fracture in model
- Computer interface
- Mechanical modular resistance
- Record pressure
- Record temperature
- Protect hardware from heat and force
- Realistic model of pediatric forearm

Software Specifications

- Single user interface presenting all data
- Live color coded pressure map
- Internal and external temperature display with alerts for high temperatures
- Fracture angle and displacement display
- Data logging enabling user to analyze



Software interface
http://sci.washington.edu/info/forums/reports/pressure_map.asp

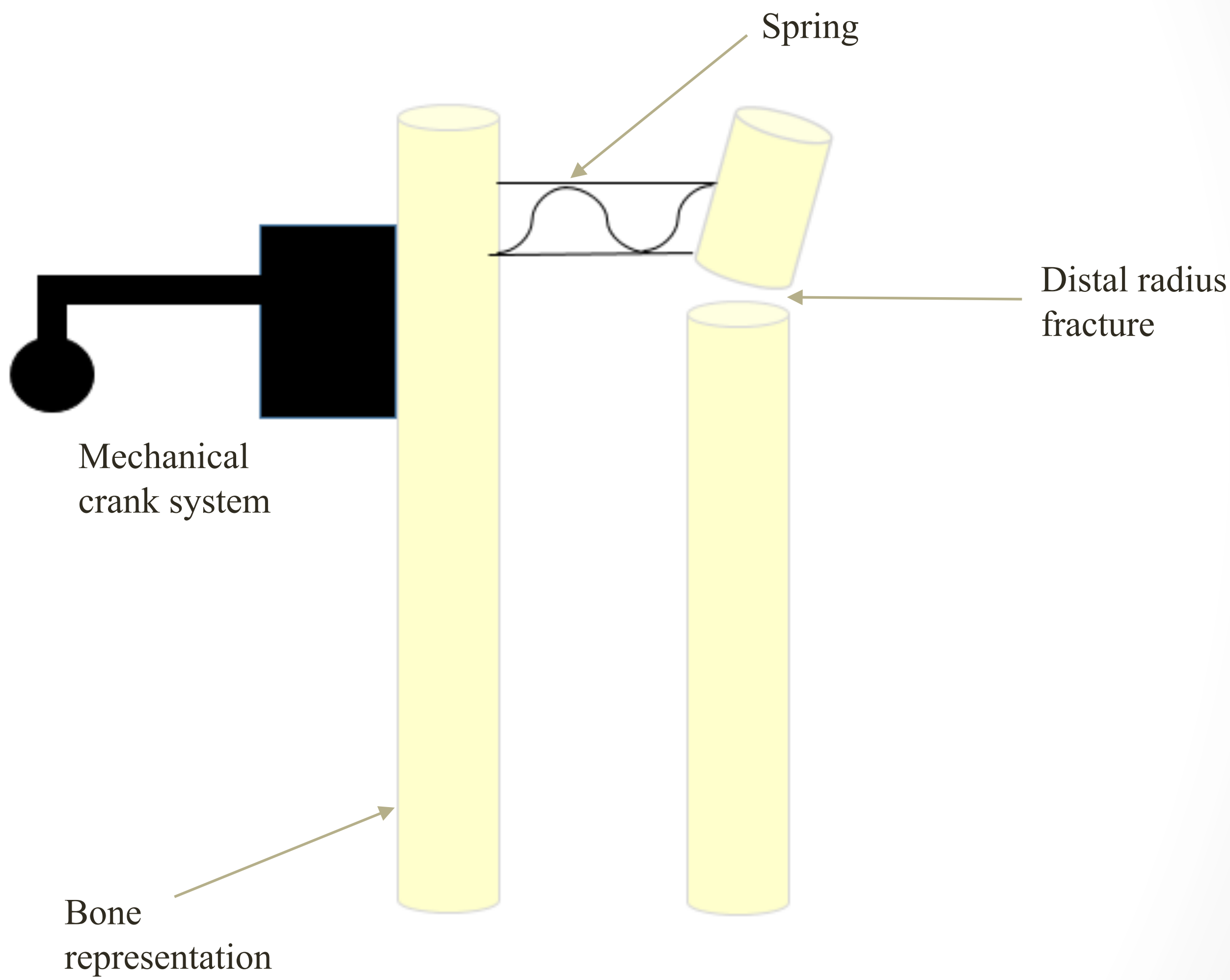
Component Design Matrices

- Pressure Mapping System
- Modular Fracture System

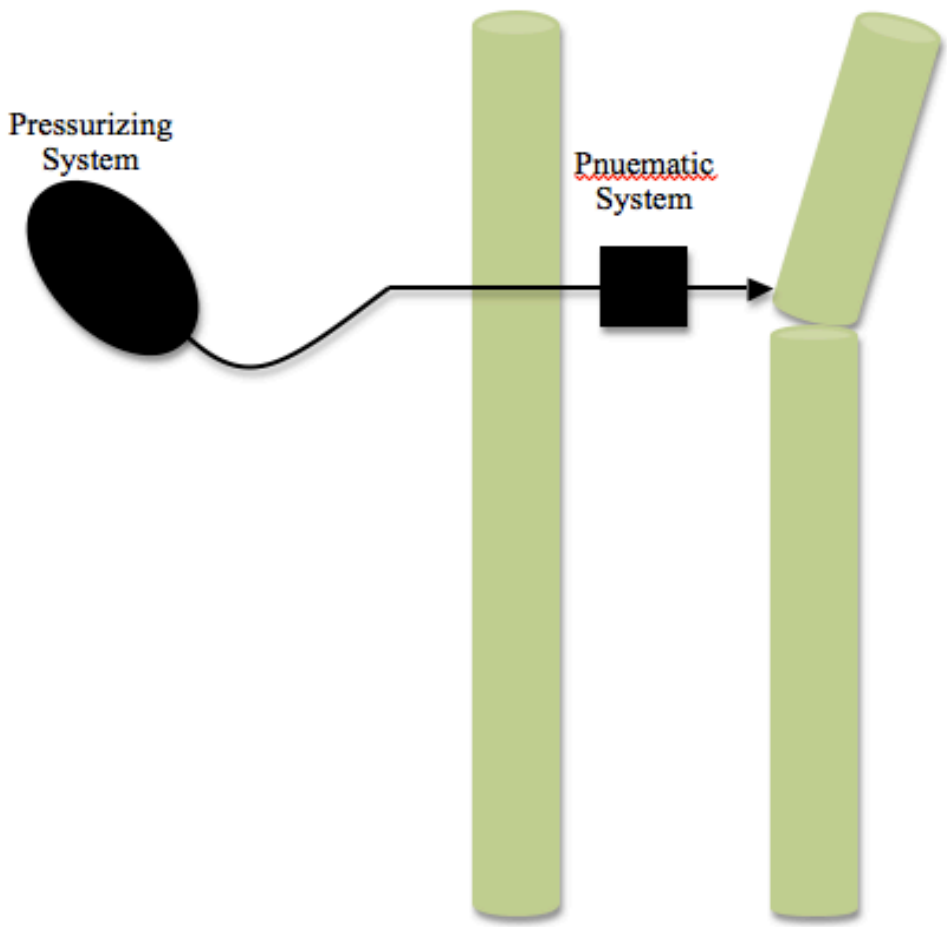
Pressure Mapping Design Matrix

Design Criteria	Weight	TekScan (Foot)		TactArray		Custom Forearm Sensors	
Accuracy	30	2	12	3	18		
Data Output	25	3	15	3	15		
Usability	20	2	8	4	16		
Cost	15	3	9	1	3		
Safety	10	4	8	4	8		
Total	**100**	**52**		**62**			

Mechanical System



Pneumatic System

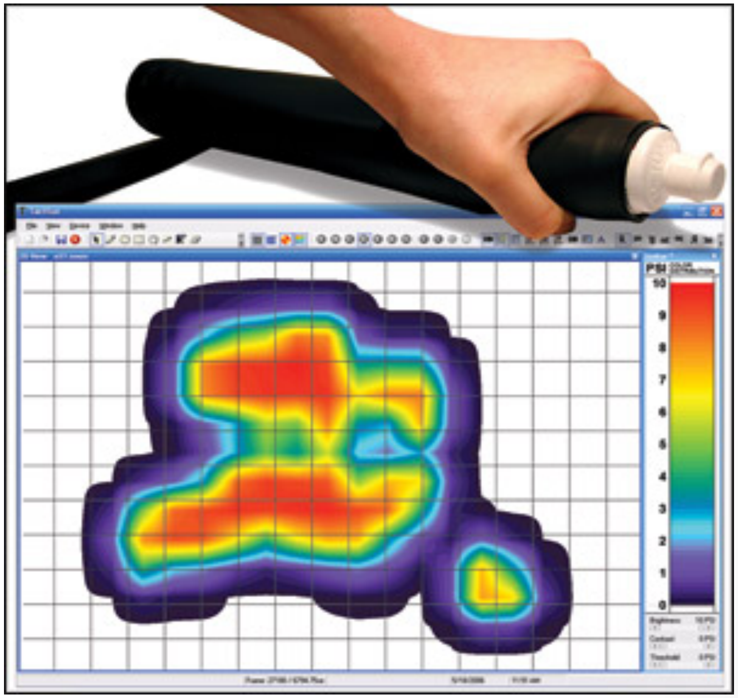


Modular Fracture Design Matrix

Design Criteria	Weight	Bands		Pneumatic System		Mechanical System	
Resistance Variability	30	2	12	5	30	4	25
Usability	25	2	10	4	20	3	15
Manufacturability	25	4	20	3	15	3	15
Cost	10	5	10	3	6	4	8
Safety	10	4	8	4	8	4	8
Total	**100**	**60**		**77**		**71**	

Final Design

- Pneumatic system for different resistances for bone fracture
- Use two bones made of PVC with 0.5” diameter
- Improve software-user interface to show pressure during casting
- Move fracture to distal
- Custom forearm pressure mapping system



Custom pressure mapping sytem
http://www.sensorprod.com/news/pr/2008-04_foodmarketing/image01.jpg

Future Work

- Purchase PVC pipe
- Explore custom forearm pressure system
- Develop pneumatic system to control fracture
- Recreate Platsil forearm representation
- Testing of pressure and alignment system
- Develop protective sleeve
- Integrate software into one user display
- Residents test device

Future Work

Tasks	September				October				November					Dec
	6	13	20	27	4	11	18	25	1	8	15	22	29	6
Background Info	X	X	X	X	X									
Design Alternatives				X	X									
Final Design						X								
Materials						X	X	X						
Construction							X	X	X	X	X			
Testing											X	X	X	X
Mid-Semester					X									
Final														X
Mid-Semester Report					X									
Final Report														X

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References

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