Hip Aspirate Model to Teach Physicians

Client: Dr. Halanski

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Overview

- Problem Statement
- Septic Arthritis Background
- Product Design Specifications
- Four Preliminary Designs
- Design Matrix
- Future Work
- Acknowledgements

Problem Statement

Normal [left] & septic [right] hip [3]

- Septic Arthritis
  - Painful infection
    - Synovial fluid build up
    - Quantity dangerous after 5-7 days of infection [1]
  - Orthopedic emergency
    - Untreated: rapid cartilage degradation, permanent joint deformities, bone loss
  - Relatively rare condition
    - 2-10/100,000 (general population) [1]
    - ⅕ cases are in the hip [2]
    - Little clinical exposure for residents

Problem Statement

- Goal:
  - Infant hip base model
    - Most susceptible ages: 1-2 & 65+ [4]
  - Practice ultrasound-guided hip aspiration & anterior surgery
    - Aspiration insert
      - Model synovial fluid buildup
    - Ultrasound and X-ray compatible

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Background

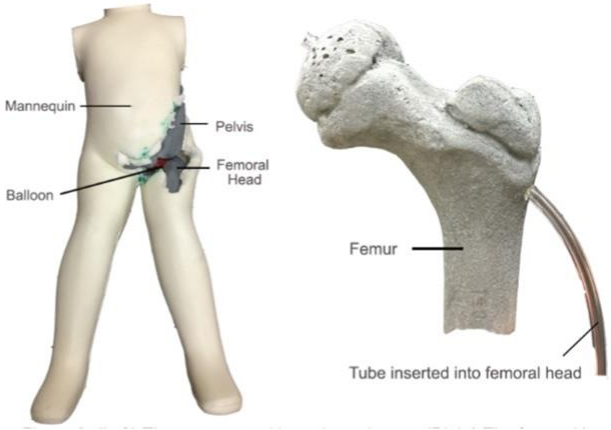
- Septic Arthritis is a rare, but serious condition involving inflammation of the synovial membrane [5]
- Occurs in the hip joints of young children
    - If not treated quickly, can result in permanent damage to the joint [5]
- Treated by aspirating synovial fluid from the hip [5]
    - Aspirating= Withdrawing fluid using suction through a needle
- Various approaches to procedure
    - Anterior, Lateral, Medial [6]
    - Ultrasound and X-Ray

Anterior Needle Approach[7]

Previous Work

- Two previous BME design teams
- Materials for artificial tissues
  - Self Healing urethane for joint capsule
  - Silicone based skin and fat materials
  - Cellulose powder for ultrasound visibility
- Demonstrated difficulties with integrating fluid

Fall 2014 [8]



Spring 2016 [9]

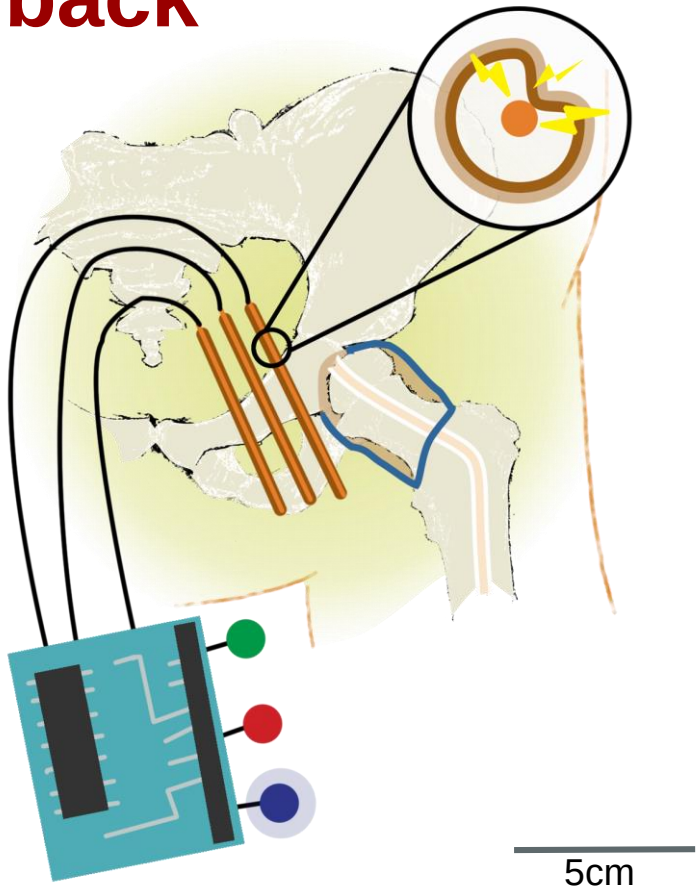
Product Design Specifications

- Must be operational under X-Ray fluoroscopy and Ultrasound
- Artificial tissues must mimic properties of real tissues
  - Resistance to puncture
  - Appearance under X-ray and Ultrasound
- Withstand 180 needle insertions without replacement
- Include all anatomical structures relevant to the procedure
  - Femoral Vein, artery and nerve
- Size and weight requirements
  - 6 pounds
  - 18-20 cm femur length
- Budget of $500

Fluid with Electronic Feedback

- Based on previous teams' designs
  - Silicon tissues
  - X-ray opaque bone
  - Polyurethane capsule
  - Refillable fluid for aspiration

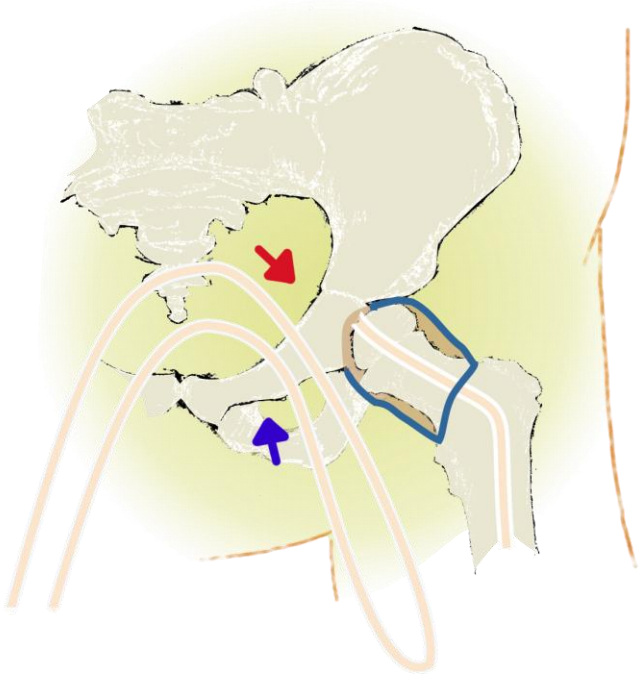
- Pressure activated LED feedback



Fluid without Electronic Feedback

- Similar to existing ultrasound simulators
- Pump system simulates pulse
  - Physical feedback
  - Doppler shift

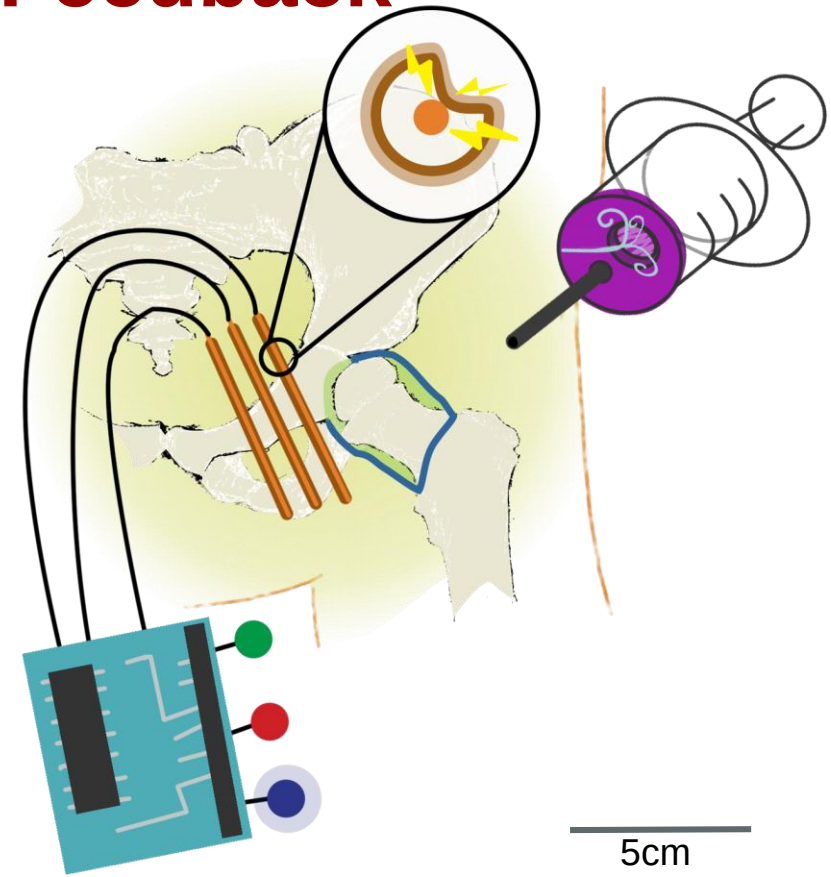
- Tube system fills capsule with mineral oil



5cm

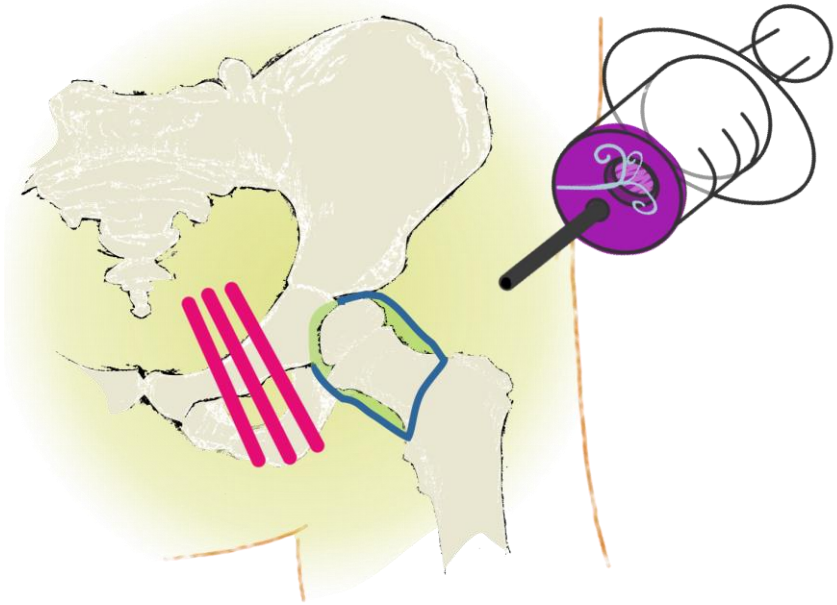
No Fluid with Electronic Feedback

- Capsule filled with gel or powder
  - Unmodified silicon gel
- Modified syringe with valve
  - Valve provides resistance
  - Hole in syringe withdraws air
- Electronic feedback system

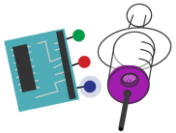


No Fluid without Electronic Feedback

- Polyethylene rods
  - Similar properties to blood in Ultrasound
  - Physical feedback
  - Indicator coating sticks to needle
- Modified Syringe
- Polyurethane capsule
  - Filled with gel



Design Matrix

Design / Criteria (weight)	Fluid with Electronic Feedback 		Fluid without Electronic Feedback 		No Fluid with Electronic Feedback 		No Fluid without Electronic Feedback 	
Anatomical Accuracy (20)	3/5	12	5/5	20	2/5	8	4/5	16
Surgical Accuracy (20)	1/5	4	5/5	20	1/5	4	4/5	16
Reusability (15)	2/5	6	2/5	6	3/5	9	5/5	15
Cost (15)	2/5	6	4/5	12	3/5	9	5/5	15
Ease of Fabrication (10)	1/5	2	2/5	4	1/5	2	3/5	6
Safety (10)	2/5	4	3/5	6	3/5	6	4/5	8
Aesthetics (10)	2/5	4	3/5	6	2/5	4	4/5	8
Total (100)		**38**		**74**		**42**		**84**

Future Work

- Foreseeable difficulties
  - Finding the correct way to combine the materials
    - Need to be ultrasound and x-ray compatible
  - Testing facilities
  - Replicable model
  - Multiple components that need to be molded
    - Little experience
    - Molded in certain shape and around bones

Fabrication

- Fabrication of Model
  - Synovial membrane
  - Molding
  - Different mixtures of silicone for various tissues
  - Polyethylene for vein, artery, and nerve

Acknowledgements

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- Prof. Walter Block
- Staff of UW Health Radiology and Pediatric Imaging Departments

References

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Questions?