Device for Quantifying Acute Compartment Syndrome

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Team: Compartment Syndrome

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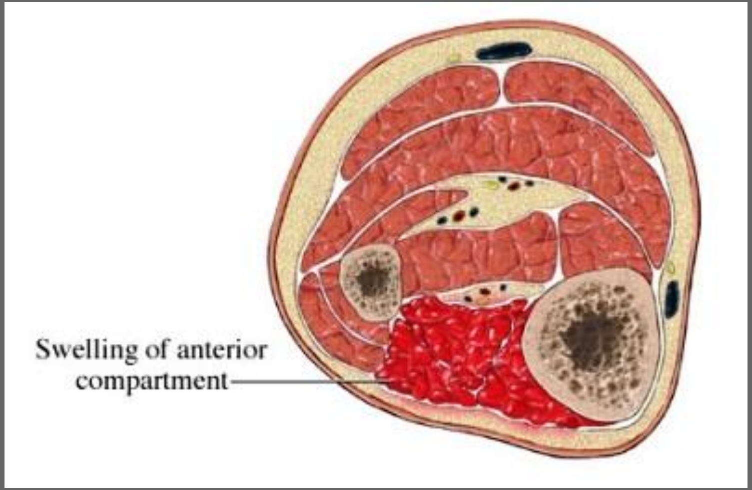
Overview

- Background
- Problem Statement
- Product Design Specifications
- Preliminary Designs
- Design Matrix
- Proposed Final Design
- Future Work



[1]

Background

- Increase in pressure in a muscle cavity
- Typically a result of internal bleeding or swelling
- Can lead to muscle death
- Oxygen levels decrease
- Rare in the US, but common in the military

[2]

Acute Compartment Syndrome → Reduction in local oxygen → Reduction in oxidative phosphorylation → Increase in anaerobic glycolysis → Reduction in metabolic factors such as pH and glucose

[3]

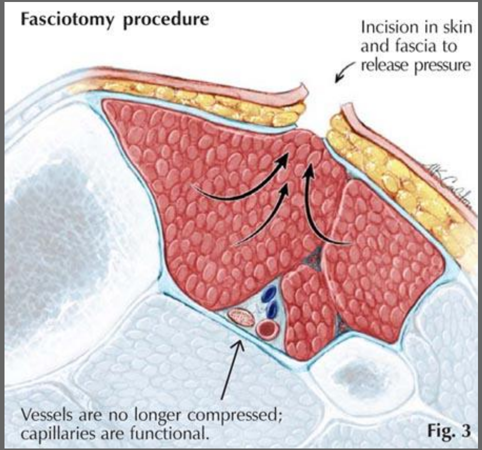
Background- Treatment

Some causes of Acute Compartment Syndrome...

- Crush injuries
- Prolonged limb compression
- Bone fracture wounds
- Gun shot wounds

Emergency Fasciotomy is the standard treatment

1. Decompression
2. Fracture stabilization
3. Vascular repair



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Background- Quantifying a Compartment by Pressure

Various studies have published differing results regarding the pressure of an acute compartment

- 30 mm Hg [8]
- 20 mm Hg [9]

Pressure surrounding tibia fractures with no sign of compartment syndrome

- 30 mm Hg diversion from diastolic

Misdiagnosis rate: 35%

[3]

Problem Statement

- Develop a device that can quickly, and safely, quantify an existing or developing acute compartment
    - Reduce the false-positive rate of diagnosis
    - Prevent unnecessary surgery
    - Reduce potential muscle damage by decreasing time prior to treatment

Product Design Specifications

Performance requirements:

- Measure metabolite inside a muscle compartment *in vivo*
  - Within 5% accuracy
- Device output should display measurement that is easily readable by the user
- Calibrate time should be less than 5 minutes

Size

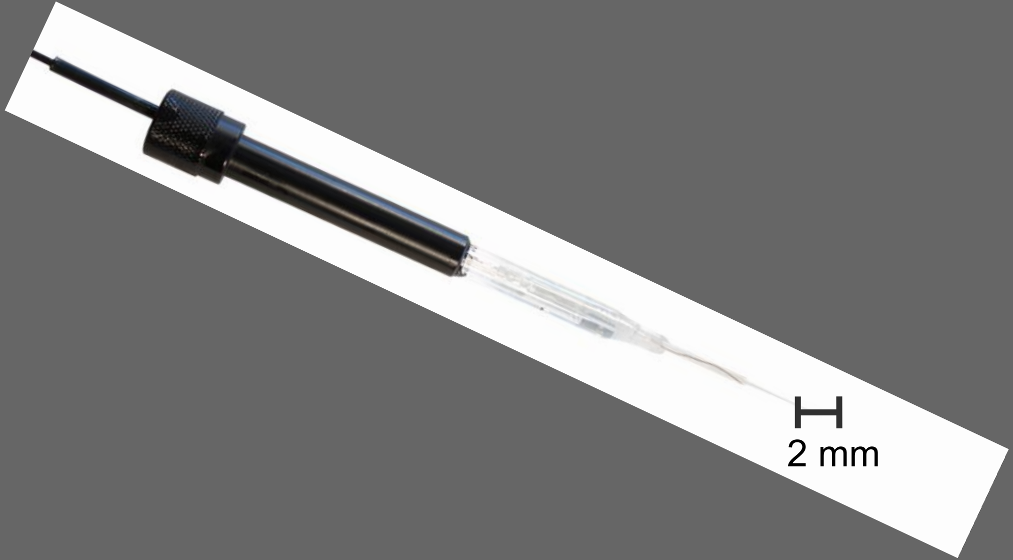
- Device must fit in 16 gauge needle (1.2 mm in diameter)
- Probe length of 4-6 cm

Preliminary Designs

Glucose Probe

[10]

Ion-selective field effect transistor (ISFET) Probe



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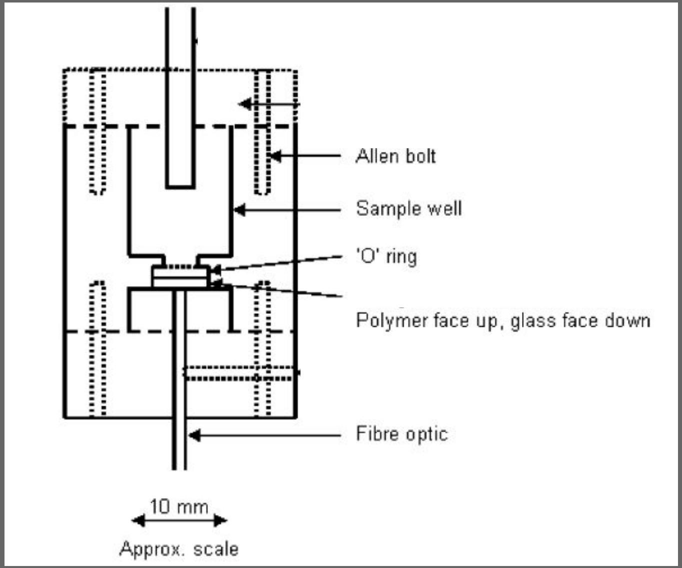
Preliminary Designs

pH polymer probe



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pH optic sensor

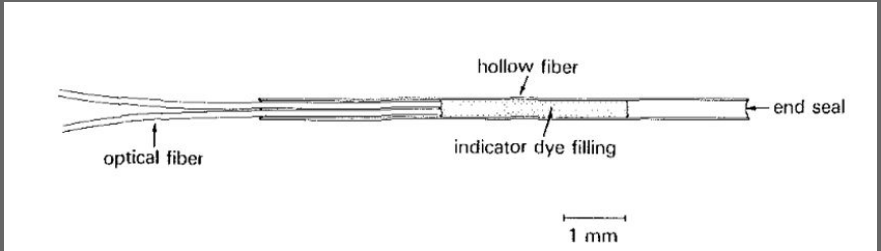


Fig. 1 Construction of fiber optic pH probe

[13]

	Glucose Probe	pH Polymer System	pH ISFET Probe	pH Microsensor	pH Optic Sensor
Size (25)	3/5 (6)	3/5 (15)	2/5 (10)	5/5 (25)	5/5 (25)
Safety (20)	5/5 (20)	5/5 (20)	4/5 (15)	4/5 (15)	5/5 (20)
Accuracy/ Reliability (15)	3/5 (9)	5/5 (15)	4/5 (12)	5/5 (15)	5/5 (15)
Ease of Use (calibration) (15)	1/5 (3)	3/5 (9)	5/5 (15)	5/5 (15)	5/5 (15)
Ease of Fabrication (10)	2/5 (4)	4/5 (8)	2/5 (4)	1/5 (2)	4/5 (8)
Sterility (10)	5/5 (10)	5/5 (10)	5/5 (10)	3/5 (6)	3/5 (6)
Cost (5)	5/5 (5)	3/5 (3)	2/5 (2)	1/5 (1)	3/5 (3)
Efficacy (0)	N/A	N/A	N/A	N/A	N/A
Totals	57	80	68	79	92

Proposed Final Design

- Probe with 2-3 optic fibers
  - Different colors come out of each fiber
- Probe tip will be connected to photodiode or spectrometer to measure wavelength
- Calculate the pH through calculation of the ratios of acidic and basic components of dye.
  - A pH indicator contains a ratio of acidic ions and basic ions
  - These ions reflect different wavelengths of light

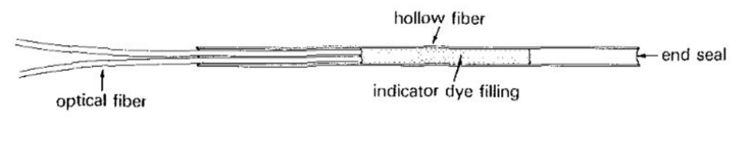
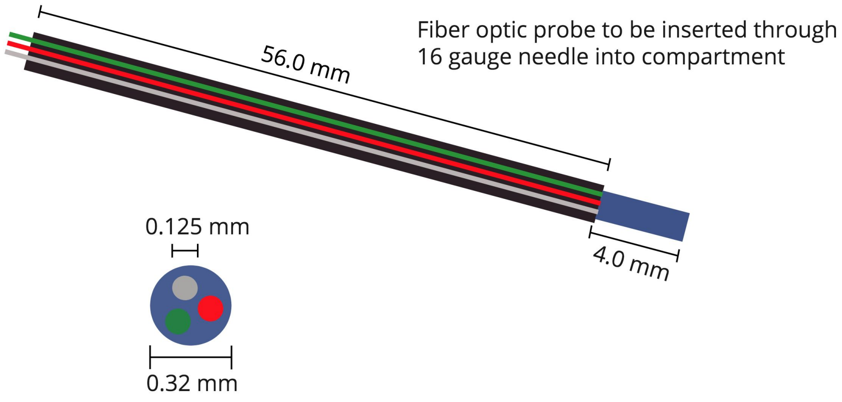


Fig. 1 Construction of fiber optic pH probe



Cross sectional view
of fiber optic probe

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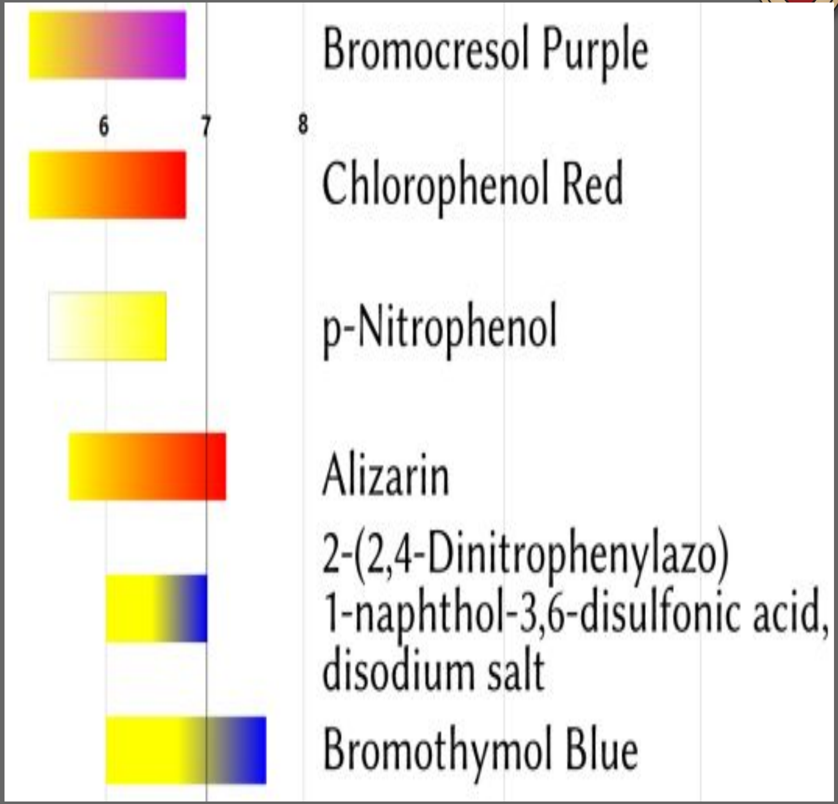
Future Work

- pH indicator

  The pH range should be 5-7

  - Bromocresol Purple 5.2-6.8
  - Bromothymol Blue 6.0-7.6



[15]

Immobilization

- Connection to the end of the optic fiber
- Sensitive coating on the surface of the sensor
  - Covalent chemical linking
  - Physical encapsulation techniques

	Physical	Chemical
Disadvantages	Not effective Leaching problems	Difficulty of fabrication Time consuming
Advantages	Simple and versatile	Excellent immobilization of the pH-sensitive dye No leaching situation

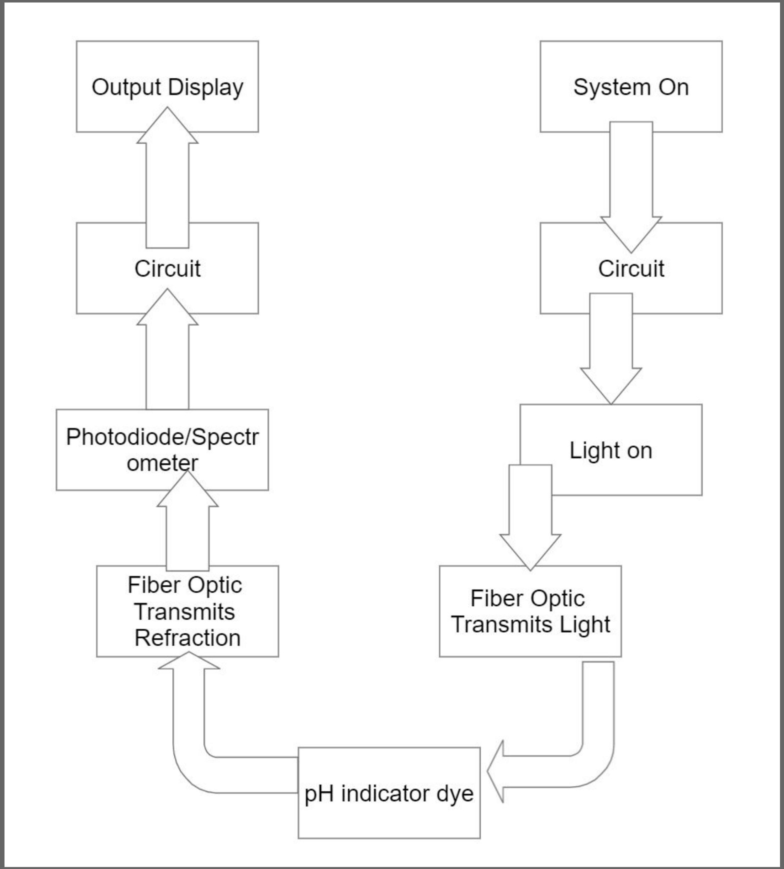
- The potential solutions:
  - PTFE
  - Sol-gel fabrication

[16]

Programming

- Hardware
  - Selection and fabrication of spectroscopy
  - Develop circuit

- Software
  - Coding and data analysis (spectrum and light intensity analysis)
  - Calibration testing (For short calibration time)
  - Sensoring testing (For accuracy)



Acknowledgements

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Questions?