Evaluation of a Novel Portable Micro-Pump and Infusion System for Drug Delivery

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JOHNS HOPKINS UNIVERSITY

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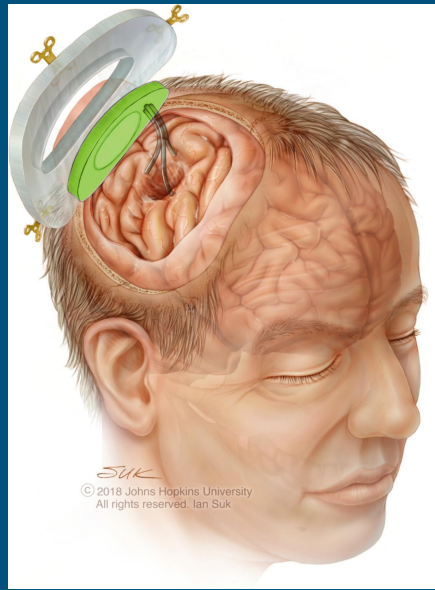
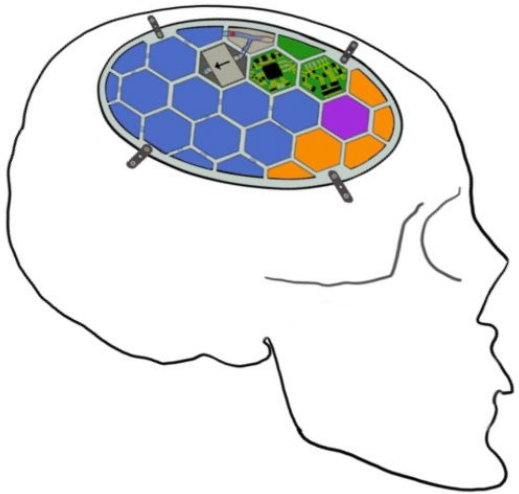
Center for Neuroplastic Surgery Research

Project Summary

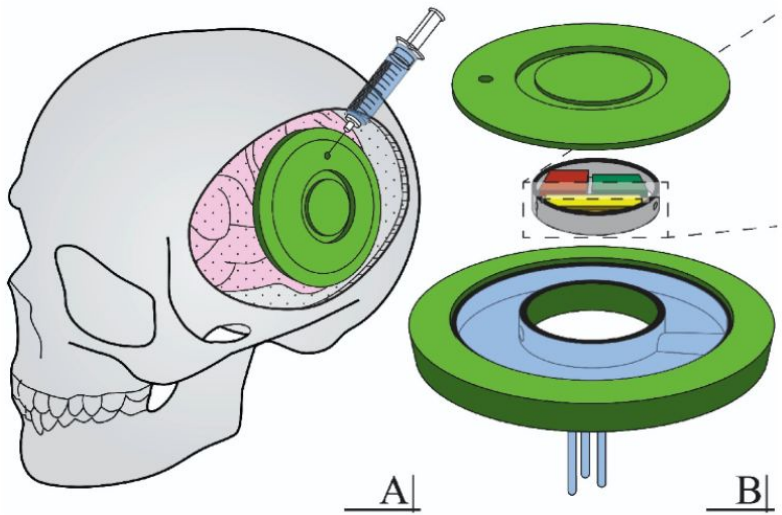
A skull-embedded implant with the

first chronic infusion of medicine directly into the brain





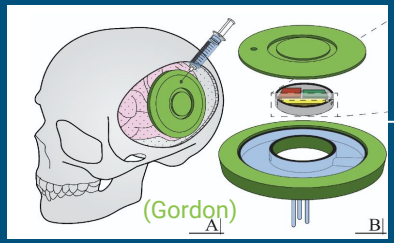
(Gordon)



Patent-pending: “Magnetic resonance imaging compatible, convection-enhanced delivery cranial implant devices and related methods” Gordon et al. 2019. Assigned to JHU.

Our Goal

1. Implement code to use information from sensing pins to perform flow rate calculations every minute
2. Implement code to use bluetooth to transmit flow rate estimates to clinicians



Medicine Delivery Device with Bluetooth connectivity

Bluetooth

Cellular Device of patients, family, and/or healthcare provider

Cellular/ Wifi

Monitoring Network of Physician/ Patient

Select data for patient/ family viewing

Control drug delivery rate

Report:
- battery life
- power transfer status
- drug delivery rate
- low drug reservoir
- reservoir status

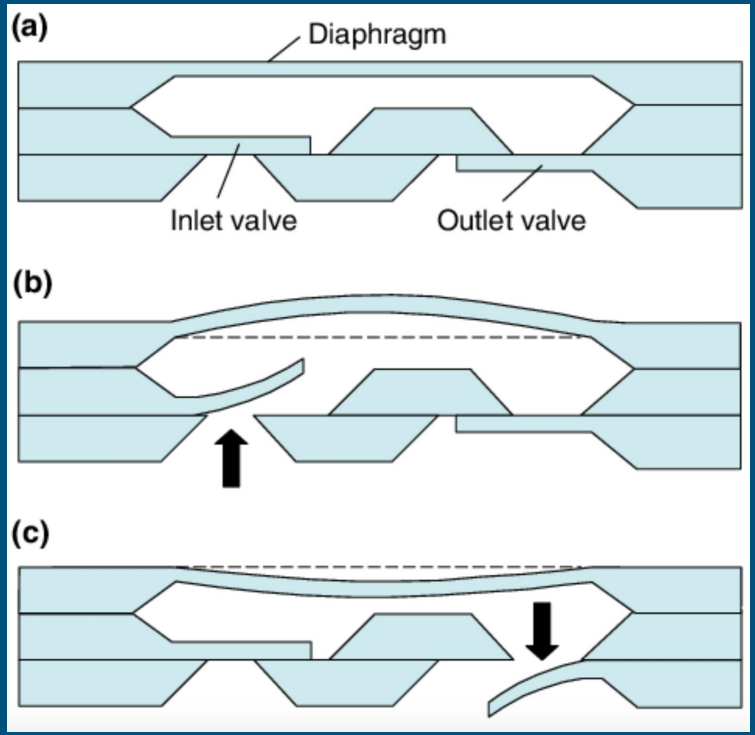
Paper Significance:

"Evaluation of a Novel Portable Micro-Pump and Infusion System for Drug Delivery"

- Relevance to project:
  - Micro-pump vs. implanted pump
  - Valuable information on safety testing and analysis
  - Feature for physicians to update and access data
- Summary and Key Results:
  - Goal: development of an accurate, single-use micro-pump
  - No evidence of wear is seen as the pump continues to run for long periods of time
  - High viscosity fluids lower volumetric efficiency of the pump

Relevant Background

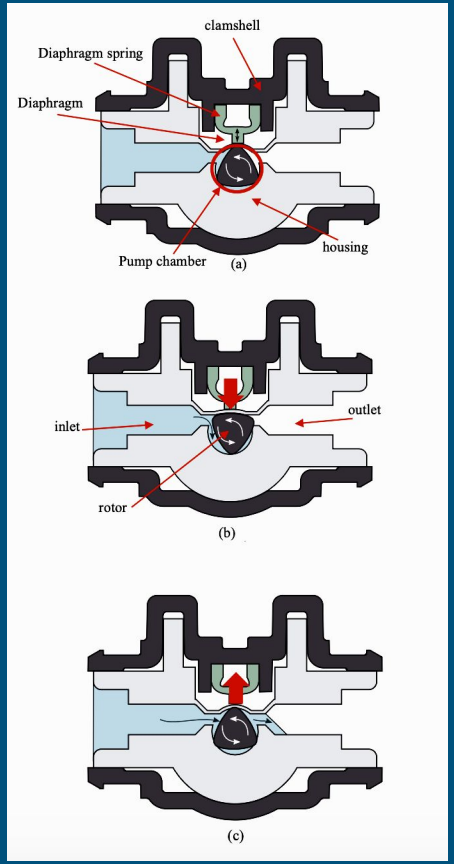
- Infusion pumps:
  - Deliver drugs and fluids into body at controlled rate
  - Disposable, micro-pumps: small size, simplicity of use, no power supply
- Displacement Pumps:
  - Use a moving boundary
  - Diaphragm: moving boundary
  - Inlet: suction portion of pump
  - Outlet: fluid release portion of the pump



(Iverson)

Micro-Pump and System

- Pump System:
  - Pump turned off
  - Pump turned on, fluid starts moving
  - Fluid eventually expelled out through outlet
- Pump is disposable
  - Pen-Drive updated by clinicians: EPROM chip
  - Battery powered



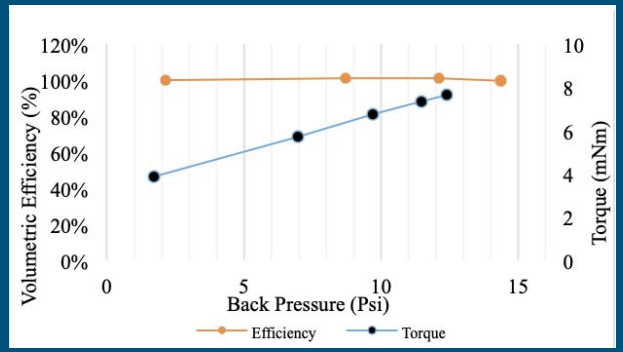
(Pankhurst)

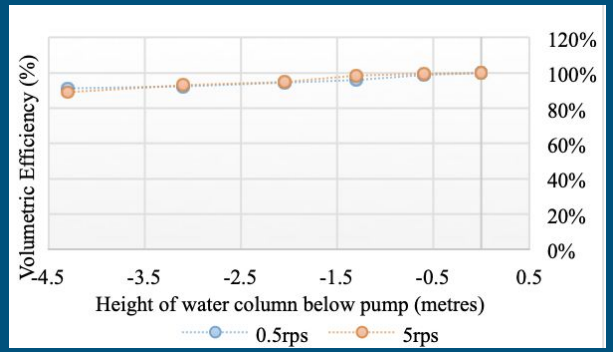
Method of Testing

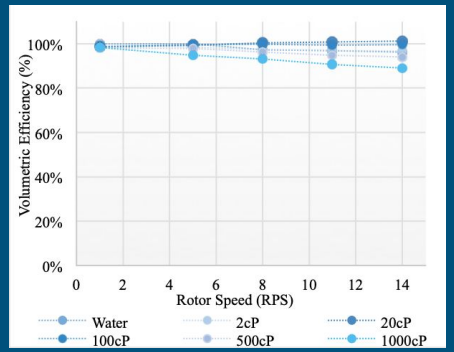
- Testing Unit: 3 bolus rotor micro-pump connected to stepper motor and torque rig
  - Stepper motors: used for precise position and speed control
  - Torque transducer: ability to measure torque
  - Calibration: water and no net pressure = baseline flow rate value
  - Volumetric Efficiency: (volume of fluid dispensed / baseline) * 100%

Test Results

1. Volumetric efficiency with water against partial occlusion in the outlet: stays relatively the same, torque increases linearly
2. Volumetric efficiency with water at negative inlet pressures: slight decrease with higher pressures
3. Volumetric efficiency with different viscosities from 2cP - 1000 cP: decrease with high speeds and viscosities







(Pankhurst)

Test Results

4. Longevity test: runs the motor over a longer range of time and measures error
    a. No significant difference in error flow between shorter and longer time frames of pump running.

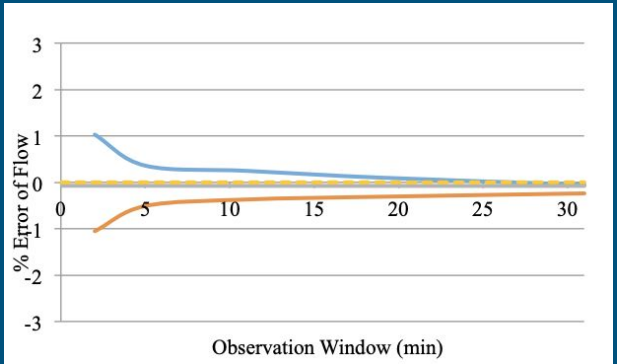


Figure 9. Trumpet curve during first hour of test period after 15m start-up period.

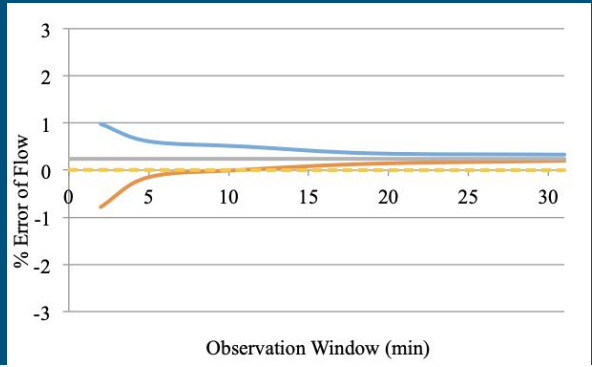
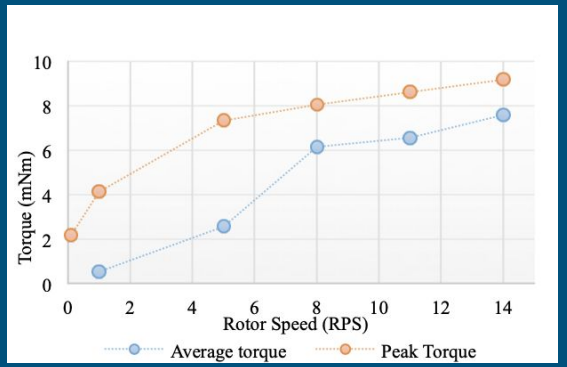


Figure 10. Trumpet curve during last hour of test period.

(Pankhurst)

Critiques

- No reasoning given behind the specific tests done
  - Mentions comparison to current infusion pump specifications
- Discussion results need to be proofread:
  - “Torque reduces at the higher rps at the higher viscosities”



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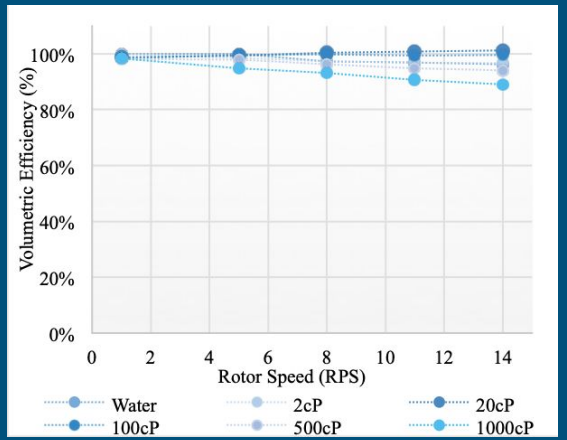
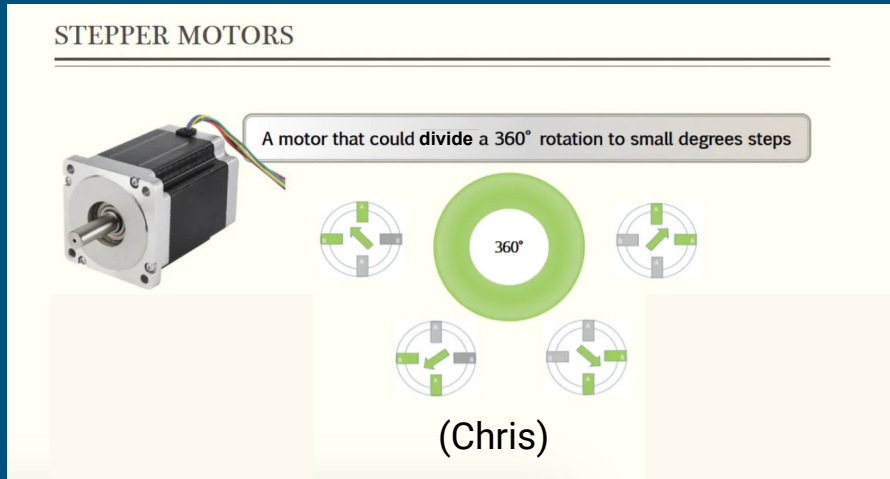


Thank you! Questions?

Appendix

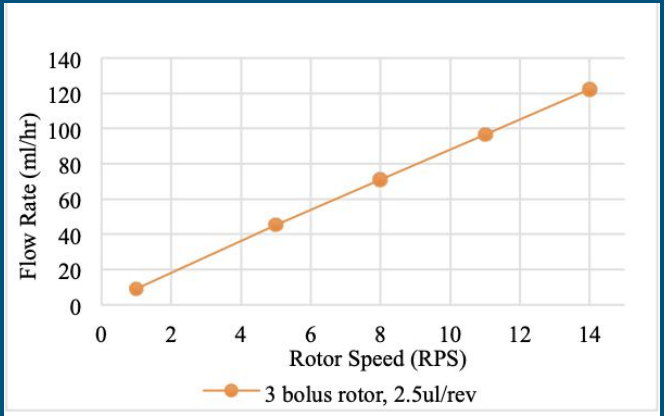
Testing Methods: Stepper Motor

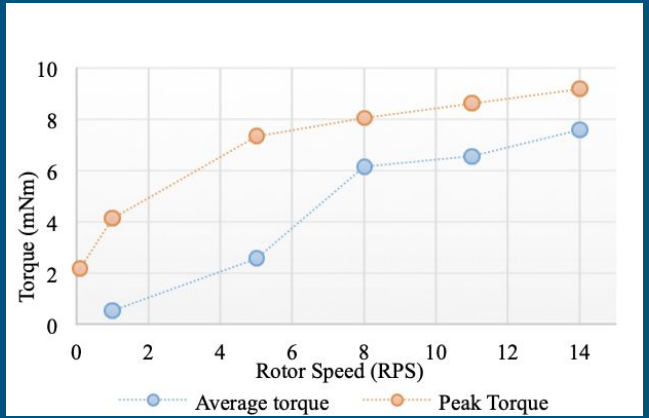
- Stepper motors: used for precise position and speed control
  - Allow the researchers to precisely control the flow rate and variables of testing
  - Greater control and more precise tests



Testing Results: Trivial Tests

1. Flow rate at different rotor speeds from 0.1 to 14 rps
2. Torque over dynamic range with water





(Pankhurst)

Reference List

[1] Gordon, Chad. Magnetic Resonance Imaging Compatible, Convection-Enhanced Delivery Cranial Implant Devices and Related Methods. CraniUS®, 2020.

[2] Hottinger AF, Stupp R, Homicsko K. Standards of care and novel approaches in the management of glioblastoma multiforme. Chin J Cancer. 2014 Jan;33(1):32-9. doi: 10.5732/cjc.013.10207. PMID: 24384238; PMCID: PMC3905088.

[3] Pankhurst, Paul, and Zahra Mcguinness Abdollahi. “Evaluation of a Novel Portable Micro-Pump and Infusion System for Drug Delivery.” 2016 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2016, doi:10.1109/embc.2016.7590740.

[4] Chris. “Large Stepper Motor Control A4988.” Arduino Project Hub, 25 May 2020, create.arduino.cc/projecthub/346002/large-stepper-motor-control-a4988-b7a9c9.