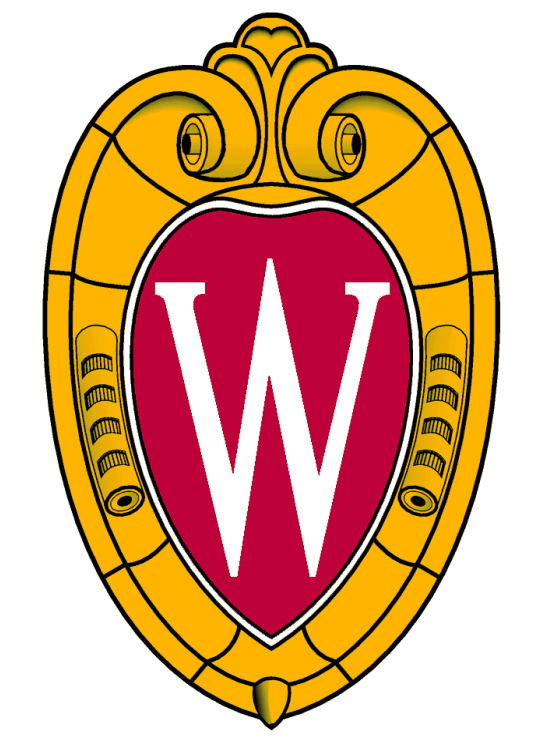


Design, Testing, and Calibration of a Small Syringe for Use with a Power Injector



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Abstract

Angiography is a medical imaging technique used to visualize blood vessels in the subject under examination. Contrast medium is injected near the point of interest, with current injection devices geared towards larger subjects. Consequently, our client has developed a prototype syringe. It is capable of delivering the necessary small amounts, but poses many problems, including difficulty in air bubble detection and removal, the absence of the preferred volume range of 0.1 to 2.0 cc, and a lack of calibration. The team has developed a twist-lock protruding syringe design to solve these issues. The prototype was tested and calibrated so that desired injection parameters can be converted to settings used with the power injector. Following testing, the team determined what future work needs to be done in order to improve the device and potentially bring it to market on a large scale.

Problem Definition

Motivation

- Small animal angiography, a growing field
- No current devices deliver desired volume with required precision and power

Current Designs

- Hand syringes
- 200 cc syringes
- Covidien Optistar LE MR Injector
- Digital Subtraction Angiography Micro-Injector
- Client Prototype



Client Prototype

Problem Statement

- Important to inject contrast medium at accurate volumes and rates for angiographies of rodents
- Current devices do not allow injections of desired small (1-2 cc) volumes
- Construct, test, and calibrate for use with commercially available power injector

Design Criteria

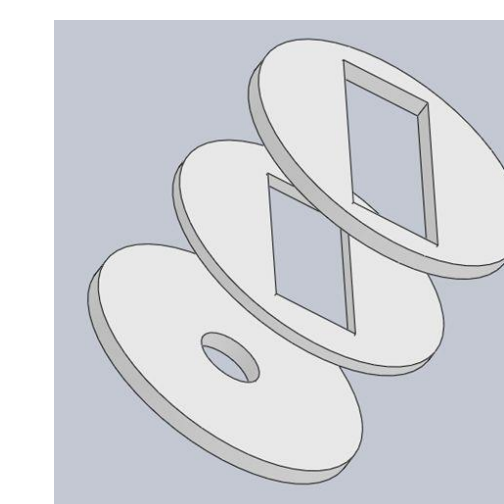
- Deliver 0.2-3 cc of contrast medium into small animals
- Syringe must meet all medical device standards
- Latex-free, durable, clear material
- Calibration system to prevent over-injection
- Compatible with current power injector
- Ease of use for loading and removal of air bubbles
- Error margin less than 3%
- Visible graduations
- Safety lock mechanism
- Disposable

Final Design

- Housing unit:
 - Modified 200 cc syringe
 - Twist and lock mechanism
 - Three disks
 - Inhibits horizontal and vertical motion
 - Polypropylene Homopolymer
 - Pressure relief holes
- Stopper:
 - Allows movement of 2 cc syringe plunger
 - Delrin 150 base
 - Slotted piece
 - Power injector piston protrusion
- 2 cc syringe:
 - Thumb press inserted into slot
 - Syringe placed in twist and lock mechanism
 - Red Nitro W.P. Custom Syringe



Assembled Prototype



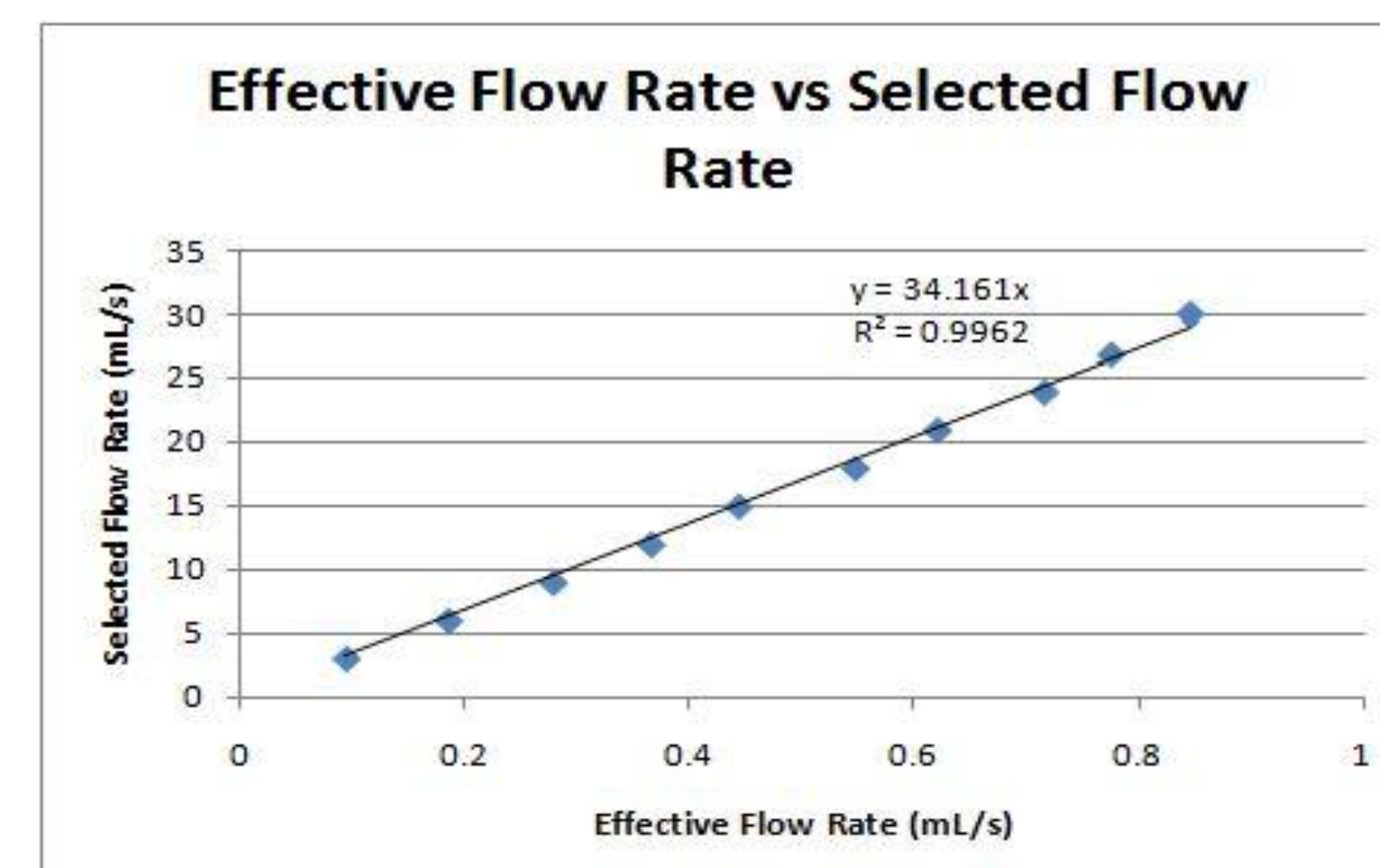
Twist and Lock Mechanism

Testing and Calibration

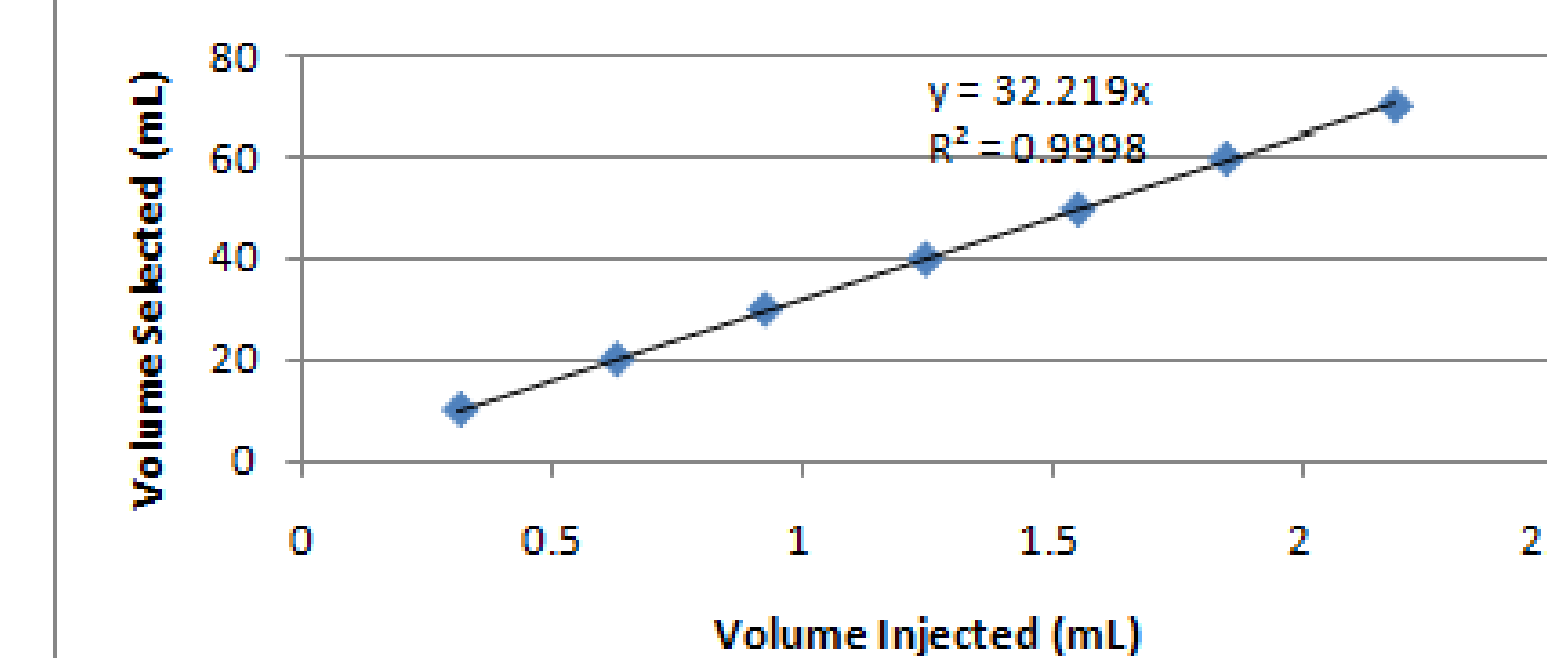
Volume Calibration

- Series of trials dispensing varying volumes
- Flow rate held constant
- Actual volumes determined gravimetrically
- Result: Linear equation relating volume injected to volume selected

$$\text{Selected Volume} = 32.219 \times \text{Desired Volume}$$



Volume Injected vs. Volume Selected



Flow Rate Calibration

- Series of trials dispensing at varying flow rates
- Volume dispensed held constant
- Actual flow rate calculated from volume dispensed and trial duration
- Result: Linear equation relating effective flow rate to selected flow rate

$$\text{Selected Flow Rate} = 34.161 \times \text{Desired Flow Rate}$$

Efficiency Testing

- Test ease of use and efficiency of loading process
- Testing performed by human subjects
- Timed loading trials
- Surveys to assess device performance
- Results:
 - Average Loading Time of 37.9 s
 - Significantly improved loading process and high user ratings

1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree	
The product was easy to use	5
The product performed the task at hand satisfactorily	5
The product was well suited for its purpose	4.88
It was easy to identify bubbles in the medium in the loaded syringe	4.71
It was easy to load the syringe without air bubbles in the medium	4.43
I would use this product in the future	4.71

Rating Scale, Survey Questions, and Average User Ratings

Parts List

- Standard 200 cc Syringe and Stopper.....\$24
- Acrylic Slot Mechanism.....\$1
- Delrin Plunger.....\$275
- Top Circular Hole Polypropylene Disc.....\$66
- Middle Rectangular Hole Polypropylene Disc.....\$65
- Bottom Rectangular Hole Polypropylene Disc.....\$65
- 2cc Red Nitro WP Custom Syringe.....\$2
- Epoxy Plastics Glue.....\$4
- Total Cost.....\$502



Stopper

2 cc Syringe

Housing Unit

Future Work

- Design improvement
 - Air Holes
 - Lubrication of the twist-lock
 - Lock for the slotting mechanism
 - Screws rather than adhesives
 - Adaptability
- Copyrighting and Manufacturing
 - Streamlined Manufacturing
 - More effective material
 - Consult an industry expert

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