COLLEGE OF ENGINEERING

Chemical, Biological, and Environmental Engineering

EpiNex: A reusable, needleless, cartridge based, epinephrine jet injector to combat anaphylactic shock

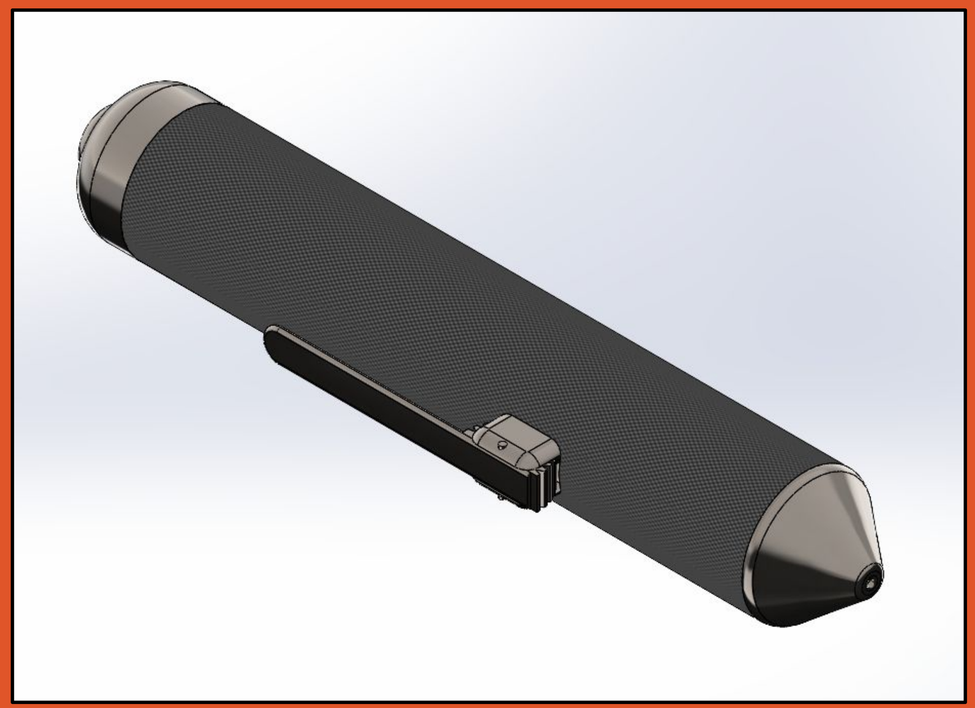
Anne Chhing, Cy Hernandez, Isaac Melick, Noah Peterson

Issues with Current Products

- ❑ Accidental Exposure
- ❑ Device Failure
- ❑ Drug Ineffectiveness
- ❑ Expired Product Administered
- ❑ Soft Tissue Infections & Lacerations
- ❑ Cost

Our Solution

To address these issues, a needle-free, cartridge-based, epinephrine jet injector for the emergency treatment of anaphylaxis, is proposed. EpiNex utilizes spring power to eject epinephrine solution out of a small nozzle at high velocity. This ejection stream is capable of penetrating the skin without causing excessive damage to the tissue, effectively performing an epinephrine injection without the use of a traditional needle. Additionally, the product will be designed with reusability in mind. The needleless injector will employ a reloadable cartridge system and a levered cocking mechanism to eliminate waste and reduce costs associated with current single-use devices.



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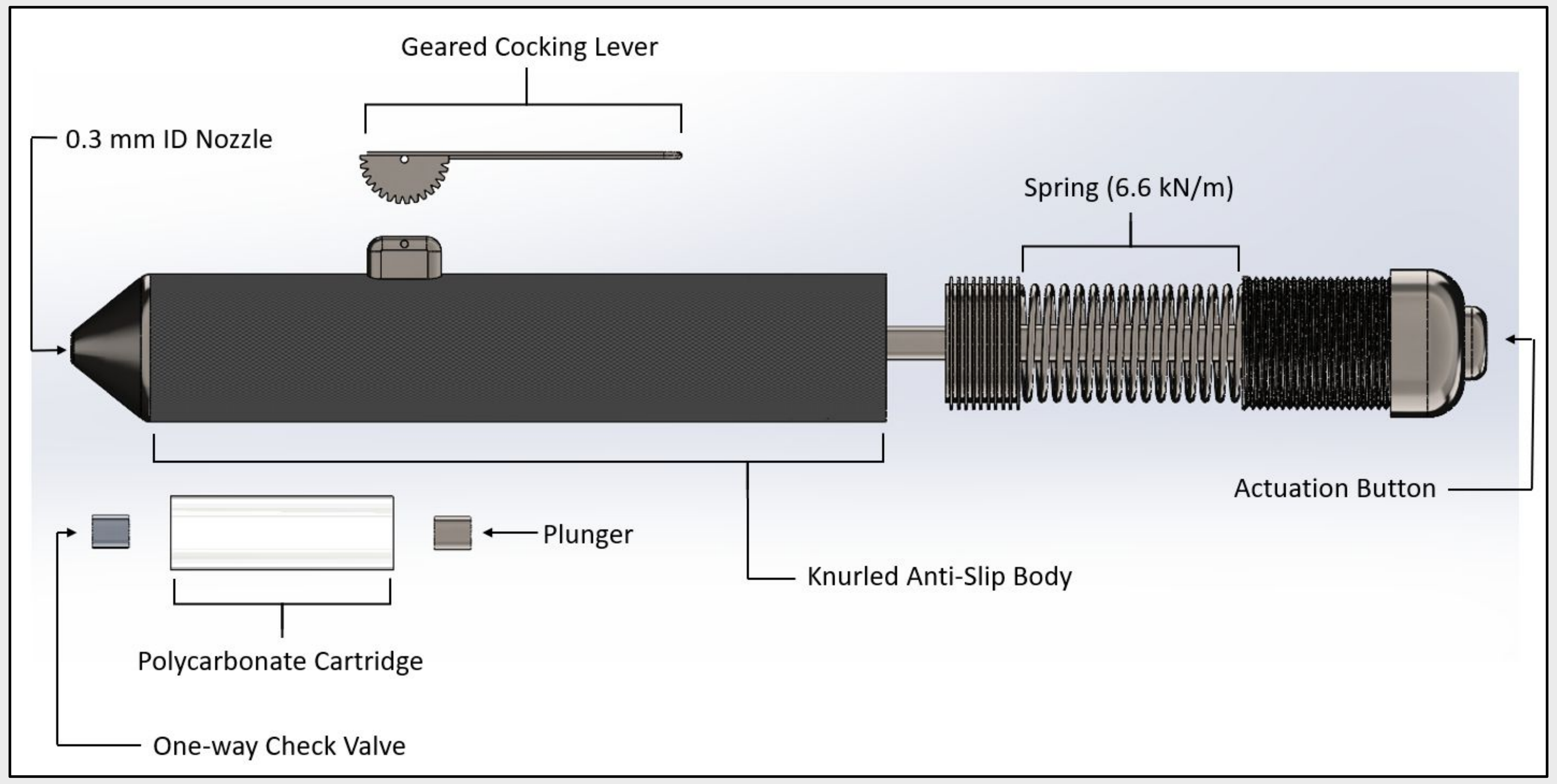
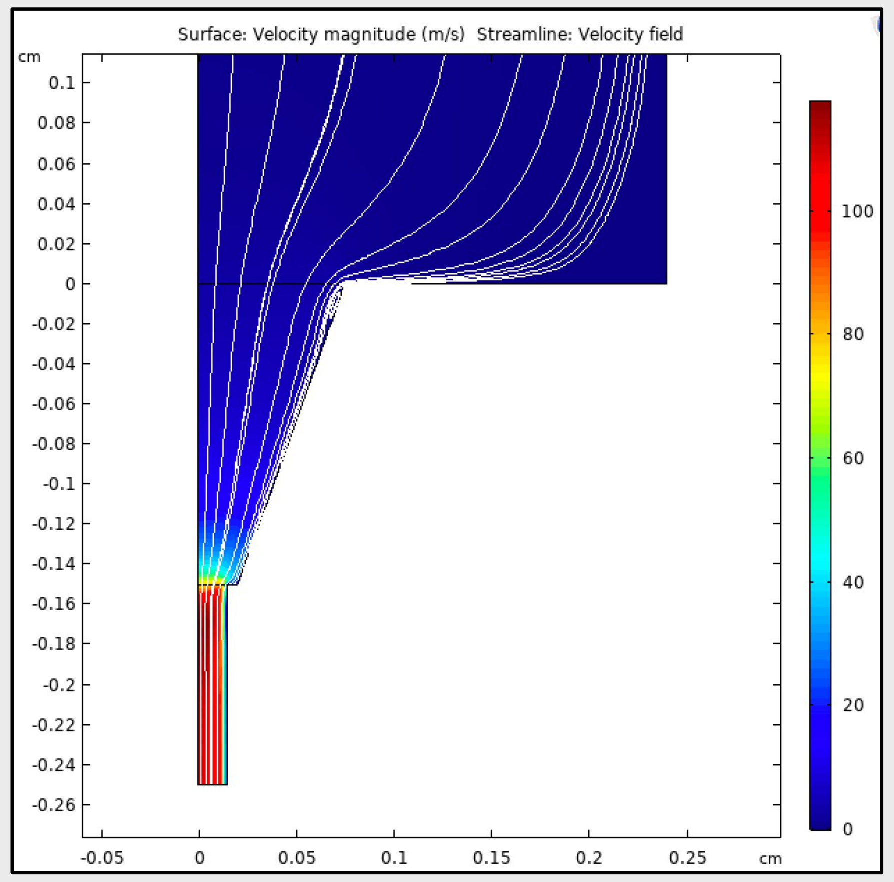


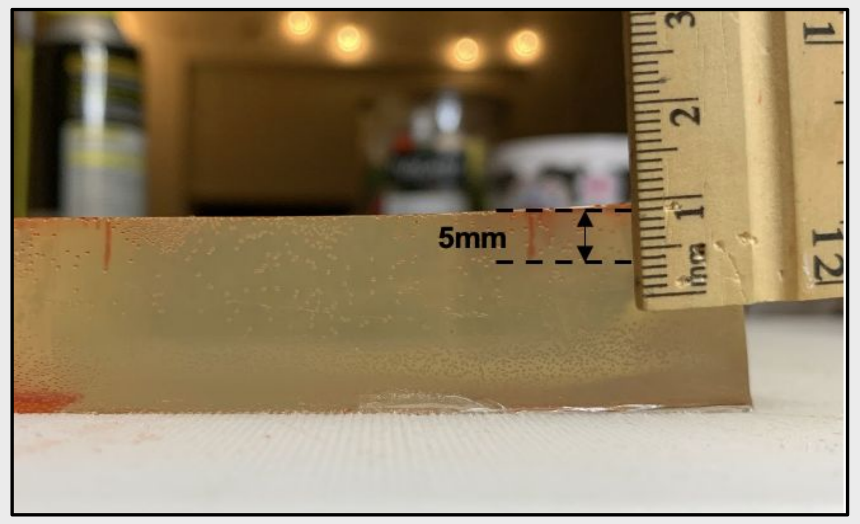
Key Features

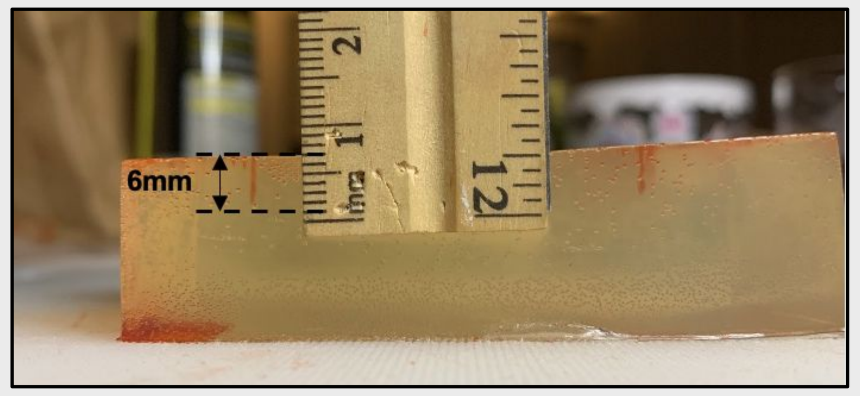
- Body, Nozzle, Cocking Lever, and Actuation Button mechanism made of 316 SS to improve reusability through increased durability, cleanability, and corrosion resistance.
- Knurled outer surface to increase grip.
- Polycarbonate cartridge housing 0.3 mL of epinephrine solution.
- Geared cocking lever to reduce the force required to cock the spring
- 6.6 kN/m spring providing mechanical power to the fluid, making the device effective in virtually every environment.
- One-way check valve to reduce backflow and to provide a seal for the epinephrine solution when not in use.
- 0.3 mm ID nozzle to provide adequate velocity ramp-up to ensure a high enough ejection velocity.
- PTFE coated plunger to reduce friction and improve ejection velocity.

Testing & Results



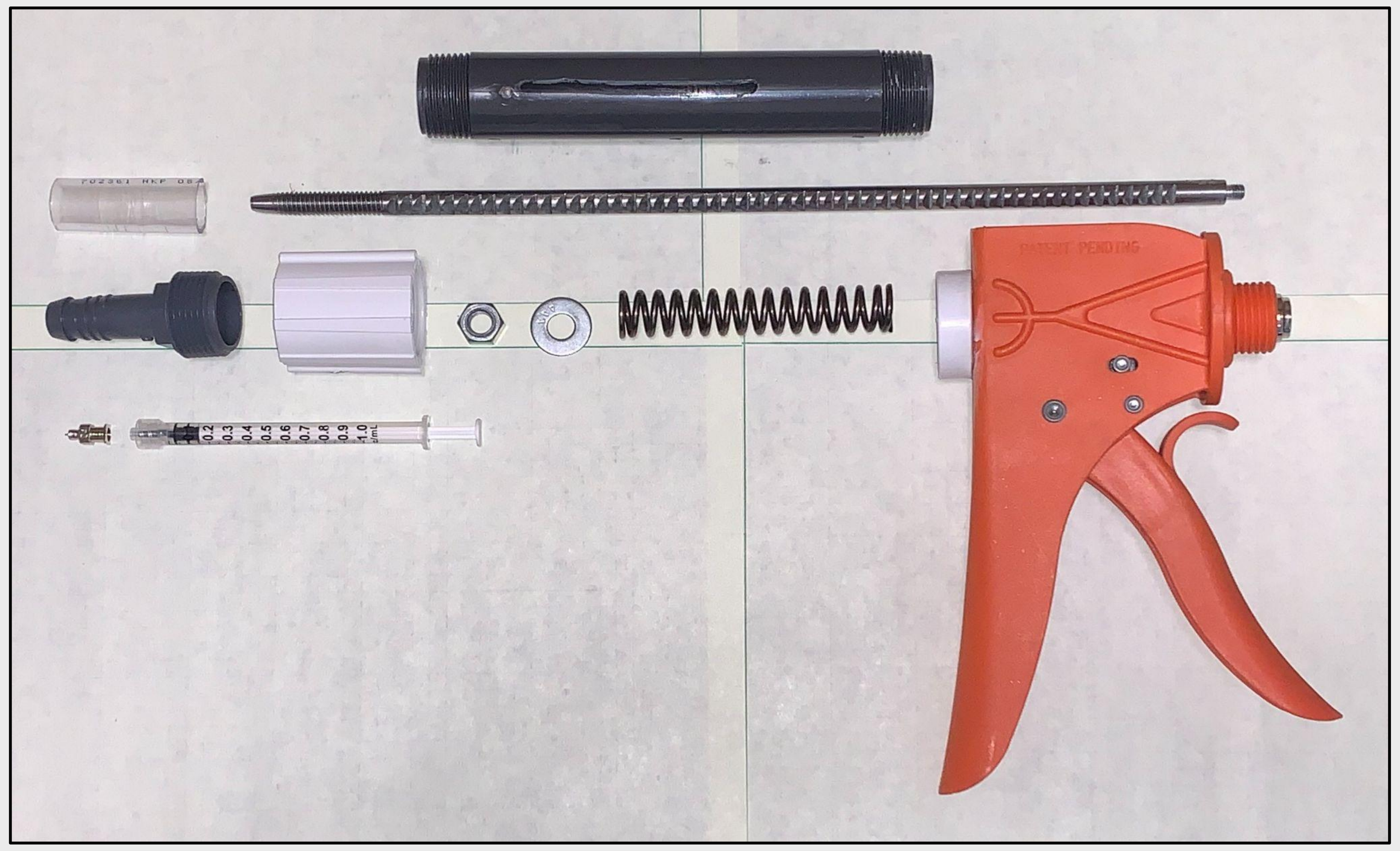
Using mathematical relationships from a collected set of literature, it was determined that an exit velocity of ~100 m/s would be required for subcutaneous injection. Using COMSOL to model the cartridge and nozzle of our device, we were able to approximate the pressure/force needed to eject fluid at the required speed. Additionally, the information provided by the simulation allowed us to calculate the necessary force output of our spring-driven mechanism.





As a proof of concept, a physical prototype was created with similar geometry and spring characteristics of EpiNex. On a gelatin based tissue analog, a penetration depth of 5-6 mm was achieved rather than the desired penetration depth of 10-20mm. This can be attributed to excessive friction due to mechanisms present only in the physical prototype. Thus, we suspect EpiNex to achieve necessary penetration depths with some small improvements to the design.

Physical Prototyping



Insights and Future Directions

With the results from our physical tests and the issues revealed through video analysis, we are able to offer some potential improvements to this device in order to make it operate more effectively. Some observed issues in addition to potential improvements are:

Issues

- Friction
- Recoil/Kickback
- Spring Toughness
- Consistent Injections/Reliability
- Durability

Improvements

- Wider syringe (Less travel distance)
- Smoother mechanism
- Eliminate standoff distance
- Refined trigger mechanism (instead of twisting/turning)
- Redesign for a single spring and nozzle