Engineering Expo Summary

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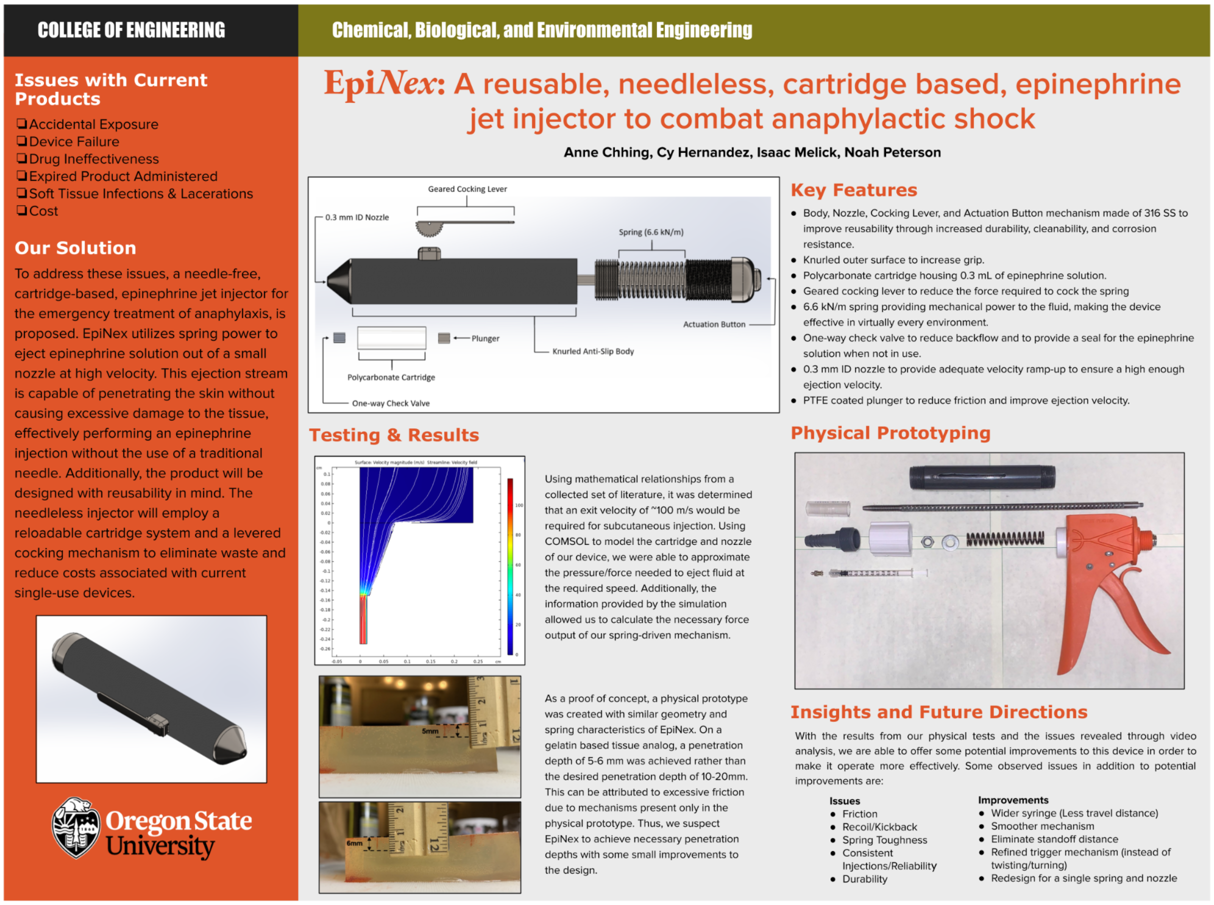
Project Description

For several years, epinephrine has been the primary treatment to address severe allergic reactions through needle-based autoinjectors such as the EpiPen, Auvi-Q, and Symjepi. However, there have been serious complications associated with these types of injections in previous years. For instance, these autoinjectors have been recalled by the FDA due to reported complications, such as accidental exposure, device failure, drug ineffectiveness, and lacerations due to embedded and hooked needles. Altogether, these complications can cause a delay in epinephrine administration and put an individual at serious risk. Additionally, needle-phobia can severely hinder effective injections. Finally, EpiPen and similar devices have seen dramatic price increases, making proper prevention and treatment out of reach for some individuals.

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.

Accomplishing our project goals involved a combination effort focused on modeling and prototyping different aspects of the device design towards understanding the feasibility of our intended design. To help facilitate succeeding prototyping efforts, modeling of some key design parameters was necessary to expand our understanding of phenomena occurring during device usage.

Project Poster



Audience Summaries

1. Other Bioengineers

For several years, epinephrine has been the primary treatment to address severe allergic reactions through needle-based autoinjectors such as the EpiPen, Auvi-Q, and Symjepi. However, there have been serious complications associated with these types of injections in previous years. Plagued by recalls from the FDA for complications such as accidental exposure, device failure, drug ineffectiveness, and lacerations due to embedded and hooked needles, these complications can cause a delay in epinephrine administration and put an individual at serious risk. Additionally, needle-phobia can severely hinder effective injections. Finally, EpiPen and similar devices have seen dramatic price increases, making proper prevention and treatment out of reach for some individuals.

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. Reusability in mind, needleless injection will eliminate bodily contaminates by utilizing a reloadable cartridge system and mechanical priming mechanism to eliminate waste and reduce costs associated with current single-use devices.

Accomplishing our project goals involved a combination effort focused on modeling and prototyping different aspects of the device design towards understanding the feasibility of our intended design. Variables of interest included depth of penetration of a therapeutics jet into the skin, velocity of the fluid upon exit from the device, and the pressure force required to cause the requisite exit velocity. Using the data provided from these models, we investigated three prototypes that would advance our goal of developing a comprehensive physical design. Employing modeling software SolidWorks and COMSOL for our first two prototypes, models of our design were tested to ensure their intended functionality. SolidWorks allowed for a complete model of our final product design to be sized and enabled tests of moving components like the priming lever to ensure the proper range of motion was achieved, while COMSOL facilitated modeling of the therapeutics cartridge using some of the parameters previously determined. Our final prototype involved physical modeling of the injection mechanism where the force generating component was combined with a therapeutics delivering agent which enabled testing the effectiveness of the delivery method.

Overall, our final design changed a bit from our initial goals for the project in light of what was learned along the way. Moving forward we would continue working on physically prototyping the injection mechanism to ensure its function and reliability before moving towards a final product design. Additionally, there would be difficulties in reusing the cartridges like we originally intended. Furthermore we feel this product has potential for adaptation into other therapeutics delivery markets.

2. **Public Adults**

For several years, epinephrine has been the primary treatment to address severe allergic reactions through needle-based autoinjectors such as the EpiPen, Auvi-Q, and Symjepi. However, there have been serious complications associated with these types of injections in previous years. Plagued by recalls from the FDA for complications such as accidental exposure, device failure, drug ineffectiveness, and lacerations due to embedded and hooked needles, these complications can cause a delay in epinephrine administration and put an individual at serious risk. Additionally, needle-phobia can severely hinder effective injections. Finally, EpiPen and similar devices have seen dramatic price increases which make proper prevention and treatment out of reach for some individuals.

To address these issues, we proposed a needle-free, cartridge-based, epinephrine jet injector for the emergency treatment of anaphylaxis. EpiNex utilizes spring power to eject epinephrine solution out of a small nozzle at high velocity, capable of effectively performing an injection without the use of a traditional needle. Reusability in mind, needleless injection will eliminate possible bodily contamination by employing a reloadable cartridge system and mechanical priming mechanism to eliminate waste and reduce costs associated with current single-use devices.

We began with concept generation steps that helped to develop an achievable project idea. This concept was developed further through mathematical modeling efforts. Modeling gave us a better understanding of different aspects of the device while helping to define some unknown factors such as fluid stream speed, plunger force, and depth of medication delivery. From this work we moved into prototyping where more sophisticated mathematical models were evaluated along with the development of a physical prototype that allowed for a few different device components to be tested simultaneously. This mock-up furthered our understanding of the feasibility of the design along with insights into how the design needed to be adjusted moving forward.

3. **Grade School Students**

EpiPens are devices that stop allergic reactions by injecting a liquid drug into your body. Having a severe allergic reaction can be really scary, especially if you have to stab yourself in the leg with a needle to stop it, like with the EpiPen. EpiPens are also really expensive and often end up not working when they are needed. Our solution to these problems is EpiNex, a needle free device that can stop allergic reactions.

EpiNex is very similar to EpiPen, but does not use a needle. Instead of having to stab oneself to inject the allergy stopping chemical, EpiNex shoots it directly into the body, making its own injection. It does this by using a spring, kind of like the one inside a pellet or BB gun, to push the liquid chemical out at over 220 MPH, which is faster than the top speed of many high performance cars like Ferraris and Lamborghinis. Even at this high speed, the injection is considered to be less painful than a traditional needle.

Our goal for this project was to make a computer model of EpiNex, perform some engineering tests on this model, and make a real-life model to see if we could get injections into fake skin. We believe that we were successful in achieving these, with our results seen on our poster. Some highlights include images of our computer model, computer-based engineering analysis using some different programs, and finally our real-life model, where injections were made into fake skin. Pig skin makes a surprisingly good substitute!

Thanks for looking!