Device for Administration of Intra-ocular Injections

**Department of Biomedical Engineering –
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BME 301

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Abstract
This paper explores a number of different design possibilities for modifications to an existing syringe to allow for the user to depress the plunger with the fingertips near the tip of the syringe. Both single use and reusable solutions are presented. The two main mechanisms for applying the needed force to depress the plunger are air pressure and the use of a spring. A locking mechanism will be used to allow the doctor to stop an injection at any time during the procedure. After considering all of the possible ideas, a reusable device was chosen as the best solution due to the fact that it would be the most user friendly and cost effective.

Problem Statement:

To design an attachment to an existing syringe to allow for a doctor to control the plunger from the tip of the syringe, allowing one person to administer injections into the vitreous body of the eye.

Background information:

Doctors are currently treating many eye conditions that deal the posterior surface of the eye, such as the retina, including age-related macular degeneration, ocular inflammatory disease, branch and retinal vein occlusion, and diabetic macular edema. In the past, medications were either given in pill form or as drops onto the surface of the eye. However, these approaches often proved to be ineffective in delivering the correct amount of medication to the back of the eye and exposed the body to possible side effects corresponding to the particular medication. In order to target the back of the eye more effectively, doctors began administering medications directly into the vitreous body of the eye with a 1cc syringe. The patient is given a topical anesthetic and sterilizing eye drop before the syringe in depressed into the eye 4 mm from the outside of the iris. The doctor uses one hand to stabilize the eye and the other to hold the syringe similar to a pencil. An assistant is then required to depress the plunger at the back of the syringe to inject the medication in the eye. Typically between 0.1 and 0.3 cc of medication are injected into the eye. These injections allow the doctor to place the medication directly at the problem site and minimize the amount of side effects on the body due to the medication. (Dr. Blodi; 02/05/02)

Description of product function:

The problem with the existing procedure in administering intra-ocular injections is that it requires the assistance of another person to inject the medication. This practice brings about the possibility of miscommunication between the two people, which could result in damage to the eye of the patient. The client is looking for a device that will allow a single doctor to administer the injections with one hand, allowing their free hand to stabilize the eye for safe and effective medication injection.

The product will inject medication into the vitreous body of the eye through minimal movement of the hand supporting the syringe and without the previously required help of an assistant. This product will use the existing 1cc syringe, as specified by the client, with the typical injection volume of 0.1cc to 0.3cc. The modification to the syringe should be easily operable with a single hand and will be easily reusable without contamination. The device should inject the medication at a slow and steady rate, allowing the doctor to stop the injection at any time during the procedure. The medications being injected often differ in viscosity, so the device should be able to apply a large enough force to push a number of different medications at an even rate.

Alternative solutions:

Hydraulic Pressure Pump:

Placed on the existing syringe is a small finger tip sized air bladder with a small hose coming out of the air sac and going into an air tight chamber in the shaft of the syringe. A sketch of this is seen below in Figure #1. This airtight chamber will fill up with pressure by pumping the bladder with a stationary index finger and create a force on

the sliding portion that moves the medicine down the syringe. The faster one pumps with his/her finger the faster the injection and it is the same for when pumping is administered slowly. This helps to deliver the shot at a variable speed. This attachment would have to make a seal on the top each of the syringes and could not be reusable. This design was not seen as very feasible due to the amount of modifications that would need to be done to the existing syringe as well as the fact that it would not be a reusable solution.

Spring Operated Administration:

This system incorporates a spring driven syringe plunger and a pivot displacement mechanism. A spring would be attached to the bottom portion of the top of the plunger and at the end of the syringe opposite to the needle (as seen in Figure #2). This spring would have a high spring constant (k) so it could deliver a large force to the plunger for the administration of the medicine. This plunger would be stopped by a strong cylindrical material located on the outside of the syringe with an arrangement of several teeth-like structures protruding perpendicular to it; catching the plunger at each click. This clicking mechanism is created by the pivot point operated by the fingertips on the outside surface of the syringe. By pressing the button by the index finger, it allows the cylindrical part to lose its hold on the plunger and cause the spring to pull in plunger down. When the index finger takes the force off the cylindrical part goes back to its normal position and catches the top of the plunger, which can vary the speed of the injection. This design is not reusable because of the attaching of the spring to the existing syringe and the placement of the pivot on the side on the syringe would need to be applied to each individual syringe. This design could be modified to place the spring

and locking mechanism in a number of different positions to better suit the application as needed.

Reusable Case Mechanism:

A larger syringe or plastic tube is the starting point to this design alternative. The tube would need to be cut down the longitudinal side of the shaft, creating two different halves. A hinge would then be used to attach the two halves together and allow for the tube to be opened and shut and a locking mechanism on the opposite side would allow the tube to remain closed. This larger capsule will be large enough to encase the existing syringe and this is shown below in Figure #3. The device will have a spring in the back that will be used to apply a force to the plunger, administering the medication. A button will be located at the tip of the device that will be controlled by the fingertips of the hand holding the syringe. A locking mechanism will hold the spring in place and will be disengaged when the fingertip depresses the button, allowing the medication to be administered into the patient. If the doctor releases the button at any time, the locking mechanism will re-engage, stopping the plunger and thus stopping the injection.

In order to use this device, the spring will first have to be “cocked” by locking the spring plate (plate below the spring which transfers the force of the spring to the plunger) in position. The loaded syringe will be placed in the larger tube. The larger tube will then be shut and locked into place. The device is now able to administer the injection. Once the injection is through, the doctor will simply open the larger tube and remove the used syringe and dispose of it.

Proposed Solution:

The solution that was chosen was the reusable case mechanism. The main criterion for this choice was the fact that this design is reusable. This will allow the client to use the same device multiple times without making alterations to each existing syringe. Also, this solution will not require the doctor to make alterations to each individual syringe, which would be both time consuming and expensive. This solution allows the doctor to load and dispose of the existing syringe as they normally do.

Potential problems and possible resolutions:

One potential problem with a reusable device is making sure that the device does not become contaminated and transmit disease, bacteria, and/or viruses between patients. The device may need to be sterilized so the materials should be able to withstand such a treatment.

Future Work:

During the rest of the semester, we will work to design an appropriate locking mechanism to be used with the spring in the reusable case design. Also, research has to be done to determine the correct type of spring that needs to be used to apply the correct amount of force to inject the various medications. Once these aspects have been solved, a prototype will be designed and constructed for testing

Appendix 1 -

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Product Design Specifications

Title: Device for administration of intra-ocular injections

Function: Develop a syringe that allows for a safe and efficient means of injecting medication into the vitreous cavity of the eye.

Client requirements:

- Allow for thumb and forefingers to be close contact to the tip of syringe
- Inject medication at a slow and steady rate
- Allow user to stop injection during procedure
- Roughly the same size as the existing syringe
- External and detachable from the existing syringe to allow for multiple uses without contamination

Design requirements

1. Physical and Operational Characteristics

a. *Performance requirements*: Attach to existing syringe and deliver medication at a slow and steady rate while the needle is being held in the eye.

b. *Safety*: Must not affect the doctors ability to hold the syringe steady while injecting medicine.

c. *Accuracy and Reliability*: Inject medicine at a slow, steady rate. Device should also allow user to stop injection at any time.

d. *Life in Service:* Multiple uses, not specified by client.

e. *Shelf Life*: N/A

f. *Operating Environment*: Normal medical clinic conditions.

g. *Ergonomics*: Device should be easy to use and require the use of only one hand.

h. *Size*: Attach to existing syringe, fitting easily in the palm of average hand.

i. *Weight*: Very light (less than one pound)

j. *Materials*: Materials should be non-hazardous

k. *Aesthetics*, *Appearance, and Finish*: Should be professional looking

2. Production Characteristics

a. *Quantity*: One (prototype)

b. *Target Product Cost*: $200 – 300 for a reusable device

3. Miscellaneous

a. *Standards and Specifications*: Needs to be certified as safe to use in clinical settings

b. *Customer*: Ophthalmologists who give intra-ocular injections

c. *Patient-related concerns*: Must allow doctor to use easily with one hand

d. *Competition*: None known, but currently searching patents