Fiberoptic Microneedle Device
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WeARE Research Area

This research focuses on the development of a device that is capable of both delivering drug and laser energy through a sharp catheter. The design parameters involving this development are light coupling efficiency, maximum light and fluid transfer rate and needle insertion force.

Motivation or Background

Traditional drug administration experiences poor infiltration as a result of limitations regarding current devices, this can result in insufficient delivery of drug to the necessary cells. It was observed that in the treatment of Malignant Glioma that local photo thermal heating increases the volumetric dispersal of drug significantly. Thus a device was conceptualized to provide both the drug delivery and the administration of laser energy.

Objectives

1. Achieve superior levels of light transmittance between the solid core and the hollow core fiber optics
2. Construct testing prototype
3. Analyze the capabilities of the device in terms of coupling efficiency, light and fluid transfer, insertion force, etc.

Methodology

This device takes a fluid capillary and a solid core fiber optic and leads them to the tip of the device, wherein then the solid core fiber optic is merged to the hollow core, transferring the laser energy to it. The capillary then feeds liquid into the center of the hollow core fiber optic, allowing it to transmit both liquid and laser energy at the tip. This setup is preferred over running a fiber optic within a capillary for the entire length because of potential unwanted interactions between the laser and the drug in addition to other potential structural issues.

Various tests were conducted to determine this devices capabilities. Each test was designed and conducted within the lab using various sets of equipment such as flow meters and force meters. The light transmittance tests were conducted using a laser setup in a specialized laser room. Efficiency was found by comparing the power measured on the output of the device and comparing it to the power being input, with the maximum power being the magnitude the device could deliver before the fiber optic joint fails.

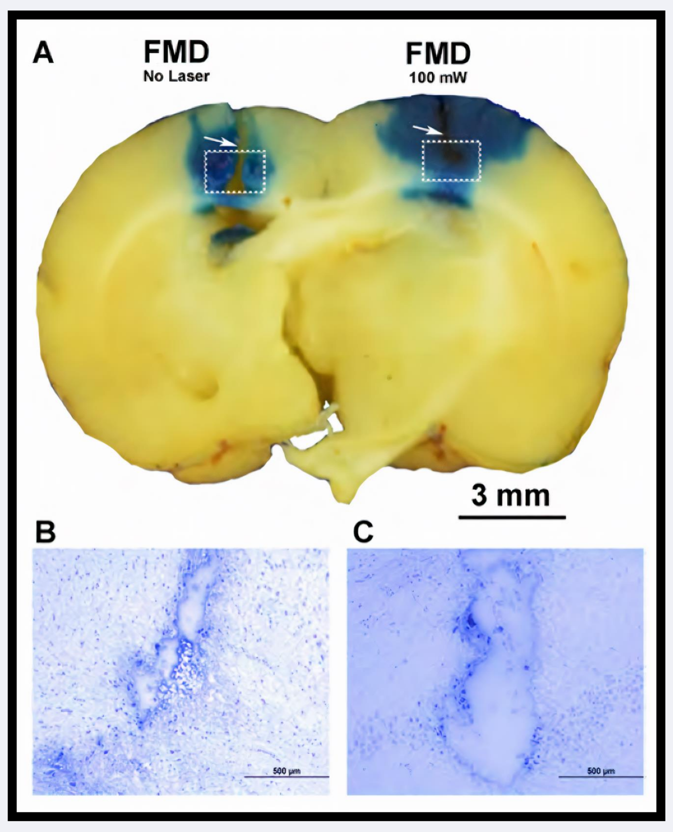

Fig. 1
FMD–CED infusion of EBA into rat cerebrum

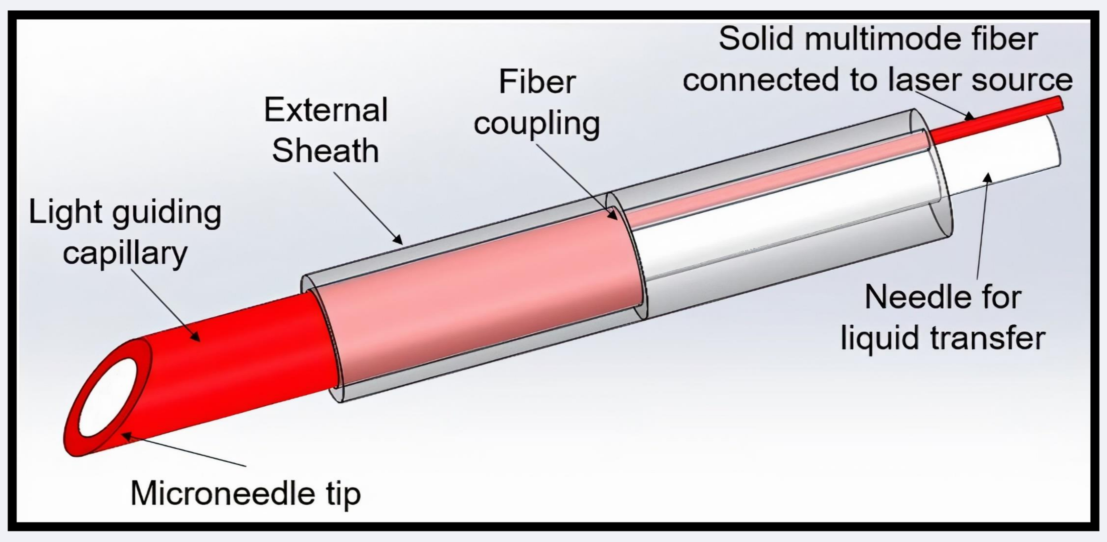

Fig. 2
Model of Fiberoptic Microneedle Device

Results

- A light coupling efficiency of 75%
- Determined that FMD has 45% more hydraulic resistance than just the capillary
- Maximum light transmittance of 1.1W
- Maximum fluid transfer rate of 13 ml/min
- Needle insertion force of <7N for a 45 degree needle and <5N for a flat end needle

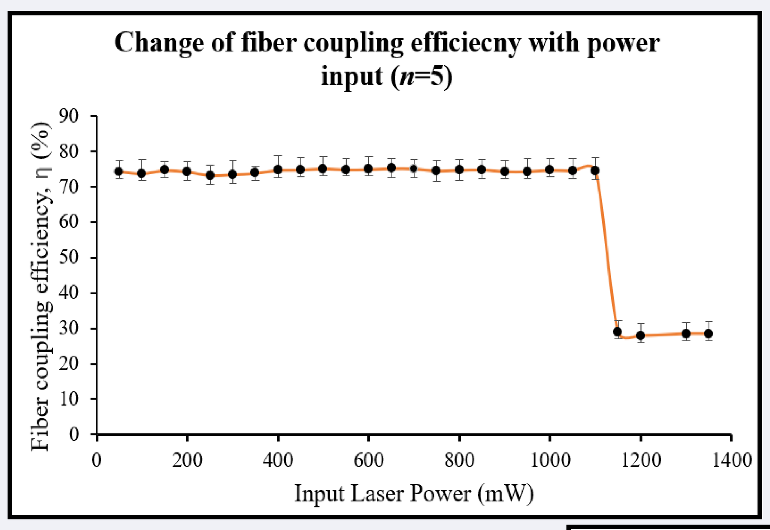

Fig. 3
Testing of Light Transmittance

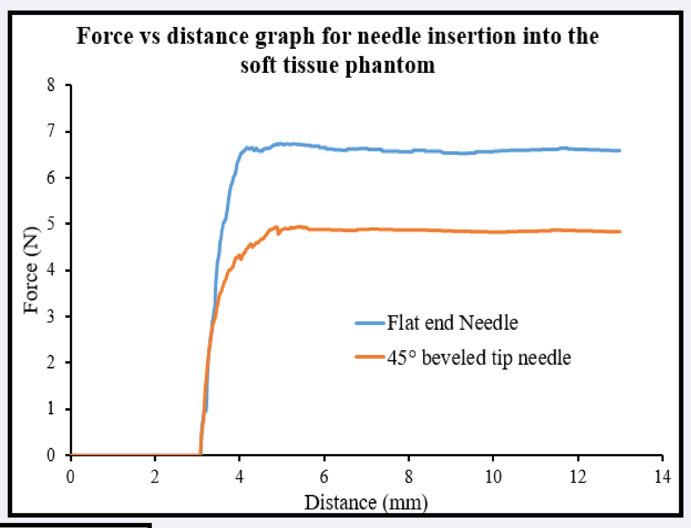

Fig. 4
Testing of Insertion Force

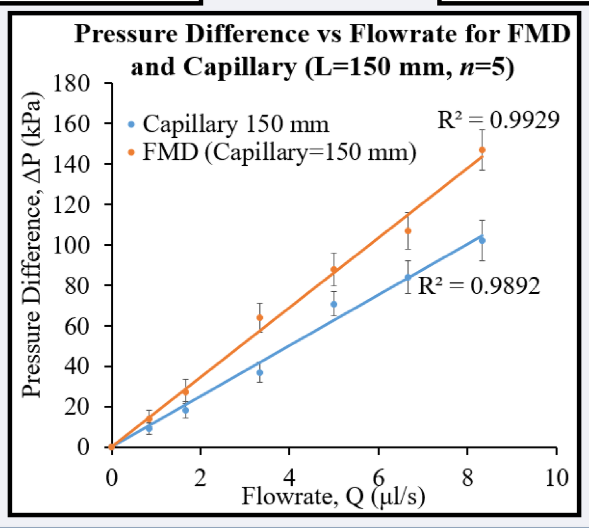

Fig. 5
Testing of Flow Rate

Skills and Experience

- Handling, polishing and fusing of fiber optic strands
- Development of experimental setups to test various features
- Analysis of data including associated errors and sample sizes

What I Learned

I learned about the device prototyping process and how to properly record and analyze data. In addition to the experience I now have working with fiber optics I also gained substantial knowledge into how the research submittal and approval process operates.

Future Plans

This device has been proposed in the treating of pancreatic cancer, to this end, testing for light transmittance, reflectance, and absorbance has begun on pig pancreas tissue. Measurements of the beam intensity using a mathematical model, in addition to measurement of thermal properties with the tissue through photothermal, heating are also planned.

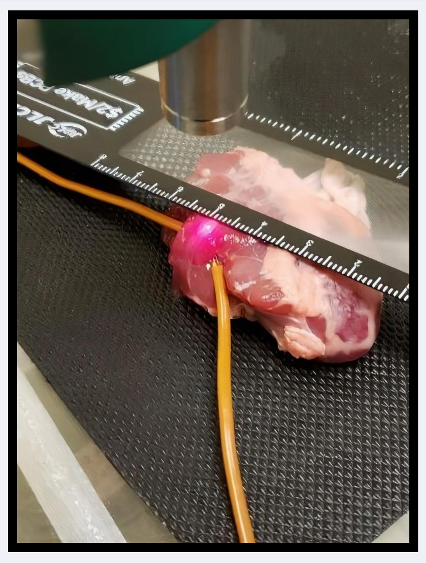

Fig. 5
Testing of Pancreas Tissue Temperature Rise

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References

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