Nose-to-Brain Drug Delivery using Electric Guidance

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Abstract
The olfactory region is an optimum location for nose-to-brain drug delivery as it allows a more efficient means for the drugs to enter the central nervous system. However, with traditional nasal drug delivery devices, only a small fraction of particles can be deposited in the olfactory region, located at the top of the nasal cavity. The objective of this study is to design and build an electric-guided drug delivery system that consists of an induction charger, a vibrating mesh nebulizer, and an air compressor. The purpose of the induction charger is to positively charge the drug particles. When released, the particles will be attracted to the olfactory region inside the patients nasal cavity under an external electric field. This method would result in a more accurate way of dispersing drugs to the olfactory region, resulting in improved therapeutic outcomes and reduced adverse side effects.

This study focused on experimental design and testing of an electric-guidance delivery system. To find the most effective electric field the tests were done using a modified dry-powder coating gun, electrodes, and a plastic nasal model to evaluate the effectiveness of the induced electric field guidance within the nasal cavity model. During our testing, two breathing modes were simulated to see which demonstrated higher deposits of particles to target areas within the nasal cavity: normal breathing and bi-directional; bi-directional mimics the behavior of the nasal passage as the soft palate closes during exhalation through the mouth. A sectional nasal cavity model was manufactured with 3-D printing and consisted of 5 pieces, including the right and left side of the nose, the rear air passageway, and the olfactory region split into a right and left side. In doing so we were able to calculate the deposition of particles that reached the olfactory region and calculate the percent deposition in the olfactory region.

Our results show that under normal breathing conditions, the dry-particle tests without electric guidance yielded depositions of approximately 1% compared to a range of 7-12% deposition with the use of the electric field. Bidirectional dry-particle tests, without the use of an electric field, yielded a 5% deposition rate in the olfactory region. In comparison, the incorporation of electric field guidance resulted in increased deposits to a range of 14-18%. The current findings suggest that a combination of bi-directional breathing and electric field guidance may lead to more efficient drug delivery devices. Consequently this research could reduce cost and waste associated with medications intended for the central nervous system.