Controlled Olfactory Delivery Using Magnetophoretic Guidance

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Abstract

Background: Even though the direct nose-to-brain drug delivery has multiple advantages, its application is limited by the low delivery efficiency (<1%) to the olfactory region with standard nasal devices. Novel delivery techniques are needed that can deliver clinically relevant dosage to the olfactory region. Our previous study has demonstrated that it is highly challenging to control ferromagnetic particles in a magnetic field due to the attractive force between a particle and the magnets. There will be a negligible force when the particle is far from the magnet, exerting no effective control on the particle motion; however, once the particle starts to move toward the magnets, it will moves faster and faster as the attractive force is in reverse proportional to the distance.

Objective: To create a magnetic track to guide drug particle towards the olfactory region without physical wall contact. There are three specific aims in this study:
1) Evaluate the feasibility of diamagnetic control in a 2D curved channel and identify the appropriate magnet strength for effective controls.
2) Identify the appropriate magnetic field intensity and the sizes of drug carrier in a 3D curved tube.
3) Identify the appropriate magnetic field intensity and particle parameters in a 3D anatomically accurate nose model.

Methods: The COMSOL Multiphysics® software was used in this study. Three modules (the Optimization Module, the AC/DC Module, and the Particle Tracing Module) will be implemented to simulate the airflow and particle motions. The influences of airflow, magnet layout, magnet strength, drug-resale position and initial velocity, and particle diameter on the olfactory dosage were tested. Clinically, the ferro-fluid in the nose will be generated by nasally inhaling nano-sized ferromagnetic particles, which will suspend in the nose. To prevent the nanoparticles from entering the lung, mouth breathing should be exercised during the drug delivery.

Results and discussion: Results in the 2D curved channel demonstrated that it is practical to guide a micrometer particle through the curve without wall contact. The magnet strength is at the magnitude of 104 A/m, which is well lower than 1 tesla (~107 A/m). On-going efforts are taken to test the feasibility of particle control in 3D geometries. Our preliminary 3D results showed that particle diameter was a critical factor in controlling its motion. The ideal particle size was found to be approximately 15 µm for efficient guided by

magnet track, while smaller particles have less interaction with magnet track and larger particles have larger inertial impaction to resist magnetic guidance. 3D modeling still remains challenging due to different magnetic layouts and magnetic field directions for ideal olfactory drug delivery.