“MRI-compatible Head Holder Device” - Design Excellence Award Executive Summary

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BME Design Excellence Award Executive Summary

Parkinson's disease is an incurable degenerative brain disorder largely affecting the elderly population that decreases the dopamine levels in the brain. The use of Convection-Enhanced Drug Delivery (CED) to overcome the blood brain barrier by direct infusion via catheter to the brain is being researched as a method of restoring dopamine in the brain tissue. Currently, real-time magnetic resonance imaging (MRI) is being used in conjunction with the CED procedure in order to effectively monitor the infusion. High quality images require the use of the additional carotid coils (similar to a large pair of headphones). Since the desired antenna array rests against the testing subject’s ears and temples (beagles and rhesus monkeys), other head holders for similar drug delivery experiments cannot be used due to the ear bars, which are commonly used to restrict the movement of the animal’s head in the x-, y- and z-directions. The procedure requires that the animal be removed from the head holder and returned to the same position later in the procedure. It is important that the head holder restricts the translational movement of the head to 1 mm or less, be entirely MRI-compatible and compatible with the current experimental setup.

A redesigned head holder device has been fabricated out of high-density polyethylene (HDPE) with modified ear bars that can be positioned under the carotid coils and adjusted on a sliding track. The ear bars are made from one piece of solid brass, designed with a thicker base that slides on the HDPE headrest and is secured using a thumbscrew through the long axis of the ear bar. These ear bars were designed to slide into a complementary grooved track built into the headrest to prevent rotational and lateral movement. This design meets the most challenging client requirements of restricting the translational movement error margin to 1mm and allowing for reproducible positioning due to its similar structure to current head holders. The device has been tested for tolerances to translational movement in the x-, y-, and z-directions by using still photography, pressure gauges to measure the force causing the skull’s displacement, and ImageJ (NIH). The images were used to measure the distance to a reference point, which was then compared to a baseline distance. The reproducibility of the device was tested by taking a baseline picture, removing the model skull, and then replacing and photographing the skull once again. The displacement of the skull in each image was measured using the baseline image. This design enables real-time CED testing within the MRI machine, which is integral to Parkinson’s disease research.