301 - Excellence - 31 - Mice Brain Holder for MRI - Executive Summary

Mice are progressively becoming more dominant than rats for clinical models due to the “much larger genetic toolbox for mice” according to Ellenbroek and Youn’s “Rodent models in neuroscience” in 2016. The client, Dr. Yu’s lab studies the microstructure of murine brains with clinical models for genetic diseases, neurological diseases, and drug interventions. They also are responsible for analyzing brains from other UW Madison research departments. These analyses are done by 18 hour $500 MRI scans that can only fit 6 ex vivo mice brains per scan. During the scan, the brains are submerged in fluorinert because any air touching the surface of the brain distorts the image and causes black marks on the image. The client currently uses 6 syringes taped together to hold the mice brains. Competing designs are similarly laborious or costly. For example, one method consists of 3D scanning and printing a mold for each individual unique brain, a technique used by Joseph R. Guy and Pascal Sati in 2015.

This project aimed to create a device that maximized the number of brains per scan in the 37.29 mm microMRI bore, orient the brains along the same axis within 2 degrees despite constant vibrations from the machine, eliminate all air bubbles directly touching the surface of the brain, and produce a functioning product that can be replaced by the client if need be.

The design process started with measuring of ex vivo brains given by the client. These measurements were then used to create an array of shapes to test for the ideal cross section of the cylindrical holders. An oval-like shape named “canted” was discovered to have the best fit. The cylinders were then integrated into a single piece of plastic that was the diameter of the MRI bore, resembling a revolver cylinder. This integrated capsule then went through many iterations to end with 8 holes with a “canted” opening on one side and an air-fluid outlet on the other side. The “canted” opening is sealed by a #10 O-ring. The air-fluid outlet is sealed by a rubber stopper that tapers to 1 mm and allows for air bubbles to escape during loading. The orientation of the brains is guaranteed by ramps on both sides; one funnel-like ramp tapering down to the air-fluid outlet and one flat ramp at the end of the plug. These ramps match the measured angle and shape of the brains. A loading protocol has been written to outline a process that is designed to prevent air bubbles from being trapped inside the capsule. The product was designed in SolidWorks, then 3D printed in waterproof FormLabs clear.

The product has been validated in collaboration with the client. The integrated cylinder was tested with sample brains to make sure fluorinert was sealed, bubbles were minimized, and orientation was guaranteed. Orientation was verified initially by using ImageJ. Following this, the client would perform short 10-15 minute MRI scans to verify that the orientation was correct, no air bubbles were obscuring the image, and that a sufficiently high definition image was obtained. The product increases the throughput of the client by 33.3% and decreases the cost to scan each brain by 25.0%. The higher throughput will improve the quality of the client’s research. It will allow for the testing of more mice specimens which will increase the statistical significance of their findings and contribute to the significance of the interventions they are testing.