Public Abstract
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The purpose of this project was two-fold. One, to test the accuracy and usefulness of a clinically unused dose calculation algorithm for the Leksell Gamma Knife Perfexion radiosurgery unit that accounts for heterogeneities in the patient volume. This process included designing, fabricating, and testing a novel phantom from idea stage through production and use. Two, to facilitate and provide dosimetry for irradiating a large number of mice and rats to develop a murine model of radiation induced necrosis in the brain.

To test the dose calculation algorithm, we used a commercially available anthropomorphic head phantom and EBT2 radiochromic film to evaluate predicted vs measured dose delivery for the clinically accepted algorithm, which assumes a homogeneous treatment volume, and the convolution algorithm, which takes into account heterogeneities within the treatment volume. In addition, we designed and fabricated a novel phantom that could accommodate various heterogeneities along with EBT2 film and an ion chamber. We again evaluated predicted vs measured dose with varying material configurations for both algorithms. To assist the murine necrosis model, we developed a novel mouse positioning and irradiation system utilizing the Gamma Knife Perfexion that was designed to be accurate, repeatable and efficient. We designed an animal immobilizing planform that could be incorporated into the clinical protocol for acquiring patient image data, image registration, and treatment planning.

We demonstrated that the convolution algorithm is accurate to within a clinically acceptable three percent in cases of extreme heterogeneities, and it is clinically significantly more accurate than the standard homogeneous algorithm when large heterogeneities are present in the treatment volume. In addition, we were able to facilitate the development of a robust murine radiation necrosis model by irradiating more than 1,000 mice to a spatial accuracy of within 0.5 millimeters in all directions and to within five percent accuracy of prescription dose.

During the course of this work we successfully completed two large undertakings that are representative of tasks often asked of a clinical medical physicist. First, to evaluate a treatment delivery option in the radiation oncology clinic and make evidence based recommendations for clinical protocols. And second, to provide a reliable and scientifically sound service to collaborators and outside research groups when physics expertise is required.