

## Dosimetric Evaluation of Interfractional Shift Corrections in Gamma Knife Radiosurgery Using a 3D Printed Phantom

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**Abstract**

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Edward Opalko <sup>1</sup>, Dheerendra Prasad <sup>2</sup>, Matthew Podgorsak <sup>3</sup>

**1.** Medical Physics, Roswell Park Comprehensive Cancer Center/University at Buffalo, Buffalo, USA **2.** Neurosurgery and Radiology, Roswell Park Cancer Institute, Buffalo, USA **3.** Radiation Oncology, Roswell Park Cancer Institute, Buffalo, USA

**Corresponding author:** Edward Opalko, eopalko14@gmail.com

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### Abstract

**Objectives:** Hypofractionated Gamma Knife treatments require daily imaging to determine interfractional shifts in patient positioning. The original plan is recalculated on the registered daily image to correct for positional deviations from the reference CBCT. Patients will experience both rotational and translational shifts, but the treatment planning system can only correct for deviations in 3-degrees by internally adjusting individual shot coordinates to match the original plan. The purpose of this study is to evaluate the system's ability to correct for various patient positions and determine the dosimetric differences between the completed plan and the original dose distribution. Additionally, this study aims to evaluate the use of 3D printing in the design of dosimetric QA phantoms.

**Methods:** A 3D printed insert using PLA was created to modify a commercial head phantom. The water equivalence of PLA was determined by comparing optical densities of irradiated film using solid water and PLA as buildup. Lesions of varying size, shape and location were created on images of the phantom to replicate various clinical scenarios. Seven 5-fraction plans were generated using typical dose objectives. Six combinations of headrests/masks were created to represent different patient positions which were changed between fractions. The 6-degrees of shift determined by the planning system for each setup were recorded along with the altered target statistics. The composite dose distributions were measured using gafchromic film and compared to the original dose distribution using Gamma Analysis.

**Results:** For interfraction corrections, the average deviation for Coverage, Paddick-Conformity Index and Gradient Index across all plans remained essentially unchanged between the completed plan and the original plan. No deviation was greater than 0.01 between the three metrics. Compared to the original plans, the measured distributions produced an average Gamma Passing Rate of 98.3% for 3%/1mm, 99.6% for 2%/2mm 96.3% for 2%/1mm and 92.7% for 1%/1mm. All but two dose distributions produced passing rates above 90%. There were no obvious correlations between passing rates, lesion location and shape, and setup position. For the dosimetric analysis of PLA, the optical densities of the irradiated film at various MU values were found to be equivalent for solid water and PLA.

**Conclusion(s):** The results of this study show that while the interfraction corrections will never be perfect, the adjustments are very close to the original dose distribution and produce clinically acceptable results. The correction algorithm can accurately adjust for various rotations and translations in all clinical scenarios. The optical density measurements of PLA and the results from Gamma Analysis comparisons prove that PLA and 3D printing can be a viable alternative as a water equivalent material in QA dosimetry phantoms.