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Abstract

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Dosimetric Comparison of GammaTile® Implants to Stereotactic Radiotherapy for Recurrent Brain Metastasis Resection Cavities

Roberto Herrera ¹, Rupesh Kotecha ¹, Tugce Kutuk ¹, D Jay Wieczorek ¹, Zachary Fellows ¹, Vibha Chaswal ¹, Vivek Mishra ¹, Michael McDermott ², Vitaly Siomin ³, Minesh Mehta ⁴, Alonso N. Gutierrez ⁵, Ranjini Tolakanahalli ⁶

1. Radiation Oncology, Miami Cancer Institute, Miami, USA 2. Neurosurgery, Miami Neuroscience Institute, Miami, USA 3. Neurological Surgery, Miami Cancer Institute, Baptist Health South Florida, Miami, USA 4. Department of Radiation Oncology, University of Maryland School of Medicine, Miami, USA 5. Department of Radiation Oncology, Miami Cancer Institute, Miami, USA 6. Medical Physics- Radiation Oncology, Miami Cancer Institute, Miami, USA

Corresponding author: Roberto Herrera, robertoherr@baptisthealth.net

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Abstract

Objectives:

Stereotactic radiotherapy (SRT) to resection cavities has been increasingly utilized in the management of brain metastases, with reduced control rates in large cavities and increased risk of radiation necrosis in the setting of prior radiotherapy. GammaTile® (GT) therapy, wherein the resection cavity is lined with collagen tiles embedded with Cs-131 seeds, is a promising new treatment option for recurrent brain metastasis. In this study, we dosimetrically compare the GT biologically effective dose (BED) to BED from multiple external beam radiation therapy (EBRT) platforms using a SRT delivery technique.

Methods:

Five patients (n=5) who underwent GT therapy (60 Gy to 5 mm extension of the resection cavity) to a total of seven cavities were replanned to 30 Gy in 5 fractions using: CyberKnife® (CK), Gamma Knife® (GK), and Intensity Modulated Proton Therapy (IMPT). Post implant MRIs were used to delineate Gross Tumor Volume (GTV)—as represented by the inner wall of the resection cavity (RC) for GT. Absolute doses using TG43-U1 formalism were computed for GT on MIM Symphony™. For all EBRT modalities, the GTV was represented by the rim of enhancement at the edge of the RC and subsequently a clinical tumor volume (CTV) was generated with a 2 mm margin. A setup margin (SM) of 1 mm was added for CK plans, and IMPT plans were planned robustly to 3.5% & 1 mm robustness criteria. Linear quadratic (LQ) modelling ($\alpha/\beta=10$ for CTV and 3 for normal tissue) was used for EBRT modalities and GT. Specifically for the Low Dose Rate (LDR) LQ model of GT, a half-life of 9.7 days, cellular repair half-life of 1.5 hours, and tumor doubling time of 5.4 days were used. Relative Biological Effectiveness (RBE) factor of 1.1 was included in the IMPT dose calculation. Statistical significance comparing BED95%, BED90% to RC+0, 1, 2, 3, 4, and 5mm margins, and V12Gy, V10Gy and V8Gy to normal brain across GT and each of the EBRT modalities were calculated using Wilcoxon- signed rank test ($p < 0.05$).

Results:

For all GT implants, the patient median age was 57 (range, 45-68) years. Patients were implanted with 1.25-3.5 (5-14 seeds) tiles with median RC volume of 3.28 cc (range, 0.08-7.7 cc). For RC+ 5 mm, mean BED90% across GT, CK, GK and IMPT were 44.5+15.0 Gy10, 43.2+4.6 Gy10, 32.9+ 6.7 Gy10, and 46.4+1.1 Gy10, respectively. For RC+ 5 mm, BED95% across GT, CK, GK and IMPT were 39.3+13.8 Gy10, 38.8+4.4 Gy10, 28.0+6.2 Gy10, and 45.0+1.1 Gy10, respectively. For RC+ 0 mm, BED90% across GT, CK, GK and IMPT were 114.3+29.3 Gy10, 71.6+7.3 Gy10, 68.6+ 6.1 Gy10, and 49.3+0.3 Gy10, respectively. No statistically significant difference in BED90%, BED95% to all RC+ [2 to 5] mm volumes were noted, however, BED90% for GT was significantly higher than CK, GK and IMPT modalities to RC+0mm and RC+1mm. Mean V12Gy normal brain doses for GT, CK, GK and IMPT were 69.4 + 53.2 cc, 65.2 + 27.8 cc, 55.4+28.1 cc, and 47.0 + 22.5 cc, respectively. No statistically significant difference was found in V12Gy, V10Gy, and V8Gy amongst all modalities.

Conclusion(s):

This study, with limited patients, indicates that GT is capable of delivering equivalent or higher BED to resection cavities when compared to a SRT approach using either GK, CK, or IMPT and also ensuring similar

normal brain doses.