Dosimetric Evaluation of an MR Linac System Compared to Multiple Stereotactic Radiotherapy Delivery Systems for Large Brain Metastases

Ranjini Tolakanahalli 1, D Jay Wieczorek 2, Yongsook Lee 2, Kathryn E. Mittauer 3, Nema Bassiri 2, Matthew D. Hall 4, 5, Michael D. Chuong 2, Minesh Mehta 6, Michael McDermott 7, Rupesh Rotecha 2, Alonso N. Gutierrez 8

1. Medical Physics- Radiation Oncology, Miami Cancer Institute, Miami, USA. 2. Radiation Oncology, Miami Cancer Institute, Miami, USA. 3. Radiation Oncology, Miami Cancer Institute, Miami, USA. 4. Radiation Oncology, Herbert Wertheim School of Medicine, Florida International University, Miami, USA. 5. Radiation Oncology, Miami Cancer Institute, Baptist Health South Florida, Miami, USA. 6. Department of Radiation Oncology, University of Maryland School of Medicine, Miami, USA. 7. Neurosurgery, Miami Neuroscience Institute, Miami, USA. 8. Department of Radiation Oncology, Miami Cancer Institute, Miami, USA

Corresponding author: Ranjini Tolakanahalli, ranjinit@baptisthealth.net

Categories: Medical Physics, Radiation Oncology
Keywords: radiotherapy treatment planning, large brain metastases, mr-guided linac

How to cite this abstract

Abstract
A new brain treatment package consisting of a dedicated head coil with an integrated stereotactic brain immobilization system was recently released for the ViewRay® MRIdianTM system. This, coupled with high-resolution volumetric MR imaging, enables treatment of intracranial lesions using a stereotactic technique. This work aims to compare the dosimetric performance of MR-guided Linac (MRL) treatment plans against established stereotactic delivery platforms, specifically Gamma Knife® (GK), CyberKnife® (CK) and Volumetric Modulated Arc Therapy (VMAT), for intracranial metastases.

Methods:
Ten (n=10) consecutive patients with large intact brain metastases who were previously treated on GK with no setup margin were re-planned using CK, VMAT, and MRL intensity-modulated radiation therapy (IMRT) to 27 Gy in 3 fractions. Plans were created for CK, VMAT, and MRL modalities with a setup margin of 1 mm added to the GTV. Plans across all modalities were optimized to not exceed OAR dose constraints and achieve a minimum target coverage (TC) of ≥ 99.5% while maximizing Paddick Conformity Index (PCI) and minimizing beam-on time (BOT) and Gradient Index (GI) in this specified order of importance. Plan quality metrics and delivery parameters between GK, CK, & VMAT and MRL were compared for all patients. Wilcoxon signed rank test (p< 0.05) was used to establish statistical significance.

Results:
Average largest linear dimension and volumes of GTVs were 2.9± 0.5 cm and 10.4 ± 6.3 cc, respectively. MRL plans were developed with 39 to 41 beams arranged in a pseudo-arc geometry with a total of 120-180 segments. All MRL plans satisfied clinical goals with a median PCI of 0.94±0.03, median GI of 3.5±0.22 and average mean brain dose of 1.9 ± 0.9 Gy. Max dose within the target ranged from 34.3 to 44.3 Gy. PCIs of MRL plans were better as compared to GK (1.1%; 0.94±0.03 vs. 0.93±0.03; p< 0.01) and CK (2.8%; 0.91±0.06; p< 0.05) and worse than VMAT plans (-2.4%; 0.94±0.03 vs. 0.96±0.02; p< 0.05). GIs of MRL plans were worse than GK, CK and VMAT plans (3.5±0.22 vs. 2.5±0.07, 2.8±0.42, 2.6±0.35; p< 0.05). Normal brain receiving V20Gy with MRL was significantly higher compared to GK and VMAT plans (14.7±11.9cc vs. 10.4±9.6cc, p< 0.05). Normal brain receiving V12Gy with MRL was also significantly higher as compared to GK, CK and VMAT plans (34.5±29.5 cc vs. 28.9±19.1cc, 25.9+20.7cc, p< 0.05). Median MRL BOT was significantly lower than GK and CK (BOT: 5.8±1.4 min vs. 33.9±4.1 min@2.5Gy/min, 23.5±5.5cc p< 0.05) and was significantly higher than VMAT (BOT: 5.8±1.4 min vs. 3.5±0.8 min, p< 0.05). Maximum dose (D0.03cc) received by brainstem and chiasm in MRL plans was not statistically significantly different to GK, CK and VMAT plans.

Conclusion(s):
Cranial SRT plans using MRL IMRT is comparable to established stereotactic delivery modalities while providing daily, high contrast and real-time imaging. Due to the fixed coplanar beam arrangements of MRL plans as compared to non-coplanar beams of other modalities, the GI is statistically significantly inferior, but within acceptable clinical goals.