Cureus

Dosimetric Impact of Setup Errors in Single-Isocenter Linac-Based Radiosurgery for Single and Multiple Brain Metastases

Open Access
Abstract
Published 04/02/2023

Denis Panizza [1, 2] , Valeria Faccenda [3] , Sara Trivellato [2] , Paolo Caricato [2] , Valerio Pisoni [4] , Raffaella Lucchini [4] , Elena De Ponti [2] , Stefano Arcangeli [5]

1. School of Medicine and Surgery, University of Milan Bicocca, Milan, ITA 2. Medical Physics, ASST Monza, Monza, ITA 3. Physics, University of Milan, Milan, ITA 4. Radiation Oncology, ASST Monza, Monza, ITA 5. School of Medicine and Surgery, University of Milan-Bicocca, Milan, ITA

Corresponding author: Denis Panizza, panizza.denis@gmail.com

Categories: Medical Physics, Radiation Oncology
Keywords: radiotherapy treatment planning, intra-fraction motion, single isocenter radiosurgery, brain metastases, stereotactic radiosurgery

How to cite this abstract
Panizza D, Faccenda V, Trivellato S, et al. (April 02, 2023) Dosimetric Impact of Setup Errors in Single-Isocenter Linac-Based Radiosurgery for Single and Multiple Brain Metastases. Cureus 15(4): a944

Abstract

Objectives:

In stereotactic radiosurgery (SRS) and fractionated stereotactic radiosurgery (fSRS) of brain metastases (BM) using single-isocenter volumetric arc therapy (VMAT), intra-fraction positioning errors may affect target coverage. This study aims to investigate geometric and dosimetric accuracy in single and multiple BM treatments.

Methods:

Seventy patients with single (n=38) and multiple (n=32) BM treated with 15-21 Gy in 1 (n=59) or 27 Gy in 3 (n=11) fractions using coplanar FFF-VMAT technique were analyzed. PTV was defined by a 2 mm isotropic GTV expansion. Pre-treatment setup errors were evaluated with cone-beam CT (CBCT) and corrected with a robotic six degrees-of-freedom couch. For each fraction, intra-fractional errors were measured by post-treatment CBCT and applied to the planning CT. Plans involving translations and rotations (Fx-plan) were re-calculated with Monaco Monte Carlo TPS. Original and Fx-plans were compared in terms of target and brain dosimetric parameters, performing the Wilcoxon-Mann-Whitney test to assess the significant level (alpha=0.05). The relationships of the BM volume, maximum dimension, and barycenter shift with the difference in target coverage between the two plans were investigated. The correlation between the target relative dose differences and the BM distance-to-isocenter was also evaluated for multiple BM cases.

Results:

The median post-treatment 3D error and the median maximum rotational error over all 129 BM were 0.5 mm [0.1–2.7] and 0.3° [0.0–1.3], respectively. The resulting median BM barycenter shift between original and Fx-plans was 0.5 mm [0.1–2.7]. The percentage of fractions in which at least one BM barycenter shifted by more than 2 mm from the planned position was 4% and 1% for single and multiple BM cases, respectively. The median single GTV volume was 0.27 cc [0.01–10.48], while the PTV had a median volume of 1.05 cc [0.12–17.05]. The median BM maximum dimension was 10.7 mm [2.9–34.1] and for multiple BM the median distance-to-isocenter was 5.15 cm [0.89–7.52]. For single BM patients, the GTV D95% was never reduced by > 5% and in 79% of the lesions, a loss of coverage below 1% was observed. The PTV D95% decreased by 1.0% on average, and a dose reduction > 1% occurred in only 11 (29%) PTV. For multiple BM patients, the target statistics were slightly worse, with 2 BM and 34 (37%) PTV for which a dose deficit larger than 5% and 1%, respectively, occurred. Anyway, in the majority of BM variations below 1% were observed in Fx-plans for both GTV and PTV D95%. The differences in brain V12Gy (SRS) and V20Gy (fSRS) were minimal in both cases, with larger than 5% increases observed for only one single BM patient. None of the two dosimetric comparisons resulted statistically significant (p>0.05). The differences in target coverage showed a moderate-to-strong correlation only with the BM barycenter shift for both single (R^2=0.70 for GTV D95% and R^2=0.73 for PTV D95%) and multiple (R^2=0.44 for GTV D95% and R^2=0.50 for PTV D95%) BM cases.

Conclusion(s):

Due to the optimal patient setup, as well as the full six degrees-of-freedom corrections, the safety PTV margin, and the fast beam delivery, the dosimetric effects of residual setup and patient motion errors for both single and multiple BM cases were negligible. These findings warrant a potential reduction in the PTV margin with this treatment technique.