Cureus

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Abstract
Published 04/02/2023

Revisiting Multi-leaf Collimator Leaf Width and Single-isocenter Multi-target Radiosurgery Plan Quality Using Latest Automated Dynamic Conformal and Volumetric Modulated Arc Therapy Planning Solutions

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Categories: Medical Physics, Radiation Oncology
Keywords: radiotherapy treatment planning, plan quality, radiosurgery, multi-leaf collimator

How to cite this abstract
Chen D, Yang Y, Lockamy V, et al. (April 02, 2023) Revisiting Multi-leaf Collimator Leaf Width and Single-isocenter Multi-target Radiosurgery Plan Quality Using Latest Automated Dynamic Conformal and Volumetric Modulated Arc Therapy Planning Solutions. Cureus 15(4): a931

Abstract

Objectives:

Linac-based stereotactic radiosurgery (SRS) is becoming increasingly popular among options for managing brain metastasis because of its high delivery efficiency and better accessibility. Due to the rapid implementation of latest planning solutions and algorithms by vendors, previous comparisons of the impact of multi-leaf collimator (MLC) leaf width for different platforms may become obsolete when a new software version is released. This study is based on the latest available versions of two leading multi-target SRS planning platforms, aiming at evaluating and updating the impact of MLC leaf width and planning techniques on the plan quality for single-isocenter multi-target (SIMT) SRS treatment.

Methods:

Twenty-four SIMT SRS plans from a cohort of eight patients with 4-8 solitary brain metastases were created and compared. A total of 46 targets with a mean diameter of (1.1 ± 0.6) cm ranging from 0.6 cm to 2.6 cm were included, of which 21 have a diameter less than or equal to 0.8 cm. Three plans were created for each patient: two automated multi-target dynamic conformal arc (Auto-DCA) plans using 2.5-mm high-definition MLC (HDMLC) (5-mm width beyond 4 cm from isocenter) and 5-mm MLC respectively, and one automated volumetric modulated arc therapy (Auto-VMAT) plan using 2.5-mm HDMLC as a reference benchmark. Prescription doses varied based on target size and ranged from 15 Gy to 24 Gy. The dose-volume histograms (DVHs) and dosimetric parameters were analyzed including RTOG Conformity Index (CI) and Paddick's Conformity Index (PCI), brain volumes receiving 12 Gy, 6 Gy, 3 Gy or more (V12Gy, V6Gy, V3Gy), mean dose to the brain, and total monitor unit (MU) number. Wilcoxon signed rank tests with a threshold p-value less than 0.05 were performed to determine the corresponding statistical significance.

Results:

For Auto-DCA plans, HDMLC resulted in significantly more conformal irradiation for targets with diameters no larger than 0.8 cm compared to the 5-mm MLC for both RTOG CI (median [range]: HD, 1.48 [1.28 to 7.71]; 5-mm, 2.00 [1.50 to 9.79]; $p < 0.05$) and PCI (median [range]: HD, 0.68 [0.13 to 0.82]; 5-mm, 0.50 [0.10 to 0.71]; $p < 0.05$), while achieving comparable conformity for larger target sizes. In terms of normal tissue sparing, no major impact from the MLC leaf width was found in brain V12Gy (median [range] in cc: HD, 25 [12 to 70]; 5-mm, 22 [9 to 83]), V6Gy, V3Gy and the mean brain dose (median [range] in Gy: HD, 2.4 [1.9 to 4.1]; 5-mm, 2.2 [1.6 to 4.7]).
As a reference, Auto-VMAT plans showed an overall greater consistency over Auto-DCA plans in obtaining better conformity indices with a particularly evident superiority for target sizes no larger than 0.8 cm with a median RTOG CI of 1.36 [1.16 to 1.67] and a median PCI of 0.75 [0.60 to 0.96]. Auto-VMAT plans demonstrated less low-dose spillage in the brain ($p < 0.05$) with a median V12Gy of 14 [7 to 50] in cc relative to the Auto-DCA plans.
Total MU for 3 cohorts: (9850 ± 3550) MU and (9180 ± 3570) MU for Auto-DCA plans using HDMLC and 5-mm MLC respectively; (8480 ± 1440) MU for Auto-VMAT plans using HDMLC. No significant impact from the MLC leaf width was found in the total MU number and the comparison between Auto-DCA and Auto-VMAT plans using HDMLC was inconclusive due to the large MU variation observed in Auto-DCA plans.

Conclusion(s):

For Auto-DCA plans, compared to 5-mm MLC, 2.5-mm HDMLC demonstrated statistically significant improvement in dose conformity for target sizes no greater than 0.8 cm with comparable normal tissue sparing and the total MU number. Auto-VMAT plans using HDMLC showed an overall superiority in both conformity and low-dose brain spillage over the Auto-DCA plans regardless of the target size. HDMLC is therefore preferred for small targets (diameter ⩽ 0.8 cm) when using the latest Auto-DCA planning technique.