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Geometrically optimized single-isocenter dynamic conformal arcs (GO-SIDCA): an efficient radiosurgery technique for multiple brain metastasis

Bao Zhao , Manju Liu , Karen Snyder , Qixue Wu , Ning Wen , Indrin Chetty , M. Salim Siddiqui , Yimei Huang

Corresponding author: Bao Zhao

1. Medical Physics, Henry Fo 2. Medical Physics, Henry Ford Hospital 3. Radiation Oncology, Henry Ford Health System 4. Medical Physics, Henry Ford Hospital 5. Medical Physics, Henry Ford Hospital 6. Radiation Oncology, Henry Ford Health System 7. Medical Physics, Henry Ford Hospital

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Abstract

Objectives: To investigate the potential of geometrically optimized single-isocenter dynamic conformal arcs (GO-SIDCA), a novel and efficient technique for radiosurgery of multiple brain metastases, and to compare GO-SIDCA with published volumetric modulated arc therapy (VMAT) and SIDCA techniques for plan quality and delivery efficiency.

Methods: Five patients with 3-5 brain metastases were studied. Each GO-SIDCA plan was created using 4 non-coplanar arcs to treat all targets simultaneously in each arc. The optimal collimator and couch angles that yield minimum MLC opening area among the targets were initially calculated using an in-house script in a pre-defined solution space. Arcs that have large amount of MLC opening area were further optimized by breaking each arc into sub-arcs and optimize the collimator angle manually in each sub-arc to reduce the MLC opening area. Target coverage and conformity were improved by adjusting the MLC block margin for individual target. Plans were evaluated using Radiation Therapy Oncology Group conformity index (RCI), Paddick conformity index (PCI), gradient index (GI), total monitor units (MUs), and delivery time.

Results: GO-SIDCA is a very efficient radiosurgery technique for multiple targets. The MUs required for 18Gy were 3272 ± 274, which saves almost 79% of SIDCA's MUs (15471 ± 3247) and 58% of VMAT's MUs (7814 ± 582). The delivery time was 11.15 ± 0.35 minutes, which is about 4 minutes quicker than VMAT and 25 minutes quicker than SIDCA. The conformity of GO-SIDCA plans (RCI = 1.23 ± 0.10, PCI = 0.80 ± 0.06) is significantly improved comparing to SIDCA ($p < 0.001$), but not as good as VMAT ($p = 0.001$). However, the gradient index (4.75 ± 0.37) was not significantly different from VMAT (4.34 ± 0.54, $p = 0.19$) and slightly higher than SIDCA (3.93 ± 0.56, $p = 0.04$).

Conclusions: Among the three techniques, GO-SIDCA is the most efficient for radiosurgery of multiple targets. It provides the best MU efficiency and comparable plan quality with SIDCA and VMAT. However, since there is no inverse optimization and modulation, the plan quality depends highly on the relative positions of the targets. For cases without good geometry,

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inversely optimized VMAT might have an advantage.