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Enhanced Leaf Modeling Improves Dose Distribution and Treatment Efficiency in HyperArc-Based Management of Multiple Brain Metastases

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Abstract
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Abstract

Objectives:

This study aimed to assess the impact of Enhanced Leaf Modeling (ELM) on dose distribution for patients with multiple brain metastases undergoing HyperArc (HA) radiotherapy. We compared treatment plans created using the previous version of the Eclipse treatment planning system (TPS) with the new ELM-equipped version.

Methods:

Ten patients with multiple brain metastases, averaging 15 lesions (range: 10-23), were included in this study. High-resolution planning involved the registration of 1 mm slice thickness computed tomography (CT) images to magnetic resonance imaging (MRI) data. Precise target delineation was performed by a radiation oncologist in Eclipse TPS. Gross tumor volume (GTV) was equated to planning target volume (PTV) for lesions >10 mm and expanded by 1 mm for smaller lesions. A prescribed dose of 27 Gy in 3 fractions was administered, covering 98% of target structures. Initial HA plans created in Eclipse version 16.1 were re-optimized and recalculated using Eclipse version 18 with ELM. Dosimetric parameters, including target volume conformity index (CI), gradient index (GI), and organ at risk (OAR) protection, were compared, as well as total monitor units for treatment duration assessment.

Results:

Integration of ELM significantly improved CI (p=0.005) and GI (p=0.005) compared to HA with Eclipse V 16.1, demonstrating enhanced PTV coverage and dose falloff. There were no significant changes in 12 Gy volume of healthy brain tissue (p=0.508) with ELM. Plans utilizing ELM exhibited significantly lower maximum brain (p=0.005) and chiasm (p=0.022) doses, along with reduced brain mean doses (p=0.008) and monitor units (p=0.005). Brainstem maximum (p=0.878) and mean (p=0.074) doses remained unaffected.

Conclusion(s):

Incorporating ELM in HyperArc optimization and calculations using Eclipse V18 for patients with ten or more brain metastases resulted in substantial improvements in dose distribution. These changes led to better target volume coverage, sharper dose falloff, reduced doses to certain OARs, and enhanced treatment efficiency.