Linear Accelerator based Volumetric Modulated Arc Therapy Stereotactic Radiosurgery Plan Strategy and Evaluation

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Objectives: Stereotactic radiosurgery (SRS) has been widely employed for brain tumors. With the implementation of volumetric modulated arc therapy (VMAT) technologies, frameless based intracranial tumors can be treated with Linear Accelerator (LINAC) in a flexible fashion. The purpose of this study was to compare the dosimetric outcomes of different SRS treatment methods in terms of brain tissue dose sparing and tumor dose inhomogeneity for SRS radiation toxicity purpose.

Methods: An index case with 3 intracranial, metastatic target lesions was used for comparison. MRI image set were fused to the planning CT. The GTV tumors were delineated based on MRI image sets. PTV volumes were made by adding a 1mm margin to GTV volumes, resulting in: 0.33cc, 0.84cc and 1.68cc. The prescription dose to each target was in accordance with our departmental SRS protocol and varied according to tumor volume with dose range (18-22.5Gy). SRS plans were based on VMAT optimization. One SRS dedicated Linac machine was used in this project with MLC size of 0.5cm width. 6X Flattening Filter Free (FFF) beam was used. For each tumor, SRS plans were implemented with 7 different levels of Normal Tissue Sparing (NTS) for the VMAT plan optimization. In this work we selected level 2 for NTS-Low plans and level 6 for NTS-High plans. Brain tissue dose sparing were evaluated and compared among these plans using: tumor conformity index (CI), brain tissue volume with more than 12Gy (V12Gy) and dose gradient index (GI). Tumor dose inhomogeneity was also compared with Dmax. Data are reported as mean ± standard deviation and differences are considered significant where paired t-test results in $p<=0.05$.

Results: The mean CI of NTS-Low plans and NTS-High plans were 1.13±0.07 and 1.21±0.06 respectively. Compared with NTS-High plans, NTS-Low plans' CI was 6.37%±1.45% lower. The mean GI of NTS-Low plans and NTS-High plans were 4.49 and 3.40 respectively. Compared with NTS-High plans, NTS-Low plans' GI was 31.54%±12.00% more. The mean V12 of NTS-Low plans and NTS-High plans were 3.14cc and 2.63cc respectively. Compared with NTS-High plans, NTS-Low plans' V12 was 23.38%±12.28% higher. The mean Dmax of NTS-Low plans and NTS-High plans were 22.14Gy and 25.34Gy respectively. Compared with NTS-High plans, NTS-Low plans' Dmax was 12.62%±0.52% lower. P was less than 0.04 for all the data analysis above.

Conclusions: This study showed NTS-High VMAT plans provide better brain tissue sparing but higher tumor dose inhomogeneity. Based on the specific SRS patient situation, radiation oncologists may need to cautiously select the NTS optimization level for the final treatment plan. Further studies are warranted to investigate the necessity of trade-off in NTS optimization level to achieve the optimal treatment outcome.