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Investigation of SRS Spine Treatment Plan Quality on a Magnetic Resonance Image Guided Linear Accelerator

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Abstract

Objectives: To investigate the treatment plan quality and adherence to Radiation Therapy Oncology Group (RTOG) 0631 Protocol for Spine Stereotactic Radiosurgery (SRS) planned for delivery on a Magnetic Resonance Imaging Guided Linear Accelerator (MR-Linac).

Methods: Two previously treated Spine SRS patients were re-planned on a Monte Carlo-based MR-Linac commercial treatment planning system (TPS). The MR-linac system combines a 0.345 T magnet with a 6 MV flattening filter free (FFF) beam delivered at a nominal dose rate of 600 MU/min. The treatment technique utilized in this study was step-and-shoot IMRT using a double-stacked MLC that can achieve field sizes down to 0.2 x 0.4 cm2. Beam geometries consisted of 7-9 posterior beams spaced at 20-25 degrees. Treatment plans were optimized to achieve the coverage and constraints dictated by RTOG 0631. Following planning, ion chamber and absolute film dosimetry (3%/1mm global gamma analysis) patient specific quality assurance (PSQA) measurements were performed to assess the deliverability and dosimetric accuracy of the treatment plans.

Results: The Monte Carlo-based TPS was capable of managing target and critical tissue constraints to result in plans that achieve prescription dose to 95% of the PTV, greater than the 90% required by RTOG 0631. Treatment plans were normalized to cover 95% of the contoured vertebral body with the 18 Gy single-fraction prescription dose. Critical tissues included conventional/partial spinal cord, esophagus, aorta, liver, and kidneys. RTOG 0631 constraints on these tissues were met (e.g. on average < 5% of the partial spinal cord receives 10 Gy, and the spinal cord max dose remains below 13 Gy). In addition to meeting the RTOG 0631 plan quality metrics, efforts were made to minimize the complexity of the delivery (less than 6 segments per field on average) and, furthermore, the delivery time. During PSQA measurements, delivery duration was monitored and averaged less than 30 minutes. PSQA ion chamber and film analysis results agreed with the TPS at 1.8 % and 92% gamma (3%/1 mm), respectively, which are within institutional tolerances.

Conclusions: This study demonstrated the feasibility of planning RTOG 0631 compliant Spine SRS treatments on an MR-Linac using the MC-based TPS. In addition to plan quality, PSQA measurements validated the deliverability and dosimetric accuracy of the planned MR-Linac deliveries.

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