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Abstract

Evaluation of Plan Quality and Accuracy of an Automated VMAT based Spine SRS Treatment Planning System

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Objectives: An automated VMAT based spine SRS treatment planning system (TPS) was evaluated. It uses automation to achieve consistent plans. This study is to evaluate the dosemetric quality of auto-generated plans compared to existing clinical plans made by experienced dosimetrists; and to evaluate the calculation accuracy by measurement with different methods.

Methods: Twenty spine SRS/SBRT patients that were clinically treated at our institution (C-Spine: n=1, C/T-Spine: n=2, T-Spine: n=6, L-Spine: n=9, and Sacrum: n=1) were selected. PTV volume ranged from 15 to 147.2 cc (64.5 ± 31.5cc). A range of dose prescriptions were included (single fraction: n=10, 12 ~ 24 Gy; three fractions: n=7, 24 or 27 Gy; five fractions: n=3, 30Gy). All clinical plans were created using RapidArc inverse optimization, based on physician requested OAR constraints. Dose calculations were performed on 2 mm dose grid using AAA algorithm with heterogeneity correction. All plans were normalized to 95% PTV received 100% of prescription dose. Varian Truebeam linac equipped with 5 mm MLC, 6MV photon beam was used (regular mode: n=16, and flattening filter free mode: n=4). They were re-planned using the automated TPS (BrainLAB spine SRS Element) with same linac and energy. Organ at risk (OAR) constraints is input only once prior to clinical implementation for each fractionation scheme as pre-defined templates. Element uses pencil beam algorithm for dose calculation with Monte Carlo as an option for large heterogeneity situation. An adaptive dose grid is used based on structure size. For an average sized spine PTV, it is 2 mm, and for a typical sized spinal cord it was 1.8 mm. Element automatically evaluates the size and shape of PTV to determine if splitting it into simplistic sub-volumes, each treated by their own arcs, will increase conformity and spinal cord sparing. A no PTV splitting plan consists of 2 VMAT arcs, while a PTV-splitting plans consists 4 or 6 arcs depending on the PTV complexity. The conformity index, gradient index, PTV D5%, and max and mean cord dose were evaluated by comparing to clinical plans. Wilcoxon rank-sum tests were performed on the statistics. Calculation accuracy was evaluated by measuring absolute dose in PTV and cord locations using dual micro ion chambers in a heterogeneity present phantom; fine resolution 2D dose distribution measurement with Gafchromic EBT3 film; and 3D dose distribution measurement and gamma index analysis with ScandiDose Delta4 phantom.

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Results: Spine SRS Element split the PTV for 10 out of 20 cases, requiring four or six arcs. Overall, Elements plans were better in conformity index, gradient index than clinical plans, and lower max and mean cord dose. The PTV D5% is higher which means the plan is hotter inside PTV. No PTV splitting plans have similar MU as clinical plans, while PTV splitting plans have more arcs and MU (higher modulation). Delta4 dose measurement showed equivalent or higher Gamma passing rate than clinical plans. (Other two measurements are in progress.)

Conclusions: Automated spine SRS Element plans achieved better dose conformity and cord dose sparing compared to clinical plans. PTV splitting technique successfully improved spinal cord sparing at the cost of more arcs, MU, and thus delivery time. Dose calculation was verified as accurate by three different measurement methods and equipment. An advantage of this system is to achieve consistent quality plans even by less experienced planners.