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Spine Elements: Delivery Quality Assurance

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Purpose

Elements Spine SRS is a highly automated software for consistent, template-based creation of treatment plans for spinal stereotactic radiosurgery (SRS) or stereotactic body radiation therapy (SBRT). Contrary to generic treatment planning systems, Elements Spine SRS employs an indication-specific VMAT implementation for spine metastasis. The software can automatically partition a complex target volume into less complex target volumes in terms of concavity and can be alleviate the optimizer by creating a duplication of arcs to create a steeper dose gradient for better sparing of the spinal cord.

Most of the work carried out on Elements Spine reveals that the system make it possible to propose an optimal dosimetry satisfying organ at risks (OAR) doses constraints [1-3] however, recent work has showed that the results can depend on the shape of the target volume [4]. The aim of this work is to assess the deliverability of these treatments using Varian's Portal Dosimetry Image Prediction module (PDIP).

Materials and Methods

Treatments were performed with a TrueBeam™ (Varian Medical Systems, Palo Alto, CA, USA) linac, equipped with a 120 HD MLC; Beam energy was 6MV FF. All plans were optimized with Elements Spine-SRS (v. 3.0, Brainlab AG). The ballistic consists in 2 partial arcs (168° lengh) with a distinct collimator rotation at 45° and 95°, respectively. The duplication arc option was activated up to a maximum of 4 hemi-arcs. Dose distributions were calculated using Monte Carlo algorithm with a 1mm dose-grid calculation. For each patient, the total prescribed dose on PTV was 35Gy, given in 5 fractions of 7Gy. PTV coverage and OARs constraints were in line with international recommandations.

The study was carried out for 15 differents locations defined in green in figure 1, representing a total of 45 arcs.
Quality control was performed using PDIP and global Gamma index analysis. Different criteria were evaluated : 5%/1mm, 4%/1mm, 3%/1mm, 2%/1mm, 1%/1mm. The plan was considered deliverable if 95% of the points defining the MLC CIAO satisfy the Gamma index criteria. The Modulation Complexity Score (MCS) values were also recorded for each plan.

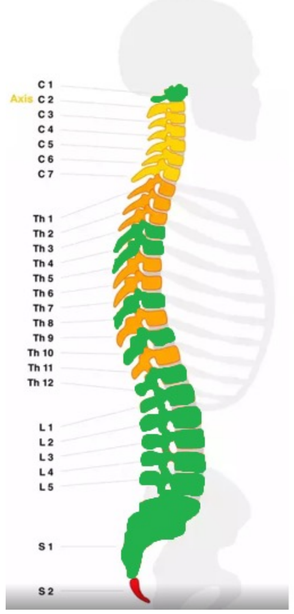

Figure 1. Green colour indicates the vertebral locations studied

Results

Figure 2 shows that 13 out of 15 plans satisfy the strict 2%/1 mm criterion, with a mean value of 96.6%. With more restrictive criterion, 1%/1mm, the fractionation of points statisfying the Gamma index ranged from 87% to 97%, with an average value equal to 93% (Table1).

Whatever the criteria used, the plans that fall outside the statistical distribution correspond to extreme vertebral positions (C1 and S1). The MCS values calculated for these two planes are low (Figure 3), indicating a high level of modulation.

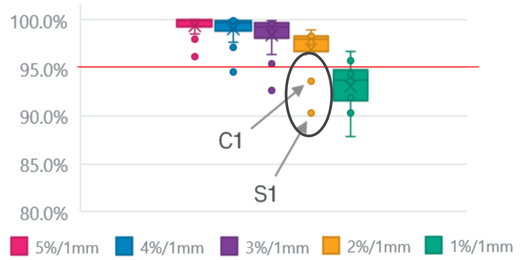

Figure 2. Gamma index scores distribution corresponding to the 15 vertebral locations, for different accuracy criteria

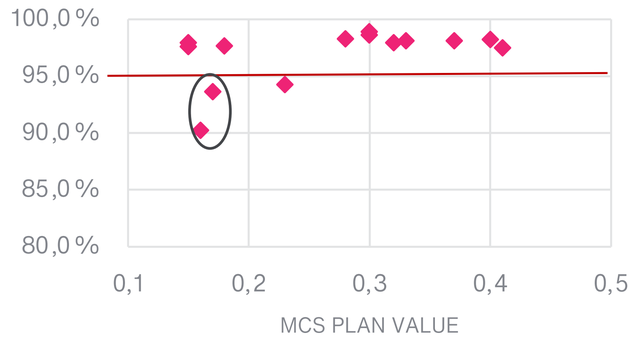

Figure 3. Gamma index score for the 2%/1mm criterion according MCS plan value

Gamma index	(5%/1mm)	(4%/2mm)	(3%/3mm)	(2%/1mm)	(1%/1mm)
Mean (%)	99.2	98.8	98.1	96.6	93.1
Deviation (%)	1.4	1.9	2.5	3.0	3.5

Table 1. Gamma index's mean and deviation for these 15 locations.

Conclusion

Plans generated by Elements spine provide a high degree of precision (2%/1mm) in the majority of case, responding to the problematic of Spine SRS treatment. However, for extrem vertebral positions, the accuracy of the proposed plan is degraded.
As the MCS values are particularly low for the two extreme locations (C1 and S1) further investigations have to be carried out in order to verify whether the unsatisfactory beam delivery is due to the very high level of modulation or to the limitation of the optimisation system for the particular shape of these extrem vertebrae.

References

1 Trager and al. Evaluation of Elements Spine SRS plan quality for SRS and SBRT treatment of spine metastases. Front. Oncol. 2020 Apr3;10 :346
2 Saenz and al. A dosimetric analysis of a spine SBRT specific treatment planning system. J Appl Clin Med Phys. 2019 Jan;20(1):154-159.
3 Deshazer and al. A dosimetric comparative analysis of Brainlab elements and Eclipse RapidArc for spine SBRT treatment planning. Biomed Phys Eng Express. 2022 Jan 27.
4 Piliero and al. Medical Dosimetry 47 (2022) 43–47