

Spinal stereotactic body radiotherapy treatment plan quality and delivery comparison between a conventional linac and a 1.5T MR-linac

M Aima*, E Han, N Hughes, T Briere, D Yeboa, P Castillo, J Wang, J Yang, S Vedam

The University of Texas MD Anderson Cancer Center, Houston, TX 77030

INTRODUCTION

- Spinal stereotactic body radiotherapy (SSRT) is a vital treatment option for malignant spinal metastatic tumors.
- The use of an MR-linac for SSRT as compared to a conventional linac can potentially provide improved soft tissue contrast for treatment delivery.
- The MR-linac geometry and beam configuration can differ considerably from a conventional linac, which may cause variability in treatment plans.

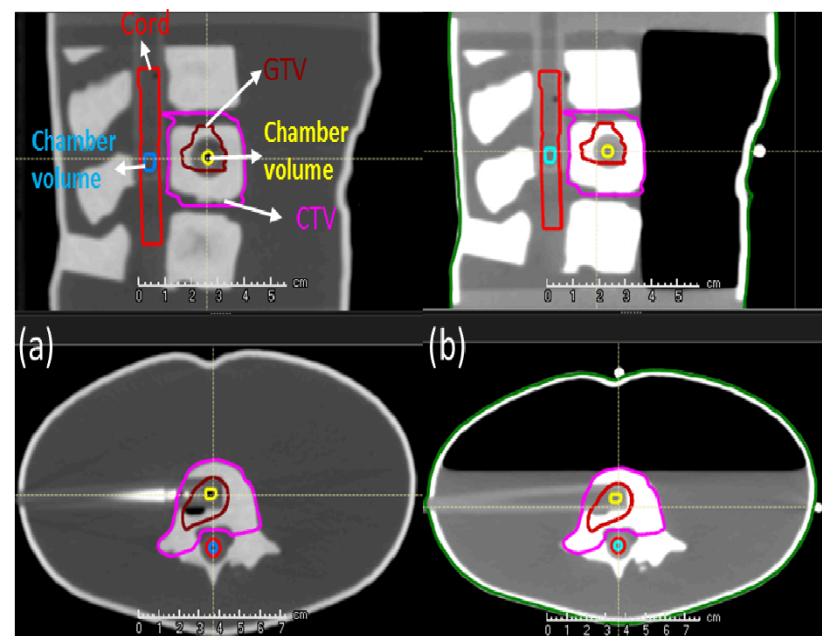
AIM

- A comparative study was performed to assess the SSRT treatment plan quality and delivery differences between a conventional linac and a 1.5T MR-linac using an anthropomorphic spine phantom.

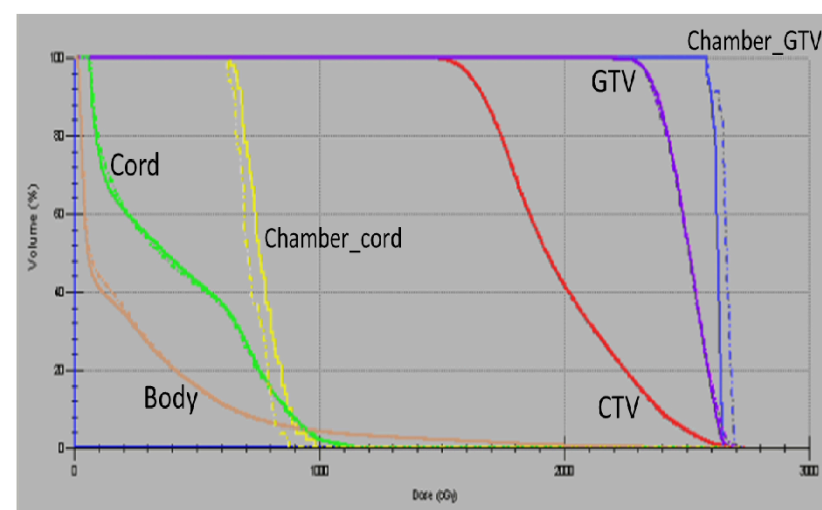
METHOD

- Representative thoracic and lumbar SSRT treatment plans were generated for an anthropomorphic phantom (Figure 1) for a conventional linac (Truebeam®) using RayStation treatment planning system (TPS), and for an MR-linac (Unity) using Monaco® TPS.
- Two cylindrical ionization chambers were used to measure dose within the phantom gross tumor volume target and the spinal cord region for plans delivered using the two linacs.
- Exactrac® and CBCT imaging systems were used for phantom positioning for the Truebeam irradiation, and the on-board MR-imaging system was used for positioning for the MR-linac.

FIGURES



(1)



(3)

Variable	MRL_LS	RS_LS	MRL_TS	RS_TS
GTV				
D95%, cGy	2402.1	2485.0	2348.8	2437.0
Minimum dose, cGy	2277.5	2321.0	2186.5	2175.0
Maximum dose, cGy	2729.3	2759.0	2651.8	2737.0
Conformity index	0.6	0.4	0.7	0.4
Homogeneity index	1.1	1.1	1.1	1.1
R50	25.9	27.9	28.1	24.9
CTV				
D95%, cGy	1600.3	1601.0	1602.8	1600.0
Conformity index	0.8	0.8	0.9	0.8
Homogeneity index	1.7	1.7	1.7	1.7
Gradient index	3.7	3.8	3.4	3.4
R50	4.09	4.28	4.09	3.78
Spinal cord				
Maximum dose, cGy	1042.4	1065.0	1109.3	1032.0
V10Gy, cm³	0.01	0.01	0.059	0.0
Beam-on time, minutes	13.0	8.1	12.7	7.5
Monitor units	5517.4	4869.3	5390.3	4522.6

(2)

Variable	Dmean, cGy			
	Lumbar spine		Thoracic spine	
	GTV	Spinal cord	GTV	Spinal cord
RayStation				
Measurement	2605.2 ± 17.4	514.3 ± 2.7	2595.5 ± 9.6	470.4 ± 3.4
Original plan	2641.0	505.0	2664.0	440.0
% difference	-1.4	1.8	-2.6	6.9
Monaco				
Measurement	2702.9 ± 113.9	601.8 ± 22.9	2684 ± 14.4	884.6 ± 37.4
Adapted plan	2671.3 ± 19.6	605.6 ± 15.6	2602.3 ± 5.8	851.3 ± 39.6
Original plan	2644.5	562.8	2595.5	788.5
% difference	1.2	-0.6	3.1	3.9

(4)

- (1) Phantom CT images and contoured structures: (a) completely water-filled phantom to simulate a lumbar spine setup, (b) partially water-filled phantom to simulate a thoracic spine setup. (2) The cumulative dose volume histogram for a sample Unity MR-linac plan showing an original plan (dotted line) and the adapted plan (solid line). (3) A comparison of the Monaco-generated and RayStation-generated SSRT treatment plans, MRL_LS and MRL_RS are the Monaco-generated lumbar and thoracic plans respectively, and RS_LS, TS are the RayStation-generated plans. (4) A comparison of the measured dose (in cGy) for the Truebeam and the MR-linac treatment plans to the calculated plan doses.

RESULTS

- Figure 2 presents a comparison of the thoracic and the lumbar SSRT treatment plans formulated using Monaco and RayStation TPS. The calculated treatment plans using the two TPS were found comparable when evaluated using various metrics for both lumbar and thoracic SSRT plans.
- The Gross Tumor Volume (GTV) and the Clinical Target Volume (CTV) dose distributions evaluated using D95%, minimum dose, maximum dose, conformity index, homogeneity index, gradient index, and R50 metrics were all found acceptable for both RayStation and Monaco calculated lumbar as well as thoracic SSRT plans.
- Spinal cord calculated maximum dose and V10Gy were similar for both the plans generated using the two TPS and within the required constraints of less than 12 Gy and less than 1 cm³ respectively for all plans.
- The average measured dose (in cGy) for the GTV region of the phantom was within ±2.6% of the calculated plan dose for the Truebeam linac for both lumbar and thoracic spine plan, and within ±3.1% for the MR-linac.
- Dose measurements performed in the spinal cord insert of the phantom, which are situated in a high dose gradient region, were within ±1.8% and ±6.9% of the calculated dose for the lumbar and thoracic plans respectively for the conventional linac and within ±0.6% and ±3.9% for the MR-linac.

CONCLUSIONS

- This study found SSRT treatment planning and delivery for an MR-linac comparable to a conventional linac when using an anthropomorphic spine phantom. It was noted that an improvement in adapted SSRT plan optimization process was required to further lower spinal cord dose for the MR-linac.

CONTACT INFORMATION

MAima@mdanderson.org