[1]*Hospital Quirónsalud Barcelona, Radiotherapy, Barcelona, Spain ;* [2]*Hospital Universitario Valle de Hebrón, Servicio de Física y Protección Radiológica, Barcelona, Spain*

Purpose or Objective

To investigate the accuracy of the dynamic MLC patterns derived for lung IMRT-SBRT plans with normalization values differing in more than 5% respect to the inverse optimization calculation.

Material and Methods

Ten cases of lung SBRT planned using Sliding and Window IMRT technique were included. IMRT optimizations were performed using the Dose Volume Optimizer (DVO, version 10.0.28) algorithm of the Varian Eclipse TPS (version 13.7.14). The Anisotropic Analytical Algorithm (AAA, version 10.0.28) was applied for the final dose calculation (2 mm grid size). Photons beams of 6 MV from a Varian linac equipped with the Millennium 120 MLC were used. Due to optimization-convergence errors [J Appl Clin Med Phys. 2009 Oct 14;10(4):3061], the final plans needed to be re-normalized to insure that 95% of the PTV received the prescribed dose. The required final re-normalization values (62%-85%) varied in more than 5% respect to the 100% value of DVO-base target DVH. To detect potential violations of the MLC operating limits, Varian advises to verify the MLC leaf sequence for normalization variations larger than 5%.

Each original SBRT plan (Plan_Orig) was delivered onto the linac EPID (Varian PortalVision aS500) to evaluate the accuracy of the dynamic MLC patterns created by the Eclipse for these re-normalization values (62%-85%). Two kinds of verifications were done: 1) the actual field fluences of the Plan_Orig were verified using the Varian Portal Dosimetry software (version 13.7.14). The 3%/3 mm and 2%/2 mm criteria, both with 10% of maximum dose as dose threshold, were applied for 2D global gamma-evaluation. A total of 85 IMRT fields were analyzed. 2) The Plan_Orig was recalculated by keeping the MUs but using the MLC files reconstructed from the Dynalog files recorded by the MLC controller (Plan_Actual). This DynaLog-to-MLC conversion was performed using a MATLAB-based code developed by Teke et al. [Radiother Oncol. 2007;84(Suppl 2):S92]. The reconstructed dose distribution was verified against the original dose distribution using a 1%/1 mm 3D global gamma-evaluation for the PTV structure. The Computational Environment for Radiotherapy Research (CERR) software was used for this task.

Results

1. The average ± 1 SD of the 2D gamma passing rates were 99.4% ± 0.9% (range: 96.1%-100%) and 97.6% ± 2.5% (range: 89.2%-97.6%) at 3%/3 mm and 2%/ 2 mm criteria, respectively.
2. A 1%/1 mm 3D gamma passing rate of 100% was obtained for the PTV in all plans.

Conclusion

The results demonstrated the reliability and accuracy of the IMRT-SBRT plans designed by the Eclipse TPS with normalization values differing in more than 5% respect to the inverse optimization calculation.

EP-1809 Comparison of Photon Optimizer (PO) and Progressive Resolution Optimizer (PRO) for SRS VMAT Plans

Y. Akdeniz[1], G. Ugurluer[2], E.B. Ispir[1], I. Kaptan[1], M. Serin[2]

[1]*Acibadem Adana Hospital, Department of Radiation Oncology, Adana, Turkey ;* [2]*Acibadem Mehmet Ali Aydinlar University, Department of Radiation Oncology, Adana, Turkey*

Purpose or Objective

Linac-based stereotactic radiosurgery (SRS) of brain lesions is typically performed by using volumetric modulated arc therapy (VMAT) technique. For SRS of small target SRS, the optimization algorithms might influence the treatment quality significantly as they model the 3D space in different way. In this study, we aimed to compare a new optimizer "photon optimizer" (PO) with its predecessor "progressive resolution optimizer" (PRO) for SRS VMAT plans.

Material and Methods

For ten patients with single brain metastases planning-CT scans were acquired with a slice thickness of 1 mm. Planning Target Volume (PTV) which was converted to high resolution segment had a mean volume of 14.85 cm^3 (range 8.6-20 cm^3). Each patient's treatment was planned using PO and PRO optimizers on version 13.6 of the Eclipse treatment planning system with 6 MV FFF photon beams. A template using the same objectives was used for each optimized plan without any intervention. For PO the highest resolution (1.25 mm) was selected and during optimization with PRO the point cloud model resolution for PTV was set to 1 mm. The prescribed dose was 18 Gy in a single fraction. Volumetric dose normalization was adopted, by normalizing 100% D_p to 99% of the PTV. Plans which were optimized with PO and PRO were calculated with anisotropic analytical algorithm (AAA, v.13.6), with the same dose grid resolution (1 mm). PO and PRO plans were compared in terms of total number of monitor units (MU), Paddick conformity (CI) and gradient index (GI) for PTV and V_{12} (the volume receiving more than 12 Gy) and D_{mean} (mean dose) for the healthy brain tissue. *Statistical* analysis was *performed* using SPSS.

Results

The values of the plan quality metrics for both PO and PRO plans are shown for all patients in Table 1. For $CI_{Paddick}$ significant advantage in favour of PRO plans were achieved. While mean $CI_{Paddick}$ value increased significantly from 0.89 ± 0.009 (for PO plans) to 0.941 ± 0.017 (for PRO plans) ($p < 0.05$), there was no statistically significant difference between PO (3.084 ± 0.242) and PRO (3.031 ± 0.184) plans in terms of $GI_{Paddick}$. We had significant reduction in V12 from 12.74 ± 3.61 cm^3 (for PO plans) to 11.52 ± 3.22 cm^3 (for PRO plans) ($p < 0.05$). Also, we found that the D_{mean} decreased in favor of PRO in statistical analysis from 124.2 ± 41.3 cGy (for PO plans) to 119.7 ± 39.6 cGy (for PRO plans) ($p < 0.05$). There was no significant difference between PO and PRO in terms of total number of MU.

Table 1. Values of plan quality metrics

	Total # of MU		D_{mean} (cGy)		V_{12} (cc)		$CI_{Paddick}$		$GI_{Paddick}$	
Pt # / Plan	PO	PRO	PO	PRO	PO	PRO	PO	PRO	PO	PRO
1	5284	4991	90.1	87.5	9.73	8.95	0.885	0.962	3.157	3.163
2	4574	4953	121.6	124.8	12.6	11.5	0.895	0.931	2.682	2.722
3	7473	6607	161.2	149.4	15.37	13.58	0.906	0.939	3.242	3.150
4	4512	4590	154.4	148.6	17.13	15.12	0.899	0.951	3.282	3.224
5	4956	4958	158.5	151.9	18.9	17.25	0.889	0.933	2.957	2.974
6	5984	5605	35.4	33.3	7.08	6.42	0.883	0.929	3.376	3.298
7	4630	4725	144.1	137.7	12.95	11.82	0.890	0.937	2.876	3.028
8	5592	5341	147	144.1	10.77	9.92	0.894	0.977	2.839	2.936
9	5684	5079	85.1	80.6	9.95	8.74	0.875	0.923	3.387	3.318
10	4614	4652	144.3	138.7	12.87	11.85	0.885	0.933	3.041	2.999
mean	5330	5150	124.2	119.7	12.74	11.52	0.890	0.941	3.084	3.081
sd	919	598	41.3	39.6	3.61	3.22	0.009	0.017	0.242	0.184
min	4512	4590	35.4	33.3	7.08	6.42	0.875	0.923	2.682	2.722
max	7473	6607	161.2	151.9	18.9	17.25	0.906	0.977	3.387	3.318
	NS		p< 0.05		p< 0.05		p< 0.05		NS	

Conclusion

This study compared plan optimization outputs for the two optimization algorithms (PO and PRO) which models 3D space differently in SRS VMAT plans. Our study showed that SRS VMAT plans optimized with PRO's point cloud model yield better results in terms of both target volume coverage and organ protection than PO. PRO might be preferred to newer algorithm PO in optimization of small target volumes.

EP-1810 Comparison of absorbed dose between medium and water on Monte Carlo algorithm for VMAT plan

N. Bhalla[1], M. Palanisamy[1], G. Anand[1], C. Saravanan[1], T. Thangaraj[1], P. Abhishek[1]
[1]*Fortis Cancer Institute, Radiation Oncology, Mohali, India*

Purpose or Objective

A comparison of absorbed dose to water (D_w) and absorbed dose to medium (D_m) on Monte Carlo (MC) dose calculation algorithm used in Monaco™ treatment planning system (TPS) for different clinical sites.

Material and Methods

Four patients from each site, a total of 20 patients, namely, larynx, lung, prostate, and brain treated with VMAT technique were chosen for this study. All plans were generated using 6MV photon beam in Monaco™ TPSV5.10 for Elekta Synergy™ linear accelerator with leaf width of 1cm. The reference plan was generated using the MC dose calculation algorithm with absorbed dose to water during final dose calculation. By keeping all other parameters constant, plans were recalculated by changing the absorbed dose to medium. Plans were evaluated using dose-volume histogram (DVH). For plan comparison, conformity index (CI), homogeneity index (HI), planning target volume (PTV) covered by 98% prescribed dose, mean and maximum dose to PTV (PTV_{max}) and organ at risk (OAR) dose was compared. In addition, the normal tissue volume receiving dose > 5Gy & > 10Gy, normal tissue integral dose (NTID), calculation time (mins), point dose measurement and gamma pass rate was compared.

Results

In all four sites, CI and HI value was 4.24%-12.4% and 3.49%-19.63% increased in D_w as compared to D_m with significant difference (p<0.05). The dose received by 98% volume and Dmax to PTV was 0.42%-2.23% and 0.9%-6.2% increased in D_w as compared to D_m (p>0.05). No significant dose difference was observed in D_{mean} to PTV, OAR, normal tissue volume receiving dose ≥ 5Gy & ≥ 10 Gy and NTID. Similarly, no significant difference was observed in calculation time, gamma pass rate and point dose measurements (p>0.05).

Conclusion

The choice of either D_m or D_w during dose calculation was based on significant clinical effect in tumor control and OAR sparing. In all clinical sites, during MC dose calculation, there was a significant increase in the point dose and inhomogeneous dose in D_w as compared D_m within the target. However, D_m will be the preferred option to achieve better accuracy in future for Monaco™ TPS.

EP-1811 Volumetric modulated arc therapy with robust optimization for larynx cancer

H. Miura[1], D. Yoshiko[2], O. Shuichi[1], N. Minoru[1], O. Keiichi[2], K. Masahiko[2], N. Yasushi[2]
[1]*Hiroshima High-Precision Radiotherapy Cancer Center, Medical Physics, Hiroshima, Japan ;* [2]*Hiroshima High-Precision Radiotherapy Cancer Center, Radiation oncology, Hiroshima, Japan*

Purpose or Objective

In the case of larynx cancer using 3D-CRT, common carotid arteries receive radiation doses essentially equivalent to the prescription due to their close proximity to the target. VMAT has been used to reduce the dose to the carotid arteries. Robust optimization plan provides significantly more robust dose distributions to targets and OAR than the PTV-based optimization plan. We speculated that a larynx cancer patient may benefit from a partial-arc VMAT robust optimization plan due to its location. The aim of this study was to perform a comparison between robust optimization and planning target volume PTV-based optimization plans using VMAT by evaluating perturbed doses induced by localization offsets for setup uncertainties in larynx cancer radiation therapy.

Material and Methods

Ten patients with early-stage (T1-2N0) glottis carcinoma were selected. The CTV, carotid arteries, and spinal cord were contoured by a oncologist. PTV-based and robust optimization plans were normalized at $D_{95\%}$ to the PTV and $D_{98\%}$ to the CTV, respectively. Both optimization plans were evaluated using perturbed doses by specifying user defined shifted values from the isocenter. CTV dose ($D_{98\%}$, $D_{50\%}$, and $D_{2\%}$), homogeneity index (HI) and conformity index ($CI_{95\%}$, $CI_{80\%}$, and $CI_{50\%}$), as well as doses to the carotid arteries and spinal cord were compared between PTV-based and robust optimization plans. Monitor Unit (MU) was also investigated.

Results

In the original plan, the CTV doses, HI, CI, OAR doses and MU using PTV-based and robust optimization plans are shown in Table 1. The robust optimization plans exhibited superior CTV coverage and a reduced dose to the carotid arteries compared to the PTV-based optimization plans (*p* < 0.05). HI, $CI_{95\%}$ and the dose to the spinal cord did not significantly difference between the PTV-based and robust optimization plans (*p* > 0.05). The robust optimization plans showed better $CI_{80\%}$ and $CI_{50\%}$ compared to the PTV-based optimization plans (*p* < 0.05). The robust optimization plans were on average 18.6% less than the total MU compared to the PTV-based optimization plans (*p* < 0.05). Table 2 compares the doses to the CTV, carotid arteries, and spinal cord obtained from the rigidly shifted plan between the PTV-based and robust optimization plans. Plan perturbed evaluations showed that the robust optimization plan has small variations in the doses to the CTV, carotid arteries, and spinal cord compared to the PTV-based optimization plan.

Table. 1
Doses to the CTV and OAR, HI, CI, and MU using PTV-based and robust optimization plans.

	PTV based plan	robust plan	p value
CTV: $D_{98\%}$ (cGy)	194.8 ± 2.0 (191.0 - 198.0)	200.0 ± 0.0 (200.0 - 200.0)	0.002*
CTV: $D_{50\%}$ (cGy)	202.1 ± 1.9 (200.0 - 207.0)	206.1 ± 1.4 (204.0 - 209.0)	0.002 *
CTV: $D_{2\%}$ (cGy)	208.8 ± 1.7 (206.0 - 212.0)	211.6 ± 2.2 (209.0 - 216.0)	0.025 *
carotid artery_left: average dose (cGy)	88.1 ± 9.0 (81.0 - 105.0)	82.6 ± 6.5 (75.0 - 93.0)	0.006 *
carotid artery_left: $D_{2\%}$ (cGy)	121.2 ± 13.2 (98.0 - 147.0)	108.7 ± 7.8 (99.0 - 123.0)	0.004 *
carotid artery_right: average dose (cGy)	92.9 ± 13.6 (81.0 -125.0)	86.5 ± 13.0 (74.0 - 118.0)	0.002 *
carotid artery_right: $D_{2\%}$ (cGy)	127.0 ± 17.2 (111.0 - 168.0)	116.0 ± 19.6 (100.0 -169.0)	0.004 *
spina cord: average dose (cGy)	33.7 ± 5.2 (26.0 - 42.0)	32.0 ± 4.4 (24.0 - 38.0)	0.254
spinal cord: $D_{2\%}$ (cGy)	42.2 ± 4.9 (34.0 - 48.0)	39.6 ± 4.0 (32.0 - 47.0)	0.152
HI	0.069 ± 0.016 (0.043 - 0.099)	0.056 ± 0.011 (0.044 - 0.077)	0.160
CTV: $CI_{95\%}$	1.801 ± 0.355 (1.282 - 2.564)	1.713 ± 0.366 (1.249 - 2.433)	0.125
CTV: $CI_{80\%}$	2.988 ± 0.581 (1.907 - 4.175)	2.784 ± 0.551 (1.939 - 3.879)	0.020 *
CTV: $CI_{50\%}$	5.276 ± 1.004 (3.484 - 7.265)	4.688 ± 0.864 (3.484 - 6.640)	0.004 *
MU	308.5 ± 43.6 (238.3 - 394.8)	260.1 ± 14.7 (235.0 - 287.1)	0.004 *

*The Wilcoxon signed-rank test resulted in a statistically significant difference (*p* < 0.05).
HI, homogeneity index; CI, conformity index; MU, Monitor unit.