

A Dosimetric Study to Assess the Feasibility of Prototype Treatment Planning Software for a New Biology-guided Radiotherapy System

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Purpose/Objective(s): Biology-guided radiotherapy (BgRT) is a new modality under development that combines a 6 MV linac with PET, CT and MV imaging systems on a ring gantry that rotates at 60 rpm. The system provides digital dose modulation using 64 binary MLC with a nominal leaf width of 6.25 mm at isocenter. An axial delivery mode is used to sequentially translate the couch in small steps then fire intensity modulated beamlets over many gantry rotations while the couch is stationary. This study is to evaluate the prototype BgRT treatment planning system (TPS) for IMRT cases without PET-guidance.

Materials/Methods: 5 post-prostatectomy patients (45 Gy in 25 fxs to the prostate bed and pelvic lymph nodes) and 5 esophageal adenocarcinoma patients (45 Gy in 25 fxs to the primary tumor and grossly involved regional lymph nodes) previously treated with helical tomotherapy (HT) were selected for the retrospective planning study. OAR constraints followed RTOG 0534 (prostate) and RTOG 1010 (esophagus) recommendations. Three plans were generated for each case: prototype TPS, VMAT and HT. Typical plan parameters were: 2 coplanar full arcs in VMAT; 2.5 cm fixed jaw, pitch 0.287, modulation factor 2.5 in HT; 2 cm fan beam width with 51 firing positions in prototype TPS.

Results: Clinically acceptable plans were achieved in all techniques with comparable plan quality in terms of target dose coverage and OAR sparing. Table 1 summarizes the averaged results of OAR doses for all cases. HT and VMAT plans had significantly better PTV dose homogeneity over prototype TPS plans (two-tailed paired t-test, $p < 0.05$). The standard deviation of prostate PTV dose was 1.4 ± 0.2 Gy for prototype TPS, 0.8 ± 0.2 Gy for VMAT and 0.6 ± 0.1 Gy for HT. The standard deviation of esophagus PTV dose was 2.0 ± 0.3 Gy for prototype TPS, 0.9 ± 0.2 Gy for VMAT, and 0.7 ± 0.1 Gy for HT. Prototype TPS and VMAT provided improved superior/inferior dose penumbra compared to HT with 2.5 cm fixed jaw. Lower mean dose to penile bulb (inferior to the prostate PTV) was found in prototype TPS (12.9 ± 4.1 Gy) and VMAT (10.1 ± 5.0 Gy) as compared to HT plans (26.1 ± 3.9 Gy), $p < 0.05$. Reduced V_{20} in kidney (inferior to the esophagus PTV) was achieved in prototype TPS ($8.2 \pm 3.1\%$) and VMAT ($8.5 \pm 2.8\%$) as compared to HT plans ($15.7 \pm 4.7\%$), $p < 0.05$.

Conclusion: A prototype BgRT TPS was investigated for prostate and esophagus cases. The system provided comparable plan quality to that obtained using VMAT or HT.

Table 1. Average Dosimetric Results

Prostate Cases (n=5)					Esophagus Cases (n=5)				
OARs	Parameter	HT	VMAT	Prototype TPS	OARs	Parameter	HT	VMAT	Prototype TPS
Bladder	Mean Dose (Gy)	30.4	28.6	30.9	Heart	Mean Dose (Gy)	21.9	24.4	23.2
Rectum	Mean Dose (Gy)	22.7	20.1	24.0	Lung	V ₂₀ (%)	8.7%	8.4%	9.4%
Penile Bulb	Mean Dose (Gy)	26.1	10.1	12.9		V ₅ (%)	56.1%	61.4%	59.4%
Bowel	Dmax (Gy)	45.3	45.0	46.7	Kidney	V ₂₀ (%)	15.7%	8.5%	8.2%
	V ₃₀ (%)	9.2%	9.0%	10.3%	Spinal Cord	Max Dose D _{0.03cc} (Gy)	35.2	31.2	33.0