

Pelvic Motion: A retrospective dosimetric study of five gynaecological patients treated with adaptive radiotherapy

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Background

With the implementation of VMAT and more conformal treatment techniques inter fraction pelvic motion during radiotherapy treatment is of increased concern. In particular the effect of organ at risk movement and it's impact on target coverage.

At the BWoSCC our gynaecological patients receive VMAT radiotherapy of 45Gy in 25 fractions with concurrent chemotherapy. We have implemented a 'Plan of the Day' approach to adaptive planning. This aims to account for possible uterus displacement due to bladder and rectal movement and the subsequent reduction in Planning Target Volume (PTV) coverage. Two different margin recipes are used when creating the PTVs. Cone beam CTs (cbCT) are utilised daily to assess where the uterus lies and allow selection of the optimum plan for treatment.

The aim of this work was to identify if further adaptive planning could improve conformality.

Method

Five randomly selected patients were retrospectively analysed for both PTV coverage and OAR sparing. Chemotherapy is delivered each Monday therefore fractions delivered on Mondays and Fridays should exhibit greatest difference in anatomy.

VelocityTM was utilised to create synthetic CTs from the cbCTs with the original planning CT scan. Organs At Risk (OAR) were delineated to describe the pelvic organ motion and imported into EclipseTM. The original plan was recalculated on the synthetic CT to create a verification plan.

A re-plan was created on the fraction 5 synthetic CT using RapidPlanTM and subsequent verification plans created for the remaining 7 synthetic CTs and DVH analysis performed.

The PTV Homogeneity Index (HI) was calculated:

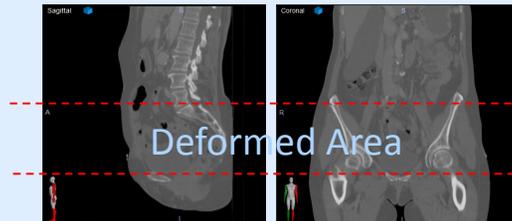
$$HI = \frac{D2 - D98}{Dp} \times 100$$

where:

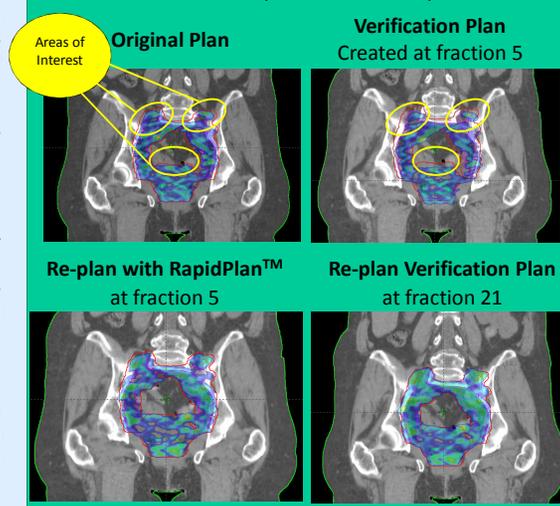
D2 = minimum dose to 2% of the target volume
D98 = minimum dose to the 98% of the target volume
Dp = prescribed dose

A two-tailed t-test (p<0.01) was used to assess significance.

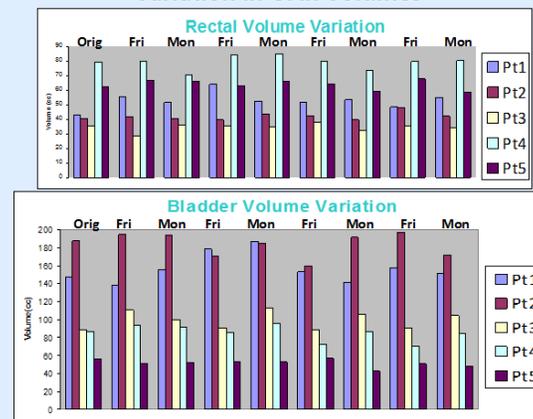
Synthetic CT created using VelocityTM



Dose Distributions (98% Colour Wash)



Variation in OAR Volumes



Results

		PTV Homogeneity Index	
Pt	Plan	Mean	
		Verif	Re-Plan Verif
1	0.084	0.17	0.12
2	0.105	0.20	0.12
3	0.097	0.21	0.26
4	0.107	0.16	0.11
5	0.127	0.15	0.13
Mean	0.10	0.18	0.15
T Test		0.018	0.229

Table 1.

PTV

Table 1 details the comparison values of the PTV for the original plan, the mean PTV of the verification plans created from the original plan and the mean PTV of the verification plans calculated from the fraction 5 data set for each patient.

Organs at Risk

Table 2 details the dose constraint for bladder and rectal OARs compared to the mean OAR doses of the verification plans calculated from the fraction 5 data set for each patient.

Pt	Bladder V45Gy		Rectum V45Gy	
	Plan	RePlan	Plan	RePlan
1	12.6	12.2	3.2	6.7
2	9.5	6.9	8.9	6.3
3	17.3	11.9	5.7	2.7
4	19.1	12.1	7.7	2.8
5	12.8	18.6	9.2	10.5
T Test	0.440		0.499	

Table 2.

- When compared to the verification plans of the original plan the RapidPlanTM replan at fraction 5 significantly improves the HI to the PTV in the subsequent replan verification plans.
- The CTV D98% coverage was greater than 97% for all verification plans.
- The bladder and rectal constraints were met on all occasions (35% of the volume receiving no more than 45Gy). There was no significant difference in OAR dose constraints observed.
- On one case, the original plan gave an improved HI coverage than the replan on the subsequent verification set.

Conclusion

Performing an additional, adaptive plan at fraction 5 can significantly improve PTV HI for this patient group without adversely affecting OAR doses. Incorporating this adaptive plan into the patient's plan library at this point in treatment would have been beneficial for four of the five patients reviewed.

The one case that this would not have been beneficial for highlights that every patient is different and continuous monitoring is the optimal solution.