

Geometric and dosimetric comparison of four intrafraction motion adaptation strategies for liver SBRT

Per R Poulsen¹, Saber Nankali², Rune Hansen³, Britta Weber^{1,4}, Morten Høyer^{1,4} and Esben S Worm³



¹Department of Clinical Medicine, Aarhus University, Denmark

²NSTRI, Radiation Application Research School, Tehran, Iran

³Department of Medical Physics, Aarhus University Hospital, Denmark

⁴Danish Center for Particle Therapy, Aarhus University Hospital, Denmark



Aarhus University Hospital

Introduction and aim

Tumor motion in stereotactic body radiotherapy (SBRT) :

- Success of SBRT is limited by tumor motion
- Many strategies exist to mitigate the dosimetric impact of motion

Aim: Compare four motion adaptation strategies for liver SBRT:

- Respiratory gating
- MLC tracking
- Baseline drift correction by inter-field couch shifts
- No intrafraction motion adaptation

Methods

Patients:

- Fifteen liver SBRT patients previously treated with Calypso electromagnetic guided respiratory gating in three fractions [1]

Treatment planning:

- 5 mm (axial) and 7-10 mm (cranio-caudal) CTV-to-PTV margins
- Conformal or IMRT plans with seven fields
- Targets covered with 67% (PTV) and 95% (CTV) isodoses

Investigated motion adaptation strategies:

- Calypso-guided respiratory gating in exhale (actual treatment)
- Calypso-guided MLC tracking (simulation)
- Couch correction before each treatment field if the mean position error during the previous field exceeded 2mm (simulation)
- No intrafraction motion adaptation, i.e. only daily adaptation to the mean tumor position by a setup CBCT scan (simulation)

Dosimetric evaluation:

- Dose reconstruction with calculation of motion-induced reduction in CTV D₉₅ relative to the planned dose (ΔD_{95})

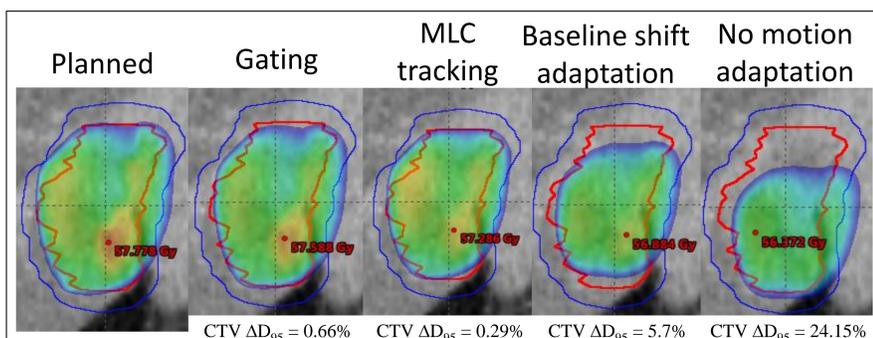


Figure 1. Planned dose distribution with 7 mm CC margin shown in a coronal plane through the CTV (red) and PTV (blue), and reconstructed dose distributions for the four motion adaptation strategies accumulated over all three fractions for Patient 1. Dose levels $\geq 95\%$ are shown.

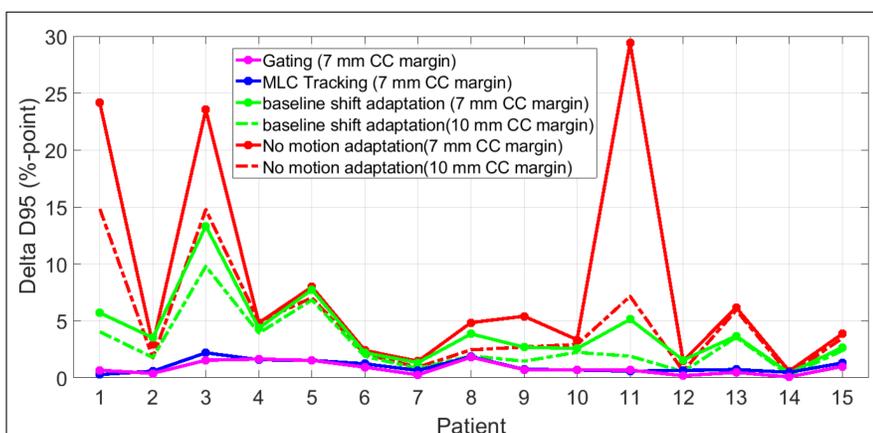


Figure 2. Mean reduction in delivered CTV D₉₅ dose relative to the planned course dose per patient for all motion adaptation strategies.

Conclusions

- Four motion adaptation strategies were compared for liver SBRT
- Inter-field couch correction can mitigate gross dose errors without the requirement of real-time motion monitoring.
- Gating and MLC tracking were much more effective strategies that ensured high similarity between planned and delivered doses
- Gating was slightly better than MLC tracking dosimetrically, but required several couch corrections and had lower duty cycle

Results

- Table 1 summarizes the number of couch corrections to compensate for tumor drift as well as the CTV ΔD_{95} of the four strategies with 7mm and 10mm cranio-caudal PTV margins.
- For three patients, systematic cranial tumor drift resulted in a mismatch between the tumor and high dose volume without intrafraction motion adaptation (Figures 1-2)
- The dose was partly restored with inter-field couch corrections and fully restored with gating and MLC tracking (Figures 1-3)

Table 1. Mean (and range) number of couch corrections and reduction in delivered CTV D₉₅ with 7mm and 10mm cranio-caudal PTV margins.

	Gating	MLC tracking	Baseline drift correction	No motion adaptation
Number of couch corrections	2.8 (0 - 7)	0	1.4 (0 - 5)	0
ΔD_{95} with 7 mm CC margin (%-point)	0.8 (0.1 - 1.8)	1.0 (0.3 - 2.2)	4.0 (0.4 - 13.3)	8.1 (0.6 - 29.4)
ΔD_{95} with 10 mm CC margin (%-point)	-	-	2.9 (0.2 - 9.8)	4.8 (0.3 - 14.8)

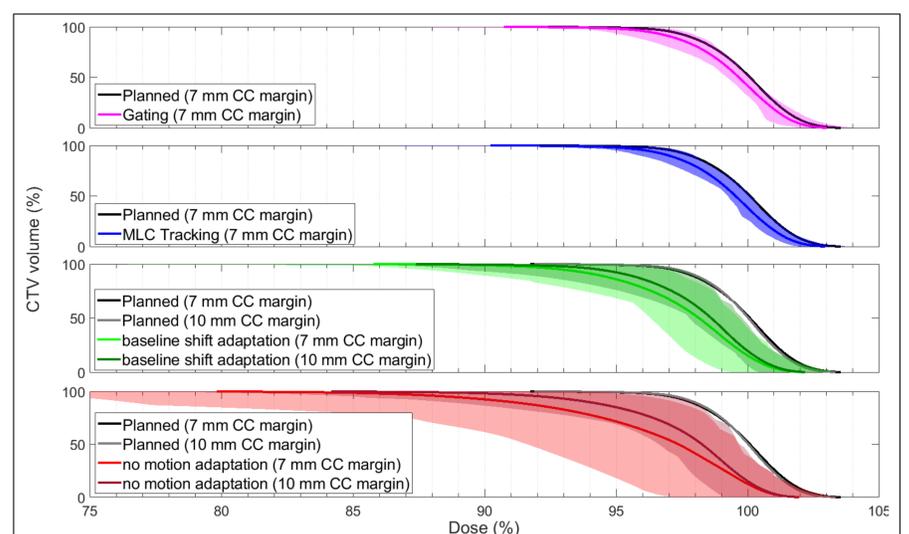


Figure 3. Mean CTV dose volume histogram of all treatment fractions. Shaded areas show the 10th-90th percentile range.

Acknowledgements

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References

1. Worm ES, Høyer M, Hansen R, Larsen LP, Weber B, Grau C and Poulsen P. A prospective cohort study of gated stereotactic liver radiation therapy using continuous internal electromagnetic motion monitoring. IJROBP 2018; 101; 387-395.

