ASSESSING THE IMPACT OF THE INTERPLAY EFFECT ON 10FFF LUNG SABR TREATMENT DOSIMETRY

R. JULIAN ~ M. HUSSEIN ~ C. SOUTH ~ V. EZHIL

ROYAL SURREY COUNTY HOSPITAL NHS FOUNDATION TRUST

INTRODUCTION

Lung stereotactic ablative body radiotherapy (SABR) treatments are currently planned locally using 6MV. Changing to 10MV Flattening Filter Free (10FFF) could reduce treatment times by >50%[1], allowing for better efficiency of service and improved patient experience and stability[2]. However, while interplay effect has been shown to be negligible with flattened beams[3,4], the faster treatment offered by FFF potentially exacerbates the effect[5,6]. The aim of this study was to compare the interplay effect on 6MV and 10FFF lung SABR treatment plans.

METHOD

CHAMBER MEASUREMENTS

Measurements were taken using a pinpoint chamber in the CIRS RPM phantom, with spherical water-equivalent tumour inserts of 1cm and 3cm diameter, sinusoidal breathing amplitudes of 1cm and 2cm, and phases of 3, 5, and 7 seconds. Measurements were repeated commencing the delivery at different stages of the breathing cycle. Static delivery was used as a 'gold standard' against which to compare the motion measurements.

The results (% diff to static) at each different starting position were then averaged, to simulate the blurring out of interplay effects over multiple fractions. Measured doses were also compared to the treatment planning system (TPS). Static measurements were compared against the dose to chamber volume as calculated on an image of the static phantom, while for comparisons to dynamic measurements, the AvIP image of a corresponding 4DCT was used.

FILM MEASUREMENTS

Using the film insert of the RPM phantom, a film was positioned centrally through the tumour in the coronal plane. Static and motion (5 seconds) films were acquired for 1cm and 3cm inserts, 1cm breathing amplitude (6MV and 10FFF), and for 3cm insert, 2cm amplitude (10FFF). Comparison between static and motion for each case was performed using gamma analysis on OmniPro I'mRT.

CLINICAL CASE

A 10FFF plan was produced on a patient who had previously undergone lung SABR (55Gy in 5#, 6MV, 2 half arcs). The plan was checked by a competent physicist to ensure that it was clinically representative. A verification plan was then produced on the RPM phantom, with the high dose region centred on the tumour insert.

Measurements were performed using the 3cm insert – phantom measurements (above) showed dose errors to be comparable between 1cm and 3cm inserts, and it was felt that the extra build-up of the 3cm insert offered more robust dosimetry. Motion measurements were taken using a 2cm amplitude, 7 second sinusoidal breathing cycle. Four motion measurements were taken, with beam delivery for each arc commenced with the tumour at SUP, INF, midpoint travelling SUP to INF, and midpoint travelling INF to SUP.

For analysis, the dose delivered from each possible combination of breathing phase per arc was calculated. In order to simulate the blurring effect caused over multiple fractions, every possible combination of those 16 doses delivered over 5#, and their ratios to static, was calculated using Python (1,048,567 combinations in total).

RESULTS

CHAMBER MEASUREMENTS

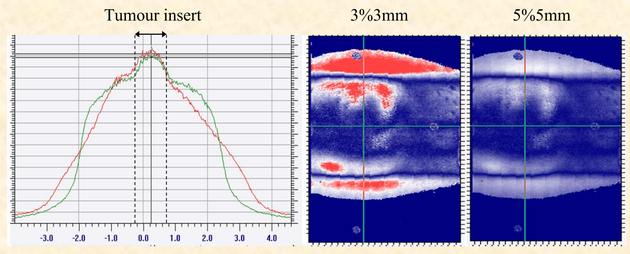
The maximum difference between static and motion was seen for 10FFF, 1cm insert, 2cm amplitude (-7.3%). Averaging the maximum differences from all inserts and amplitudes, the 10FFF average maximum difference was 0.1% (SD ± 6.7%), while the 6MV average maximum difference was 0.6% (SD ± 2.9%). Averaging over breathing phases significantly reduced the SD, giving a 10FFF average difference of -0.7% (±1.5%), and a 6MV average difference of 0.6% (± 2.2%).

Insert (cm)	Amplitude (cm)	Energy (6MV or 10FFF)	% diff			
			Static vs TPS	Motion vs static (max diff)	Motion (ave) vs static	Motion (ave) vs TPS CT_{AvIP}
3	2	6	-5.2	4.4	2.2	-2.3 (SD = 3.7)
		10	-1.7	6.9	-1.4	0.2 (5.4)
	1	6	-4.4	-1.1	-0.9	-5.0 (0.2)
		10	-3.3	4.5	1.5	-0.1 (2.8)
1	2	6	2.8	1.4	-0.1	9.0 (1.2)
		10	2.6	-7.3	-0.9	4.5 (3.3)
	1	6	2.9	-2.1	-1.4	4.5 (1.0)
		10	1.7	-3.5	-1.9	2.8 (1.8)

FILM MEASUREMENTS

Gamma analysis between static and moving films saw an agreement of >98.5% (3% 3mm) for both 6MV and 10FFF with a 1cm insert, 1cm amplitude, and of >95% (5% 5mm) for 1cm and 3cm inserts, 2cm amplitude. Most failures were seen in the shoulder regions of the field, as expected.

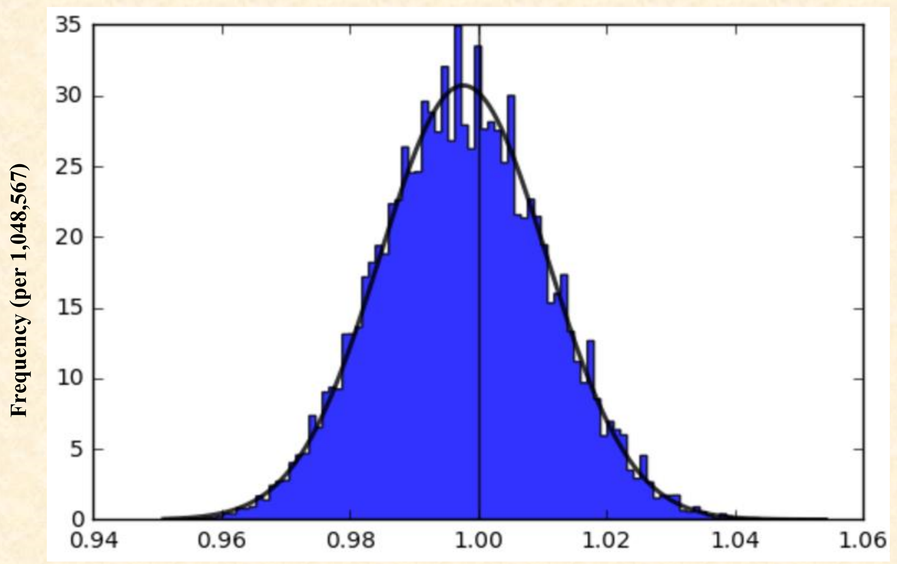
Insert (cm)	Amplitude (cm)	Energy (6MV or 10FFF)	Gamma 3%3mm (5%5mm)
1	1	6	99.1
		10	98.9
	2	6	76.7 (96.6)
		10	74.0 (97.1)
3	2	10	74.6 (95.1)



Profile and gamma comparisons between 1cm insert, 2cm amplitude 10FFF static and motion measurements

CLINICAL CASE

- Of all of the combinations of arcs (single fraction), the mean difference between static and moving measurements was -0.2%, range -4.9 to 5.4%, SD 2.9%.
- Dose difference vs static of all possible combinations delivered over 5# gives a normal distribution, shown in figure 1, centred about a mean of -0.2%. 98.0% of combinations agree within 3%, and 100% agree within 5%.



Histogram showing the dose difference of all possible combinations of breathing (2 arcs per fraction, 5 fractions per treatment) between dynamic and static delivery

CONCLUSION

Differences between the interplay effect observed on 6MV and 10FFF was found to be minimal, especially so for the smaller 1cm amplitude, with the effect becoming negligible when blurred over several fractions. 10FFF has therefore been implemented for lung SABR treatments with breathing amplitude <1cm.

1. Tambe, N. S. et al, 2016. *Biomed Phys & Eng Exp*, 2(6). [online] goo.gl/1vw4wE [Acc. 12/6/17]. 2. Stieb, S. et al, 2015. Radiation Oncology, 10(27). [online] https://goo.gl/05MfYV [Acc. 12/6/17]. 3. Rao, M. et al, 2012. *Int J Rad Onc, Bio, Phys*, 83(2):251-256. 4. Ong, C. et al, 2011. *Int J Rad Onc, Bio, Phys,* 79(1):305-311. 5. Ong, C. et al, 2013. *Int J Rad Onc, Bio, Phys,* 86(4):743-748. 6. Budgell, G. et al, 2016. Physics in Medicine & Biology, 61(23):8360-8394.