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The effect of reducing treatment delivery time using FFF on intra-fractional positional error in non-lung SABR



Introduction

- 35 SABR patients (105 fractions) treated between 2013 and 2016.
- 17/35 patients treated with 6MV and 18/35 with 6MV FFF.
- The treatment sites are spine (n=22), lymph node (n=7), bone (n=4) and adrenal (n=2).
- 6MV patients underwent 6DOF pre-treatment, mid-treatment and post-treatment imaging.
- 6MV FFF patients underwent pre-treatment and mid-treatment imaging. For setup imaging all corrections were applied and if positional error exceeded the action level 1mm and 1° mid-treatment shifts were applied.



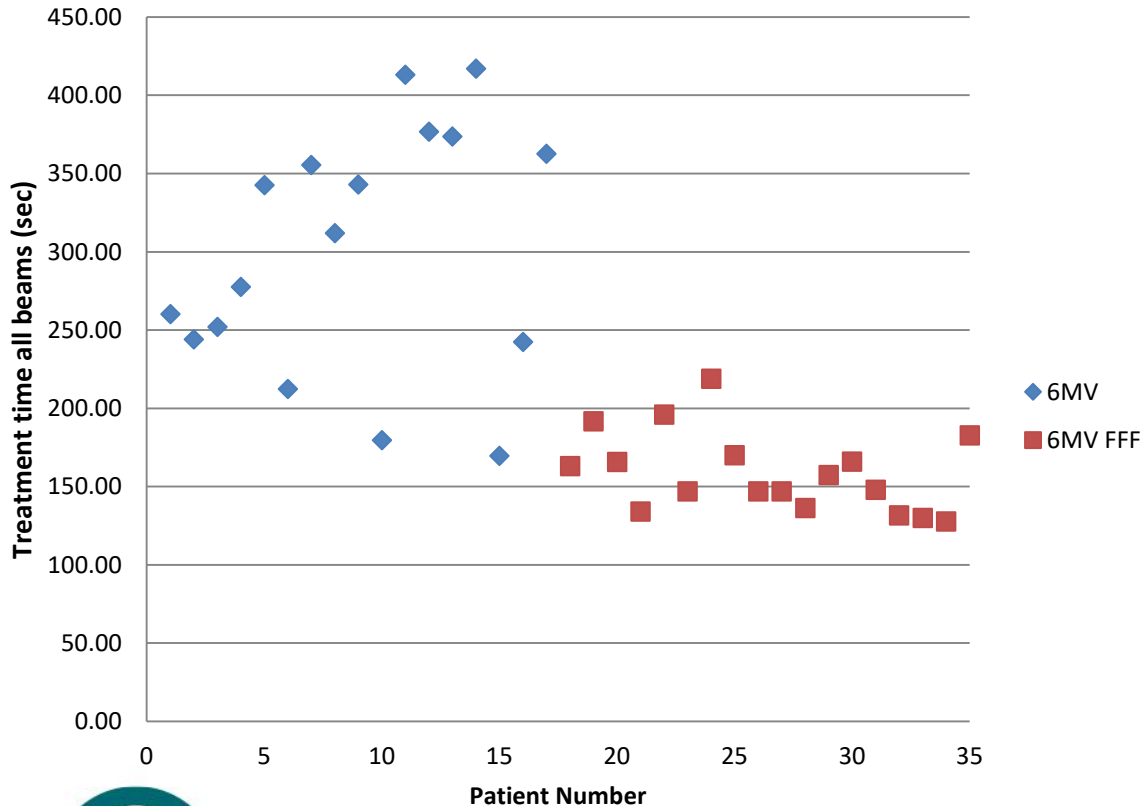
Method

- Using the SABR booking diary to identify patients.
- Offline review in ARIA used to identify the treatment timeline for each fraction and extract match data from imaging.
- Exactrac data taken from imaging reports on the Novalis system at CCCA and cross referenced with ARIA to identify timing of the images.
- Treatments plans checked in Eclipse for MU data.



Treatment time

“Beam on” treatment time for all arcs



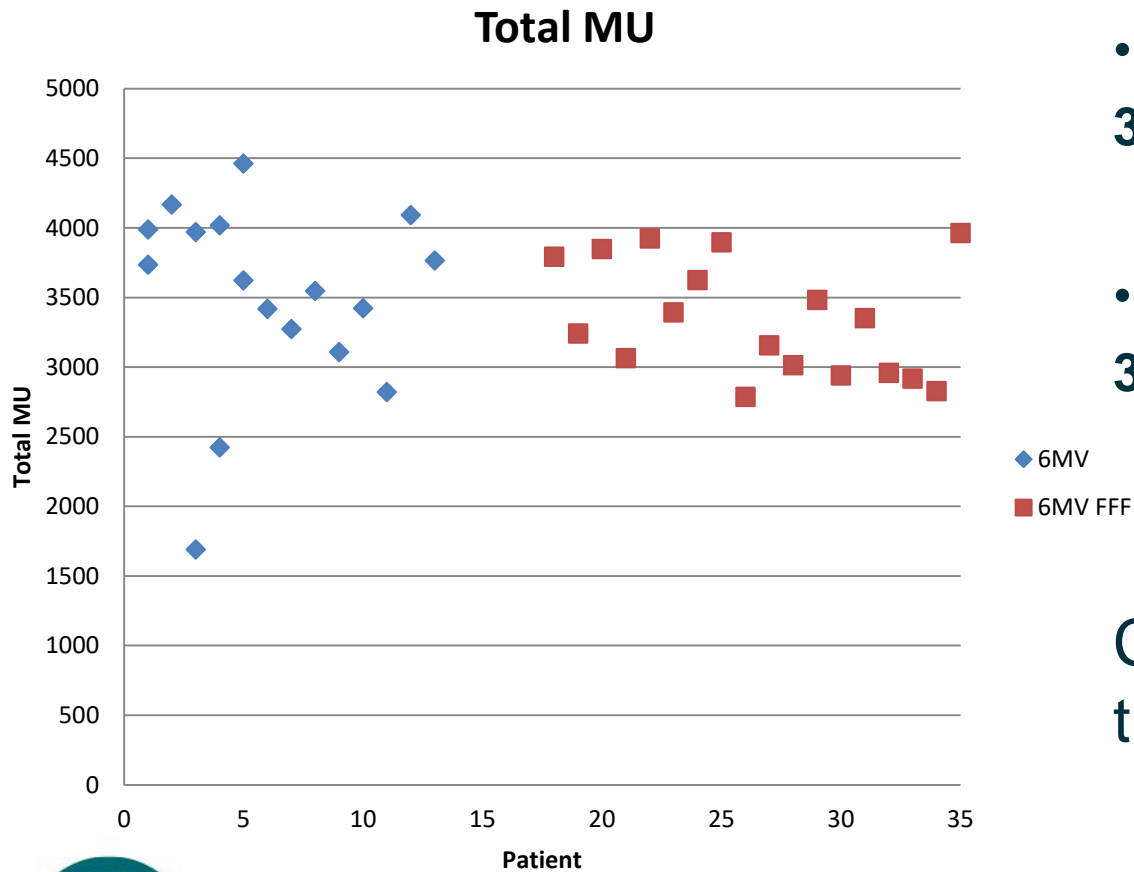
- Median time 6MV:
312 sec

- Median time 6MV FFF:
153 sec

Beam delivery time halved using 6MV FFF ($P < 0.0005$)



Treatment MU



- Average MU 6MV:

3502±694MU

- Average MU 6MV FFF:

3296±412MU

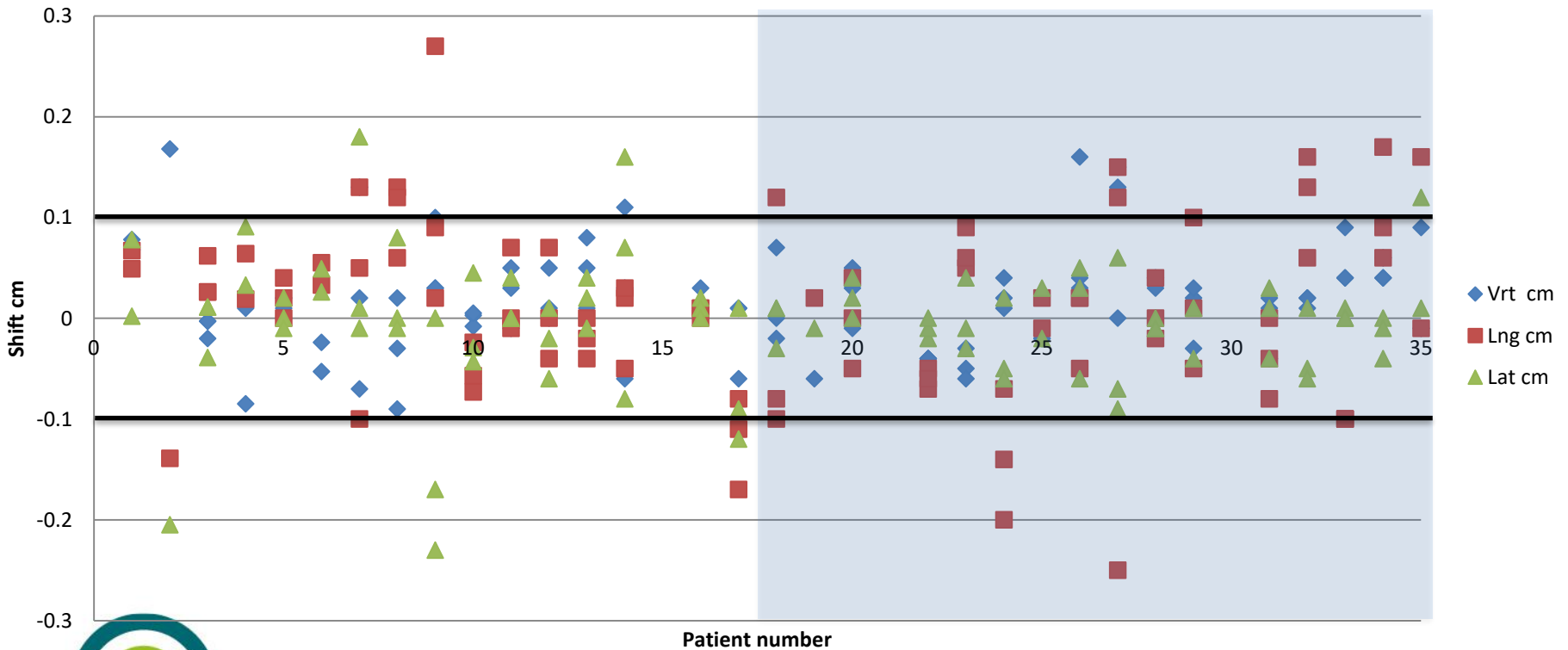
Consistent MU for
treatment plans



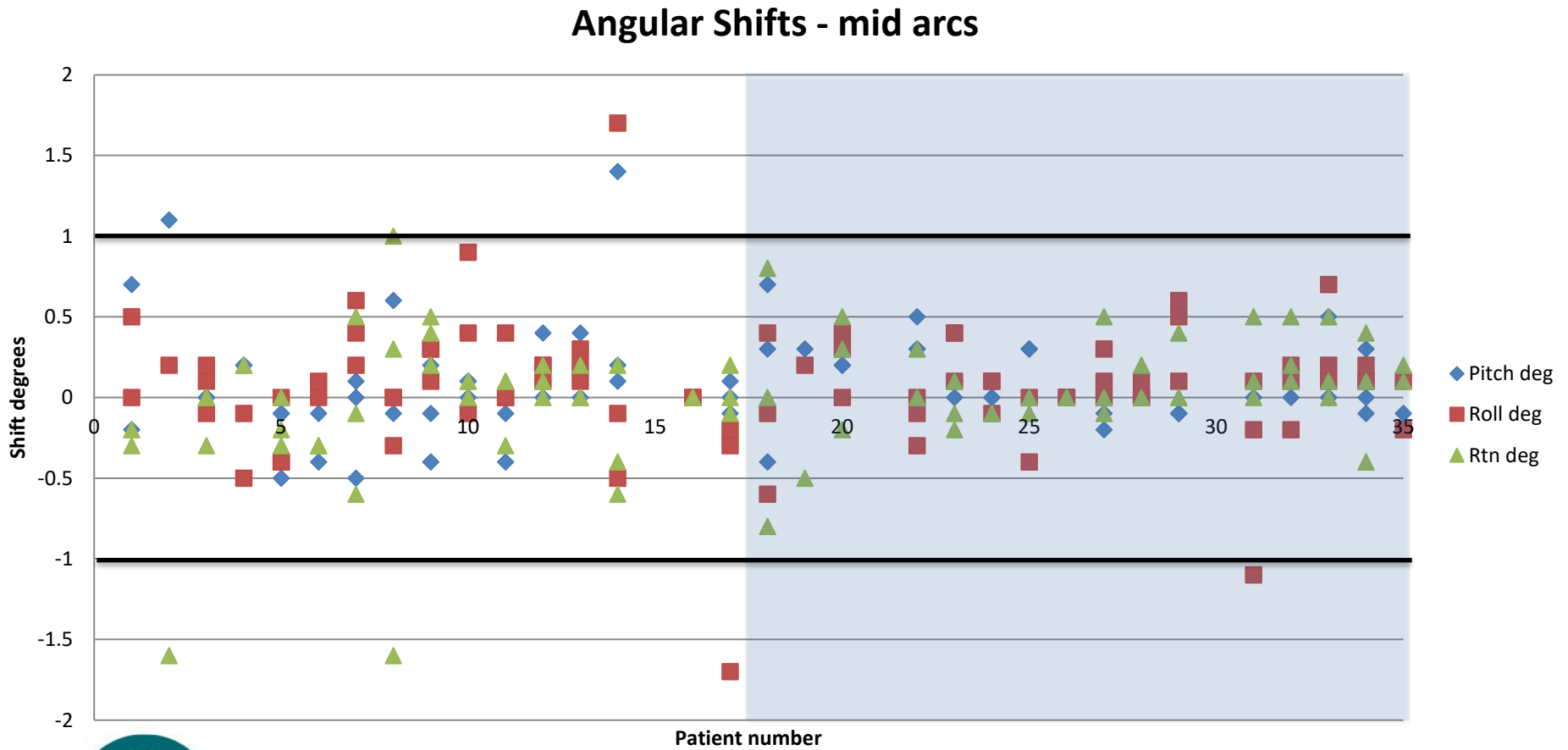
Shifts mid arcs

- Take first imaging mid arc before shifts applied

Linear Shifts - mid arcs



Shifts mid arcs



Shifts mid arcs

		Vert cm	Lat cm	Lng cm	Pitch °	Roll °	Rtn °
6MV	Mean (amplitude)	0.033	0.048	0.042	0.18	0.24	0.23
	SD	0.039	0.054	0.058	0.28	0.36	0.35
6MV FFF	Mean (amplitude)	0.033	0.061	0.023	0.13	0.17	0.16
	SD	0.036	0.060	0.026	0.16	0.22	0.21

- 26% of 6MV fractions and 27% of 6MV FFF exceeded 1mm and 1° in one dimension.
- 5% of 6MV and 2% of 6MV FFF exceeded 2mm or 2°.



Shifts post arcs

	Vrt cm	Lat cm	Lng cm	Pitch °	Roll °	Rtn °
Mean (amplitude)	0.014	0.014	0.016	0.10	0.12	0.12
SD	0.024	0.026	0.033	0.18	0.24	0.26

- Generally smaller shifts than mid arcs
- 40 fractions used post-treatment imaging with 12.5% having a positional error exceeding 1mm and 1°; but none exceeding 2mm or 2°.



Summary

- The median beam-on time reduced from 312 seconds (6MV) to 153 seconds (6MV FFF) ($P < 0.0005$).
- Modulation of treatment plans remained consistent with mean values of 3502 ± 694 MU (6MV) and 3296 ± 412 MU (6MV FFF) respectively.
- There is no significant difference in the mid-treatment positional error. 26% of 6MV fractions and 27% of 6MV FFF exceeded 1mm and 1° in one dimension. 5% of 6MV and 2% of 6MV FFF exceeded 2mm or 2° .
- 40 fractions used post-treatment imaging with 12.5% having a positional error exceeding 1mm and 1° ; but none exceeding 2mm or 2° .
- A preliminary version of this study was used to support the removal of post-treatment imaging for non-lung SABR patients. The results of this study support the continued use of mid-treatment imaging and positional correction for SABR patients treated with 6MV FFF.

