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Long-Term Monitoring of Patient Delivery Parameters Using Trajectory Logs

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INTRODUCTION & PURPOSE

• This study evaluates the utility of long-term monitoring of patient-specific delivery parameters using linac trajectory logs.

• The 6-month pilot study concentrated on three primary endpoints:

(1) Daily gamma pass rate comparing trajectory log fluence maps to the original DICOM treatment plan export file for a subset of H&N VMAT patients

(2) MLC leaf trajectory errors as a function of daily treatment delivery for a subset of prostate VMAT patients.

(3) Linac Beam-holds and gating using a surface-tracking system for motion management of abdomen VMAT patients.

METHODS

• A subset of patients treated on two linear accelerators were monitored for six months using trajectory logs in addition to conventional quality assurance methods including pre-treatment measurements and weekly chart checks.

• The study focused on patients treated with IMRT, VMAT, Dynamic Conformal Arc, and Field-In-Field planning and delivery techniques.

• An in-house trajectory log reader was developed and customized to parse all trajectory log files for a given patient and compare the linac delivery parameters versus the DICOM treatment planning file.

• The software parses the delivery control points from the trajectory logs (20 msec temporal resolution) and compares the daily control point snapshots with the treatment planning control points

RESULTS

DAILY GAMMA PASS RATE

• The MLC leaf position and monitor unit control points were extracted from the trajectory logs for 42 H&N treatment plans and synthetic fluence maps were generated for each treatment fraction and all treatment fields.

• A daily gamma map was calculated for each treatment beam using the calculated fluence map and corresponding DICOM plan fluence map (Fig. 1)

• The average gamma pass rate for 1254 treatment fractions was 94.4 ± 2.9% For a given patient treatment course, the standard deviation in the calculated gamma pass rate was typically less than 0.1% (Fig. 2)

MLC LEAF TRAJECTORY ERRORS

• MLC leaf trajectory errors were evaluated for a subset of 24 prostate patients and 721 VMAT delivered trajectory log files.

• The absolute value of the average maximum leaf position difference (expected versus actual) for all patient plans and treatment fractions was less than 1.7mm..

LINAC BEAM-HOLDS AND MOTION MANAGEMENT

• Treatment delivery beam-holds were evaluated for a sub-group of 31 abdomen patients in the context of motion management and linac gating.

• VMAT delivery was used for all treatments and the patients were coached for deep-inspiration breath hold (DIBH) or end-expiration breath hold (EEBH) and the VisionRT surface tracking system was used to gate the linac when the reference patient surface deviated from a translational and rotational tolerance setting (2-4 mm).

• The average number of beam-holds was 5.4 ± 3.5 and 4.1 ± 1.6 for DIBH and EEBH coaching respectively. Table 1 illustrates the treatment delivery demographics.

Table 1 - Treatment Delivery Demographics

	≤5	>5		
Treatment Fractions	17	14		
	2	3	4	5
# of VMAT Arcs	12	16	2	1
	EEBH	DIBH		
BREATH-HOLD	11	20		
	2mm	3mm	4mm	
VisionRT Tolerance	6	23	2	
	0sec	1sec		
VisionRT Time Tolerance	16	15		

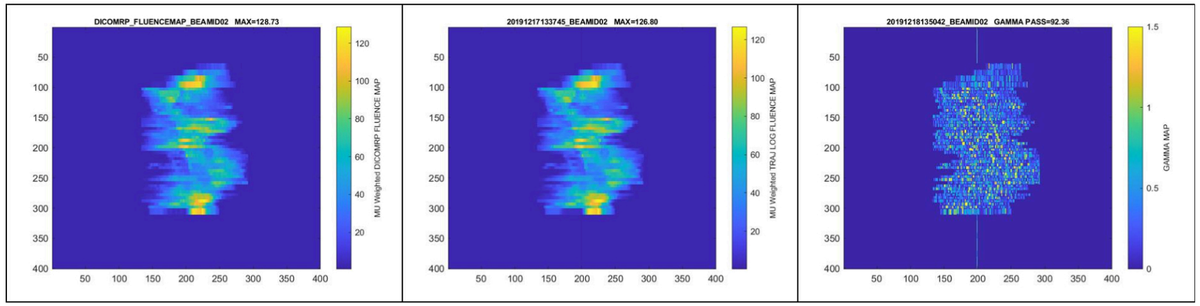

Figure 1 - Example synthetic fluence map, DICOM plan fluence map, and the calculated gamma distribution for one arc of a H&N VMAT plan. The gamma map is calculated using a 1% dose difference, 1mm DTA, and 10% normalized dose cutoff (global normalization).

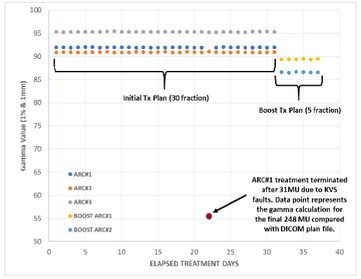

Figure 2 – The daily gamma pass rate for a representative H&N treatment plan. The plan utilizes VMAT delivery, 3 arcs for the initial plan and 2 arcs for the boost plan.

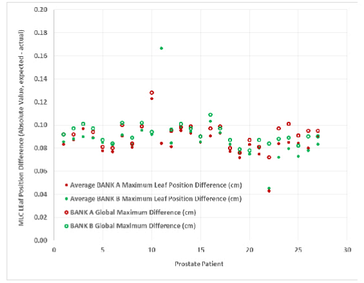

Figure 3 – The average Leaf Bank A and B maximum MLC leaf position difference and the global maximum MLC leaf position difference for the 24 prostate patients.

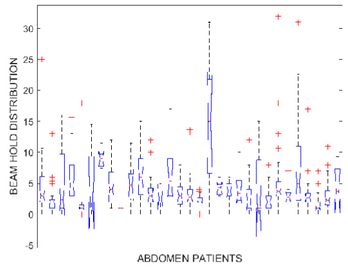

Figure 4 – The beam-hold distribution for 31 abdomen patients treated with DIBH or EEBH. Red cross represents outliers x3 standard deviations from the median.

CONCLUSIONS

• Linac delivery control points were extracted from the trajectory logs for >200 patients treated over a 6-month period.

• The daily trajectory logs for a subset of H&N, prostate, and abdomen patients were evaluated with emphasis on daily gamma pass rate, MLC leaf trajectory errors, and linac beam-holds respectively.

•Long-term monitoring of daily trajectory log files is possible although the post-processing requirements are significant.

• Future will work concentrate on connecting the analysis of daily gamma pass rate with MLC leaf trajectory errors and extending the analysis of motion management as a function of patient and treatment demographics.