

Dosimetric verification of RapidArc™ treatment delivery using the Delta4® phantom

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Background:

Radiotherapy beam delivery in arcs has the potential of delivering a highly conformal dose to the target while spreading the dose to the surrounding tissue and thereby sparing organs at risk from receiving high radiation doses. This spring, Varian Medical Systems, Inc. has introduced a new arc delivery technique termed RapidArc™. In this approach, the treatment is delivered in a single arc rotation of the linac gantry, during which the MLCs are moving dynamically while the dose rate and the gantry speed are also varied throughout the rotation of the gantry. As this new technique is introduced into clinical practice, extensive dosimetric verification is required to ensure correct treatment delivery.

Purpose:

The purpose of this study is to measure the delivered dose for treatment plans optimized in the RapidArc application. For each treatment plan, the consistency between measured absorbed dose and absorbed dose as planned and calculated in the Eclipse RapidArc environment will be assessed. Furthermore, the reproducibility of dose delivery will be investigated.

Materials & Methods:

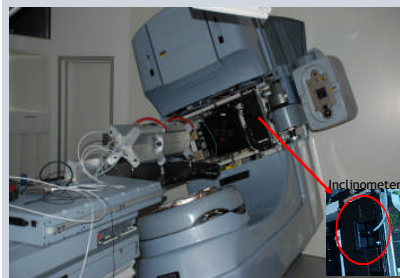
Treatment plans:

- 4 head and neck cases; 4 plans
- 4 prostate cancer cases; 5 plans whereof four were actually used for RapidArc patient treatment.

Plan characteristics:

- 300 degrees rotation
- 2 Gy per fraction
- Collimator -45 degrees
- Jaw openings 5-15 cm.

Delta4® phantom setup:



Delta4:

- Cylindrical PMMA
- 1069 p-Si diodes in two orthogonal planes
- Independent inclinometer

Measurements:

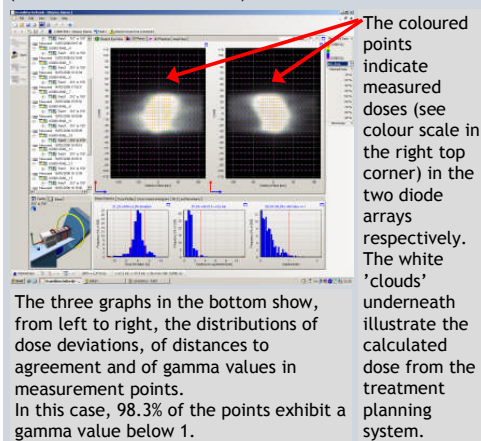
Patient	Cancer site	Measurements	MUs
Patient 1	Prostate	19 deliveries over 6 days	667
Patient 2	Prostate	15 deliveries over 5 days	646
Patient 3, first plan	Prostate	7 deliveries over 2 days	353
Patient 3, second plan	Prostate	7 deliveries over 2 days	529
Patient 4	Prostate	1 delivery	385
Patient 5	H&N	1 delivery	657
Patient 6	H&N	1 delivery	708
Patient 7	H&N	1 delivery	509
Patient 8	H&N	1 delivery	578

Analysis:

Gamma analysis using 3 mm distance-to-agreement and 3% dose deviations (relative to isocenter dose).

Results:

Measurement example showing consistency between measured and planned dose (from Delta4 interface):

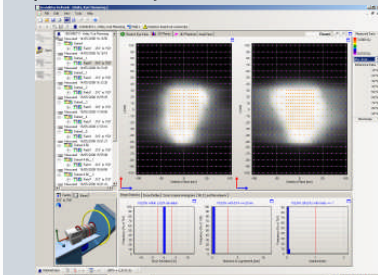


The coloured points indicate measured doses (see colour scale in the right top corner) in the two diode arrays respectively. The white 'clouds' underneath illustrate the calculated dose from the treatment planning system.

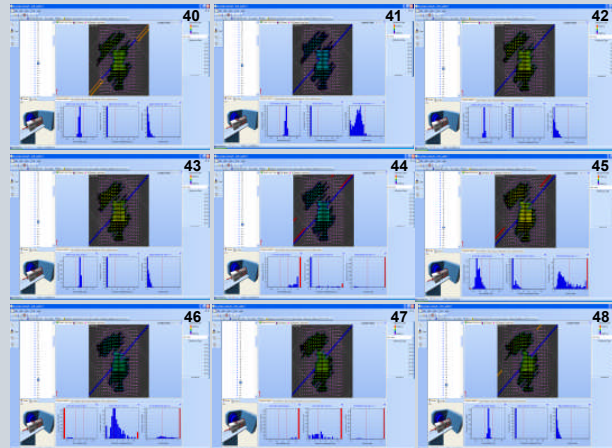
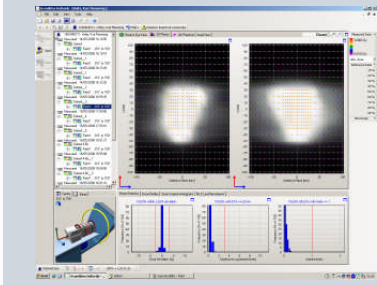
Percentage of measurement points with gamma values below 1 for all measurements:

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Patient 1	96.7 96.7 96.9 96.7	98.8 98.8 99.0	97.1 97.8	96.9 97.6 98.3 98.1	97.9 98.1 98.1	97.2 97.1 97.3
Patient 2		99.1 99.3 99.3	98.7 99.3 99.3	99.3 99.3 99.5	98.9 99.1 99.5	99.1 99.1 99.1
Patient 3, first plan			100.0 100.0 100.0	100.0 100.0		
Patient 3, second plan					99.0 99.0 99.0 99.0	96.7 97.0 96.8
Patient 4	99.8					
Patient 5	96.2					
Patient 6	96.2					
Patient 7	98.7					
Patient 8	98.5					

Reproducibility of immediate redelivery: Reproducibility of delivery subarc by subarc (~2 degrees/2-4 MUs):



and on a consecutive day:



For the subarc analysis, the gamma dose criterion 3% - <1.2 mGy, which means that deviations are on the same order as the measurement resolution. Comparison between subsequent deliveries is shown for nine consecutive subarcs (40-49). Segments with dose deviations are typically counter-balanced by following segments with deviations of the opposite sign, indicating that the deviations amount to few accelerator pulses 'slipping' between subarc measurements.

Summary:

The measured dose of RapidArc beam delivery corresponded well with calculated dose distribution for a number of different cases. The delivery was reproducible within the same day, and from day to day.

