Evaluation of a commercial EPID dosimetry system for pre-treatment QA, transit dosimetry and adaptive radiotherapy

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Introduction

Dosimetry Check (DC) (Math Resolutions LLC, USA) is the first commercially available system for transit dosimetry using electronic portal imaging devices (EPIDs). It reconstructs the three dimensional dose distribution delivered to the patient by back projecting exit portal images acquired during treatment onto a reference CT dataset [1].

A trial of the system was undertaken during September – November 2011 at The Clatterbridge Cancer Centre across 4 linear accelerators, all with aSi EPIDs: 2 Varian OBIs, an Elekta Precise and a Novalis Tx. The potential of the system for both quality assurance measurements prior to treatment and transit dosimetry during treatment was assessed. All treatment sites and techniques making up the routine workload of the linacs were considered: static fields, dynamic and physically wedged fields, VMAT and stereotactic cranial and body treatments.

Materials and Methods

Dose deconvolution kernels were generated for each energy / EPID combination by measuring the EPID signal on the beam central axis over a range of field sizes and through different depths of water then fitting the sum of a series of 5 exponentials [1-3]. The process was streamlined by using the ARIA RT management system to deliver beams according to a predefined plan. An additional set of measurements was required for the Elekta physical wedge to account for the different energy spectrum at the detector due to beam hardening by the metal [3].

Reference plans were calculated in the treatment planning system (TPS) against a series of geometrical and anatomical phantoms. The kernels were validated by delivering the plans in both pre-treatment (phantom not present) and transit (phantom present) scenarios.

Following validation, the DC was regularly used alongside Delta4 (Scandidos, Sweden) for pre-treatment VMAT QA and, where possible, transit dosimetry was utilised to verify delivery of the first fractions of all treatments undertaken over a two week period on all linacs where the system was installed.

A preliminary investigation of DC as part of an adaptive strategy was undertaken, calculating transit dose distributions on CBCT scans acquired during the same fraction.

Results and Discussion

Commissioning took around 1 hour per energy / wedge combination for linac measurements (i.e. 2 hours per Varian linac and 4 hours per Elekta linac) and 3 hours (away from the linac) to fit the kernels. Kernel fits were within 1% of all measurements and the validation plans were within 1-2% of the TPS doses. Additional iterations of the fitting algorithm were required for 2 of the kernels before this agreement was achieved.

DC compared well with Delta4 for pre-treatment measurements. The longer computation time for DC was offset by the time saved not setting up a phantom. Ad hoc QA measurements by treatment staff are therefore viable.

Transit measurements were within 5 ± 2% of the TPS values for all beams except those with physical wedges, which initially were within 12 ± 8%. These relatively poor results for wedges were in line with expectation [3]. However, refinement of the Dosimetry Check algorithm during the trial resulted in comparable agreement between wedged and unwedged fields. This is reassuring, is consistent with transit dosimetry results in the literature [1,4] and is comparable with diodes [5], the primary alternative for *in vivo* dosimetry.

Dosimetry Check had no impact on treatment times and the treatment staff preferred the measurement process to that involving diodes. A comprehensive cost-benefit analysis demonstrated that the EPID-based system was considerably more cost effective that using diodes.

The main limitation with any EPID dosimetry system is the inability to measure fields too large for the imaging panel. This can be mitigated through limited use of diodes and to some extent by modifying patient plans to accommodate the verification process.

Calculations were successfully performed on CBCT datasets but further work is required to make the process efficient and allow visualisation of results summed over time.

Conclusions

Dosimetry Check is an efficient and viable solution for pre-treatment QA and *in vivo* dosimetry of conventional and VMAT treatments. Overall performance was at least as good as would be expected with diodes, but with less likelihood of false positives due to diode placement errors.

Further work is required to streamline workflow processes and to apply DC as a QA tool in an adaptive strategy. This is being performed in conjunction with the manufacturer.

Following completion of the trial The Clatterbridge Cancer Centre has invested in the Dosimetry Check product across all 12 linear accelerators.

Acknowledgements

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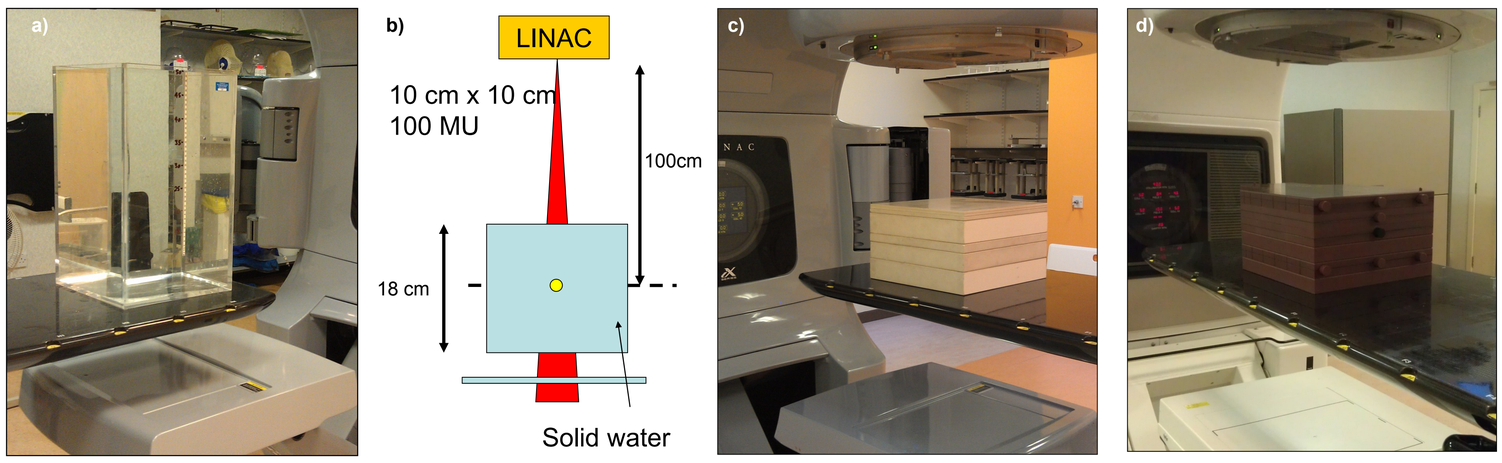
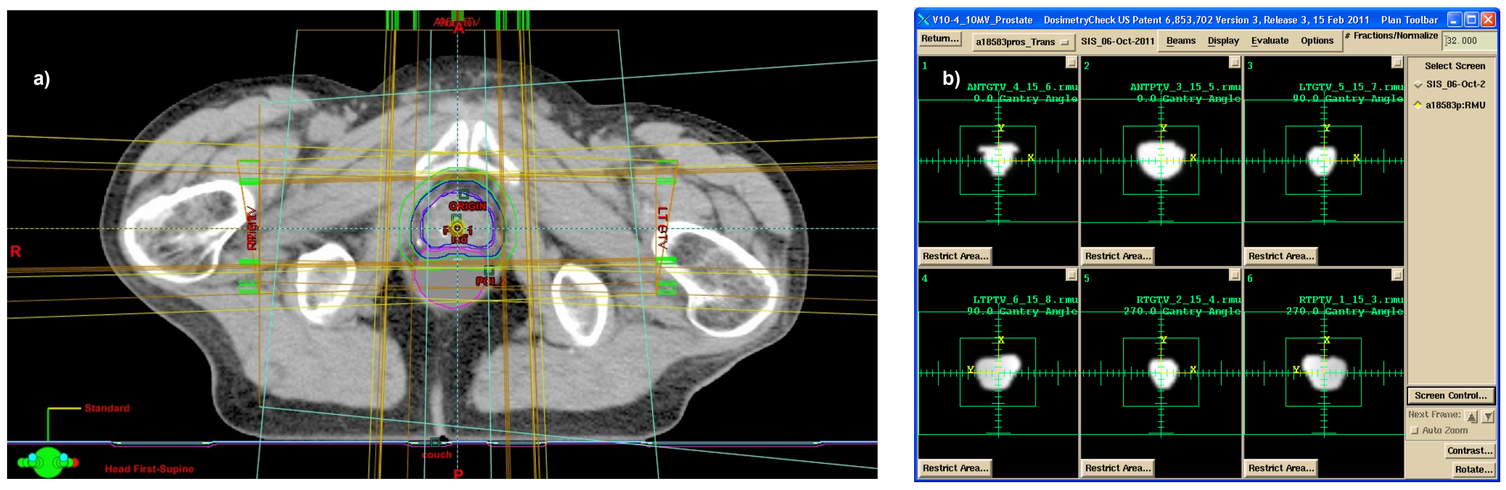
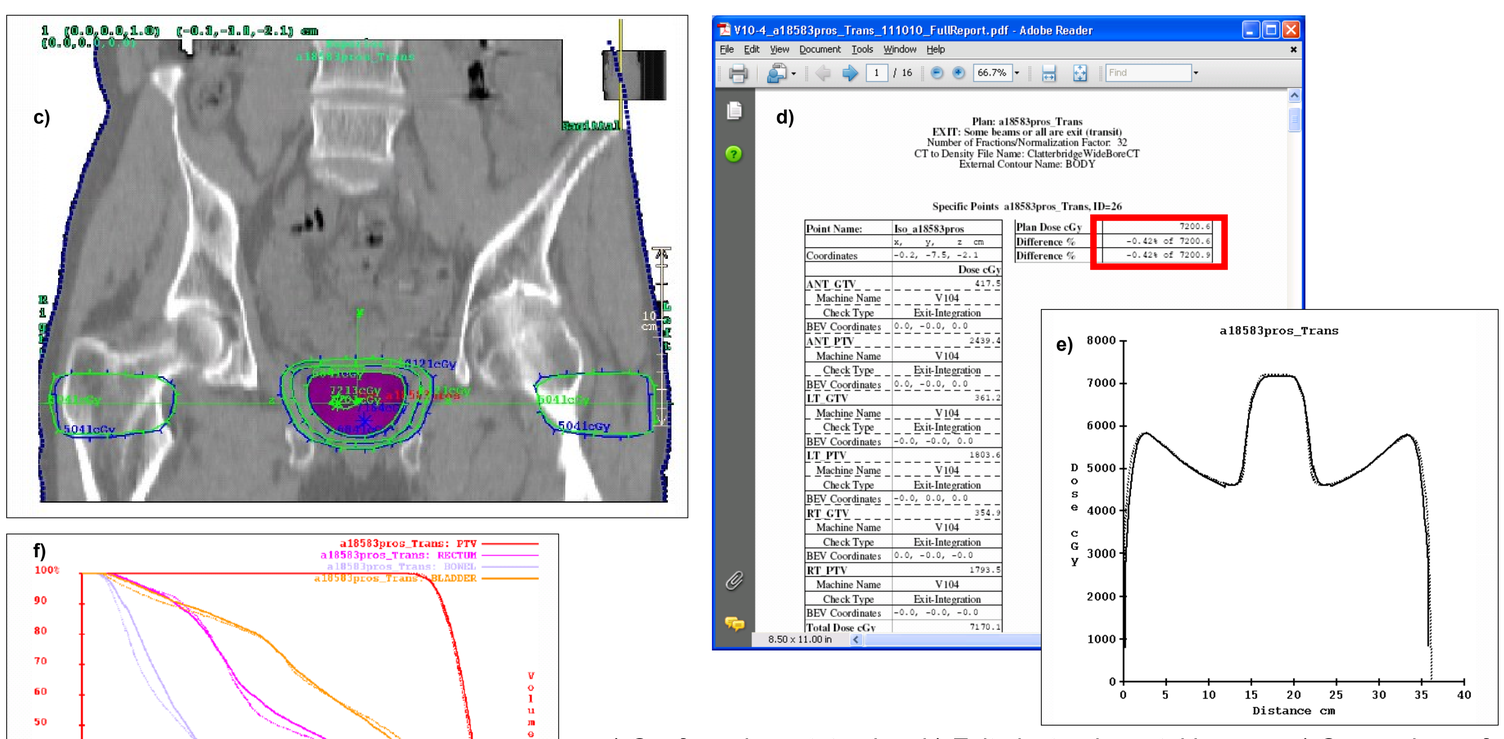
Commissioning Process



a) Characterisation of deconvolution kernel. b) Simple test geometry. c) Measurements with CIRS Plastic Water. d) Measurements with Standard Imaging semi-anatomical IMRT phantom

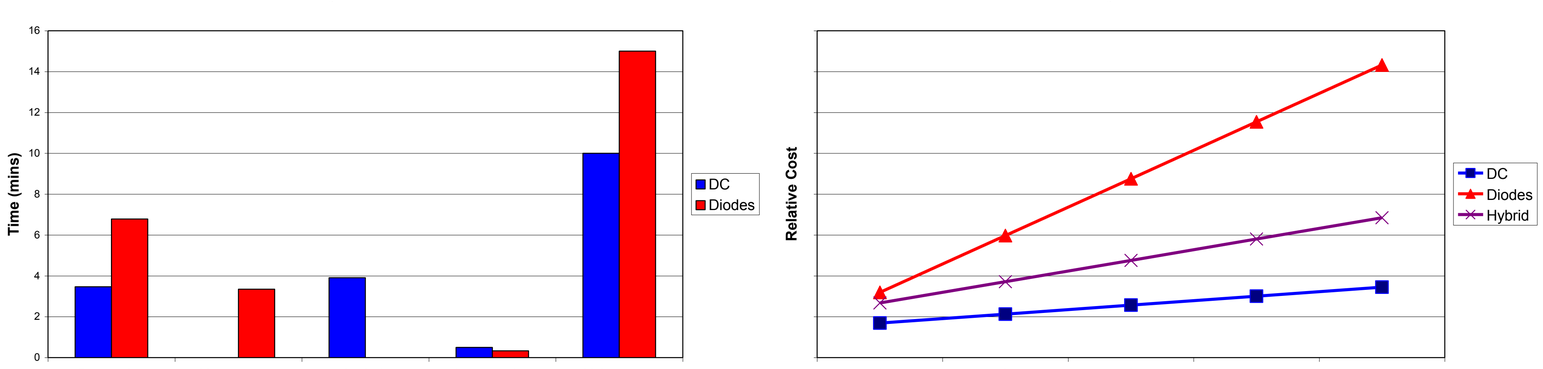
Patient Measurements





a) Conformal prostate plan. b) Exit electronic portal images. c) Comparison of TPS (green) and transit (blue) dose distributions in Dosimetry Check. d) Point dose report generated by Dosimetry Check. e) Comparison of TPS and transit dose profiles through target. f) Comparison of Dose Volume Histograms (DVHs) for TPS and transit dose distributions, calculated by Dosimetry Check.

Viability Studies



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