Journal of Physics: Conference Series

Application of portal dosimetry and Dolphin in clinical machine and patient-specific quality assurance

To cite this article: M Cai *et al* 2020 *J. Phys.: Conf. Ser.* **1662** 012001

Application of portal dosimetry and Dolphin in clinical machine and patient-specific quality assurance*

M Cai[1,2], B Archibald-Heeren[1,2], Y Wang[1,2]
[1]Icon Cancer Centre Wahroonga, Sydney Adventist Hospital, Wahroonga, Australia
[2]Centre of Medical and Radiation Physics, University of Wollongong, Wollongong, Australia

E-mail: emma.cai@icon.team

Abstract. This paper introduces Varian portal dosimetry and IBA dolphin detector. Clinical machine QA examples were presented including DLG measurement and monthly beam constancy check. For patient-specific QA, both detectors generated similar passing rates to film and were able to identify an erroneous delivery with 3mm MLC offset.

1. Introduction

The effectiveness and safety of radiation therapy is underpinned by a comprehensive quality assurance (QA) program. The International Commission on Radiation Units and Measurements (ICRU) specifies dose delivered to the patient to be within ±5% of the prescribed dose [1]. This is achieved through a thorough quality control of both machine performance and individual treatment plans [2].

Varian's Portal Dosimetry Image Prediction (PDIP) algorithm (Varian Medical Systems, Palo Alto, USA) predicts the panel response by convolving planned fluence with an imager response kernel, which is established in the PDIP commissioning process. The predicted response can then be compared with measurement in the Portal Dosimetry workspace in Aria (Varian Medical Systems, Palo Alto, USA) for IMRT/VMAT pre-treatment verification. Portal dosimetry can also be used for machine QA without the PDIP algorithm by examining the acquired portal image, and/or by comparing one measurement with a baseline measurement.

Dolphin (IBA Dosimetry, Schwarzenbruck, Germany) is a gantry-mounted 2D transmission detector. It comprises of 1513 parallel plate ionisation chambers plus one diode that cover the full field size. The chambers, each measuring 3.2mm in diameter, are spaced every 5mm in the central 14cm x 14cm detector region and sparser towards the periphery. For patient-specific QA, the results are analysed in Compass (IBA Dosimetry, Schwarzenbruck, Germany), which provides both 2D response comparison and 3D dose comparison. In the 2D response mode, plan parameters are taken from the DICOM RT plan, fed through the commissioned beam model to calculate the nominal fluence. This fluence is convolved with a detector kernel to generate predicted response, which can then be compared with Dolphin measured response. This 2D response comparison can be performed per beam or segment. In the 3D dose mode, Compass can produce either calculated dose or reconstructed dose. The former is calculated by applying collapsed cone convolution (CCC) algorithm to the nominal fluence in the patient reference CT dataset. The latter is calculated by first deconvolving the Dolphin

* This work was presented at Micro-Mini & Nano Dosimetry (MMND) 2018.

measurement with detector kernel, then applying the same CCC algorithm to the deconvolved fluence in the patient geometry. Both calculated dose and reconstructed dose can be compared with TPS dose. For machine QA, the results are analysed with either myQA Machines or myQA FastTrack (IBA Dosimetry, Schwarzenbruck, Germany).

Both portal dosimetry and Dolphin are used clinically at our institute. This paper presents some of their applications in machine and patient-specific QA.

2. Method

2.1. DLG verification using portal dosimetry
Dosimetric leaf gap (DLG) refers to increased transmission through closed MLC leaf ends due to rounded leaf curvature. This is modelled as an effective gap in the treatment planning system. At commissioning, measurements were taken using a static chamber with sliding MLC gaps of various sizes and DLG was determined by extrapolating to closed-gap value. As an example, DLG for our Varian TrueBeam 6MV beam is 1.5mm. Portal dosimetry was used as a sanity check on the DLG setting. Three plans were created with different amounts of MLC overlap to compensate for DLG. The beam arrangements are listed in table 1. Each plan was delivered to the portal imager and a composite portal image was created from the two beams. Mid-leaf profile across the junction was inspected for leaf gap / overlap.

Table 1. Beam arrangement for DLG verification.

Plan	Beam 1	Beam 2
Zero overlap	X1 = 5, X2 = 0, Y = 20, Coll = 90	X1 = 5, X2 = 0, Y = 20, Coll = 270
1mm overlap	X1 = 5, X2 = 0, Y = 20, Coll = 90	X1 = 5, X2 = -0.1, Y = 20, Coll = 270
2mm overlap	X1 = 5, X2 = -0.1, Y = 20, Coll = 90	X1 = 5, X2 = -0.1, Y = 20, Coll = 270

2.2. Monthly photon dosimetry QA using Dolphin
Dolphin was used to acquire 30cm x 30cm photon beam profiles. The acquired data were compared with baseline measurements in myQA FastTrack.

2.3. Patient specific QA
A good dosimeter should have both low false positive rate (able to pass plans that are deliverable) and low false negative rate (able to identify plans that are undeliverable).

A standard set of commissioning plans were selected. The plans cover four different treatment sites – head-and-neck, breast, lung and prostate. Two plans were created for each site using 6MV flattened and 6MV flattening filter free (FFF) beams as per clinical protocol. All plans were optimised using VMAT / IMRT in Eclipse V15.1. The plans were delivered from a Varian TrueBeam linac to gafchromic film, portal imager and Dolphin. Measurement results were compared with TPS using 3mm/3% gamma analysis with 10% threshold.

To test the sensitivity of the dosimeter to MLC positioning error, the 6MV head-and-neck VMAT plan was selected. MLC sequence was modified such that at all control points, all the leaves on bank A were opened further by 3mm. This error plan was recalculated and compared against the original plan delivery to film, portal imager, Dolphin and ArcCheck (Sun Nuclear Corporation, Florida, USA). The same gamma criteria as above were applied. For Dolphin, 2D response comparison and DVH comparison were performed in addition to gamma analysis.

3. Result

3.1. DLG verification using portal dosimetry

Figure 1 shows the profile comparison for the three plans. Increased transmission from the zero overlap plan demonstrated the DLG effect. This was reduced, though insufficiently, in the 1mm overlap plan. The valley from the 2mm plan suggested that a 2mm overlap over-compensated for the DLG. Overall, the measurement results were consistent with DLG parameter of 1.5mm.

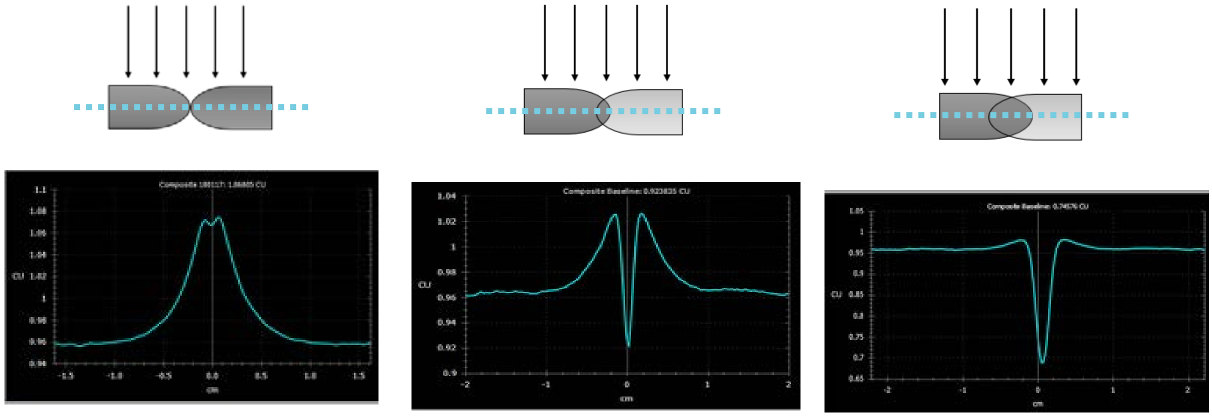


Figure 1. Profile comparison for the zero (left), 1mm (middle) and 2mm (right) overlap plan.

3.2. Monthly photon dosimetry QA using Dolphin

For each beam, acquired profiles were overlaid with baseline in myQA FastTrack. Central axis output, symmetry and flatness were compared to baseline. All parameters reported under 1% deviation. This method provides an efficient one-scan solution to routine photon dosimetry QA.

3.3. Patient specific QA

For all standard commissioning plans, gamma pass rates using 3mm/3% criteria 10% threshold were above 95% for all of film, PDIP and Dolphin.

For the MLC error plan, gamma pass rates were 67%, 74%, 93% and 96% from film, portal dosimetry, Dolphin and ArcCheck respectively. For Dolphin, 2D response comparison, which was analogous to portal dosimetry, was more sensitive to the MLC error, as shown in figure 2. This may be explained by the same relative position of MLC and detector, which brings out the MLC error at the fluence level more than at a ‘blurred’ dose level. Dolphin was able to demonstrate the dosimetric impact of the MLC error in the patient anatomy. This is shown in figure 3 by similar DVH difference between the original and error plan as computed by TPS and Compass. This information facilitates decision making that is clinically meaningful.

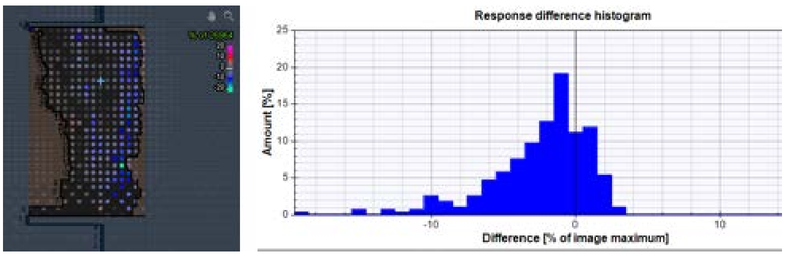
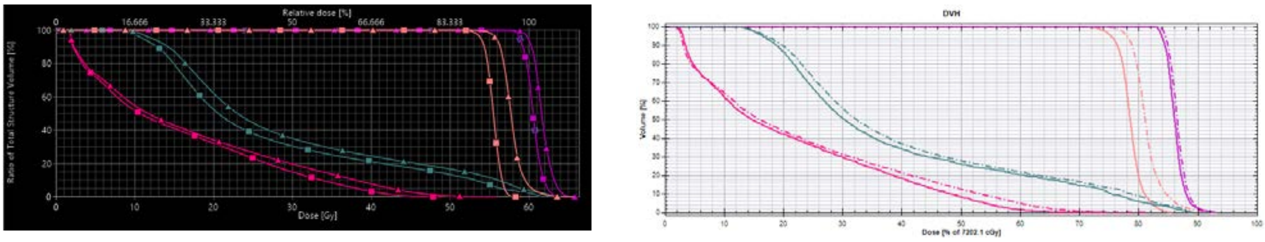


Figure 2. Dolphin response comparison for one beam: detector (left) and histogram view (right).



Dose difference	PTV high: mean	PTV low: mean	Brain Stem: D1	Larynx: mean
TPS	2%	4%	5.2Gy	2.5Gy
Dolphin	1%	4%	5.1Gy	1.3Gy

Figure 3. DVH from TPS (left) and Dolphin (right) showing similar difference between original plan and error plan.

4. Conclusion
Both portal dosimetry and Dolphin were shown to be versatile tools for clinical machine and patient-specific QA.

5. References
[1] ICRU Report 24 1976 International Commission on Radiation Units and Measurement, Bethesda
[2] Vial P *et al* 2006 *Phys. Med. Biol*. **51** 5517