PO-0789 Demystifying failed VMAT PSQA measurements with ArcCHECK

P. Kinsella[1], L. Leon-Vintro[2], B. McClean[3]
[1]*St Luke's Radiation Oncology Center, Physics, Dublin, Ireland*
[2]*University College Dublin, School of Physics, Dublin, Ireland*
[3]*St Luke's Radiation Oncology Network, Physics, Dublin, Ireland*

Purpose or Objective

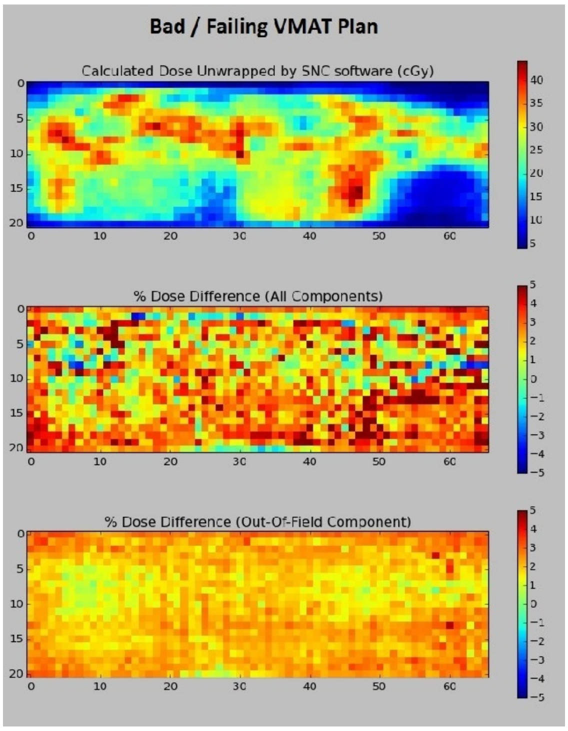
A means of reducing PSQA measurements for VMAT is currently a popular topic of discussion due to the resource burden it generates and the increased use of VMAT. The reluctance to reduce or replace PSQA may be partly due to the difficulty in identifying the cause/s of plan failures. Plans may fail due to a large number of potential factors caused by the TPS, linac or measurement device. The goal of this study was to uncover the reason/s why a selection of VMAT plans have failed.

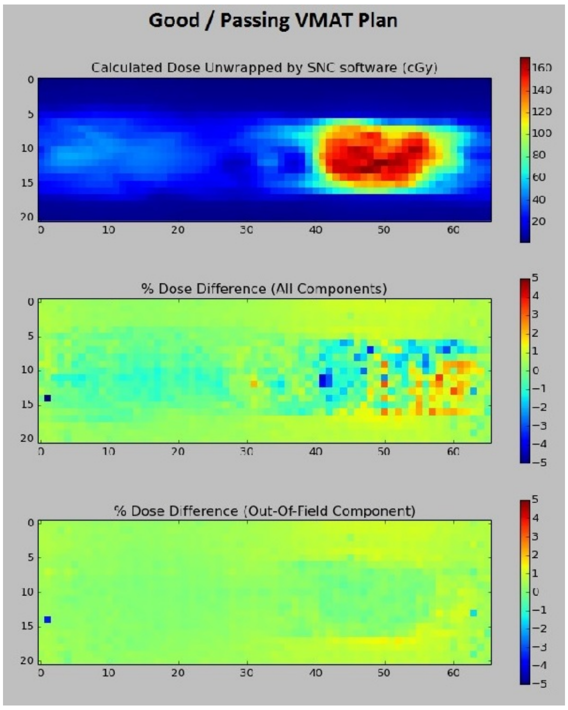
Material and Methods

Five 'bad' plans yielding low (failing) gamma pass-rates and high average gamma-values were s elected for analysis. Two 'good' plans yielding high gamma pass-rates and low average gamma values were also used for comparison. The plans were measured with SNC ArcCHECK (1220 Model) cylindrical detector diode array and analysed with gamma analysis in SNC Patient software. The institutional tolerance was ≥95% of the points must pass a gamma analysis with 3% and 2mm gamma criteria, with a 10% threshold and with the Van Dyk option (global gamma analysis) turned on. The control points for each plan were broken up into separate static fields applying the small arc approximation used by TPSs to calculate dynamic arc beams. The fields were then calculated in the Eclipse TPS (AAA) and delivered to the ArcCHECK. The individual static field measurements were compared to the individual calculations using an in-house Python script. Dose-differences were tracked field-by-field for each diode and categorised into 5 components according to the location of the diode in the irradiation geometry: In-field Entrance side, in-field exit side, penumbra entrance side, penumbra exit side and out-of-field. Results presented highlighted the contribution each component had to the overall dose difference.

Results

A composite measurement of individual control point fields compared with the conventional PSQA measurement showed minimal difference indicating that the main reason for PSQA fail was not due to the dynamic delivery. The out-of-field component appeared to have the greatest impact on the overall pass-rate as highlighted in the figures below where an example of both a 'good' and 'bad' plan are shown. It has been widely reported that diodes over-respond to low energy photons. A proposed solution to the problem was to use the latest version of the SNC Patient software (v6.7) which provides out-of-beam corrections for this over-response. The impact of applying the out-of-field correction resulted in all previously failed plans passing the gamma criteria stated earlier.





Conclusion

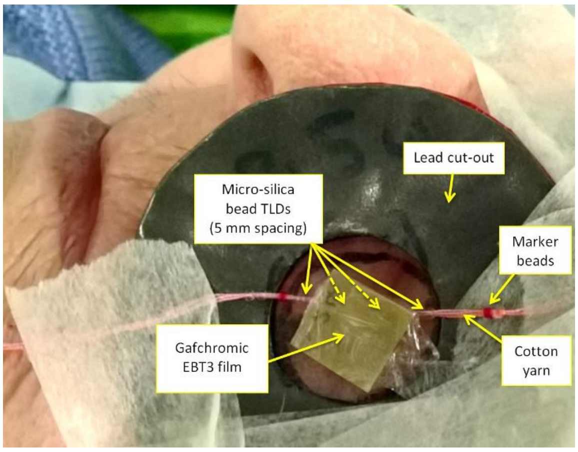
Deconstructing failed PSQA measurements proved useful in identifying the main source of error and lead to proving that these were false-positive results due to detector limitations. The manufacturers have released a new version of software with the ability to reduce this limitation. The results of this study indicate this correction should be adopted.

PO-0790 In-vivo dosimetry for kV radiotherapy: clinical use of micro-silica bead TLD &Gafchromic EBT3 film

A.L. Palmer[1], S.M. Jafari[1], J. Mone[2], S. Muscat[1]
[1]*Portsmouth Hospitals NHS Trust, Medical Physics Department, Portsmouth Hampshire, United Kingdom*

[2]University of Surrey, Physics Department, Guildford, United Kingdom

Purpose or Objective
kV radiotherapy continues to be an important modality in modern radiotherapy, but has received less research attention in recent years. There remains a challenge to accurately calculate and verify treatment dose distributions for clinical sites with significant surface irregularity or where the treated region contains inhomogeneities, e.g. nose and ear. The accuracy of current treatment calculations has a significant level of uncertainty [1, 2]. The objective of this work was to characterise two novel detectors, micro-silica bead TLDs and Gafchromic EBT3 film, for in-vivo measurements for kV treatments, and to compare measured doses with conventional treatment calculations.
[1. Currie (2007) Australas Phys Eng Sci Med, 2. Chow (2012) Rep Pract Oncol Radiother.]
Material and Methods
Micro-silica bead TLDs (1 mm diam.) and Gafchromic EBT3 film were calibrated against an NPL traceably calibrated ionisation chamber using an Xstrahl D3300 kV radiotherapy treatment unit. Energy response was evaluated over 70 to 250 kV and compared to 6 MV, useable dose range was evaluated from 0 to 25 Gy, and uncertainty budgets determined. Silica beads were cleaned, annealed, and TL response individually calibrated. EBT3 film was used with triple-channel dosimetry via FilmQAPro® with procedures to reduce uncertainties. Commissioning tests were undertaken in standard conditions using Solid Water blocks and in simulated clinical treatment condition using a custom made 'wax face with nose' phantom. Pilot in vivo measurements were made for a consecutive series of eight clinical patient treatments, including cheek, ear, nose and rib sites, over 70 to 250 kV, and 4 to 18 Gy. Results for the two dosimetry systems were compared to conventional treatment planning calculations.
Results
Energy response varied by 460% for beads and 9% for film, from 70 kV to 6 MV, necessitating energy-specific calibration. Both dosimeters were useable up to 25 Gy. Standard uncertainty was 3.1% for beads, 2.1% for film. The figure shows typical film and bead positions within the lead cut-out of a kV treatment to the cheek. The table provides calculated and measured doses. Average deviation over 6 patients was -1.3% for beads, -0.9% for film. 3 patients had larger deviations; See table note 1: tumour sitting over the maxillary sinus may reduce dose. Note 2: beads placed along surface of tumour into ear, most distal bead received dose -17.5% from prescription, doctor made compensation. Note 3: Increased uncertainty due to curved surface, film required offset to corner as patient sensitive to contact. Note 4: Uncertainty increased due to large respiratory motion at treatment site.



Dose per #, energy and site			EBT3 Film		Micro-Silica bead		Notes (see text)
			Measured dose, Gy, (±2.1%, k=1)	% diff. to calc.	Measured dose, Gy, (±3.1%, k=1)	% diff. to calc.	
10 Gy,	100 kV,	Cheek	9.176	-8.2	9.090	-9.1	1.
4 Gy,	250 kV,	Ear	3.998	0.0	4.030	0.7	2.
4 Gy,	70 kV,	Nose	4.015	0.4	3.992	-0.2	
7.5 Gy,	100 kV,	Cheek	7.253	-3.3	7.240	-3.5	
10 Gy,	140 kV,	Ear	10.154	1.5	10.053	0.5	
8 Gy,	250 kV,	Rib	7.053	-8.3	7.528	-5.9	3.
18 Gy,	100 kV,	Ear	17.471	-2.9	17.308	-3.8	
4 Gy,	250 kV,	Rib	3.861	-3.5	3.721	-7.0	4.

Conclusion
Both micro-silica bead TLDs and EBT3 film were characterised as suitable for in vivo dosimetry in kV radiotherapy, providing assurance of delivered doses. Film is simpler to prepare, use and read. A line of beads allows conformation to irregular anatomy across the field. A clinical service is now available to verify dose delivery in complex clinical sites.

PO-0791 Determination of water mean ionization potential for Geant4 simulations of therapeutical ion beams
A. Perales[1], M.A. Cortés-Giraldo[1], D. Schardt[2], J.A. Pavón[1], J.M. Quesada[1], M.I. Gallardo[1]
[1]*Universidad de Sevilla, Dpto. Fisica Atómica- Molecular y Nuclear, Sevilla, Spain*
[2]*GSI, Biophysics Division, Darmstadt, Germany*

Purpose or Objective
To characterize protons and ion beams to determine the mean ionization potential (I-value) of water to be used in Monte Carlo simulations with the Geant4 Monte Carlo toolkit at energies of interest in particle therapy. The magnitude of this parameter has a strong influence on the Bragg Peak spatial position which, to our knowledge, is a key factor for treatment planning.
Material and Methods
The energy deposition distributions with respect to depth in water were obtained using an experimental setup (figure 1) which consists in a water tank, which thickness can be varied with micrometric accuracy, and two ionization chambers (ICs), the first one placed downstream the beam exit window (IC1) and the second one just behind the water tank (IC2). The mean energy deposition relative to the mean energy deposition at the entrance as function of depth in water were obtained from the ratio between the ionization produced in IC2 with respect to that of IC1. These measurements were carried out for various ion species covering a range in water between 5 and 28 cm, approximately. The absolute depth in water was determined with an estimated uncertainty of 0.2 mm.
Our Geant4 simulations were done using an ideal geometry (figure 2) composed by a water tank containing cylindrical scoring volumes, with a radius of 28 mm (actual radius of the ICs) and a thickness of 50 microns (similar to the water equivalent thickness of the ICs), to tally the energy deposition.
For the simulation of each particular beam the energy spread was adjusted by fitting the width of the experimental distal fall-off prior determining the optimum I-value by matching our calculated 82% distal depth with the experimental one.