Optical Scanning

A prototype optical-CT system for PRESAGE 3D dosimeter readout
Miles, D., Yoon, P., Kodra, J., Adamovics, J., Oldham, M.
(2017) Journal of Physics: Conference Series, 847 (1), art. no. 012026

This work introduces the Duke Integrated-lens Optical Scanner (DIOS), a prototype optical-CT system designed for convenient and low-cost readout of PRESAGE 3D dosimeters. A key novelty of the DIOS is the incorporation of a multi-purpose light-collimating tank (the LC-tank). The LC-tank collimates light from a point source, maintains parallel ray geometry through a dosimeter mounted inside the tank, and refocuses emergent light onto a CCD detector. A second purpose is to dramatically reduce the amount of refractive matched fluid required in prior optical-CT scanners. This is achieved by substituting large quantities of refractive-matched fluid with solid RI-matched polyurethane. The advantages of DIOS include eliminating the need for expensive telecentric lenses, and eliminating the impracticality of large volumes of RI matched fluid. The DIOS is potentially more susceptible to stray-light artifacts. Preliminary phantom testing shows promising agreement between PRESAGE/DIOS readout and prior commissioned optical-CT scanners, as well as with Eclipse dose calculations.

Optical-CT 3D dosimetry using Fresnel lenses with minimal refractive-index matching fluid
Bache, S., Malcolm, J., Adamovics, J., Oldham, M.
(2016) PLoS ONE, 11 (3), art. no. e0152606,

Telecentric optical computed tomography (optical-CT) is a state-of-the-art method for visualizing and quantifying 3-dimensional dose distributions in radiochromic dosimeters. In this work a prototype telecentric system (DFOS-Duke Fresnel Optical-CT Scanner) is evaluated which incorporates two substantial design changes: the use of Fresnel lenses (reducing lens costs from $10-30K t0 $1-3K) and the use of a 'solid tank' (which reduces noise, and the volume of refractively matched fluid from 1ltr to 10cc). The efficacy of DFOS was evaluated by direct comparison against commissioned scanners in our lab. Measured dose distributions from all systems were compared against the predicted dose distributions from a commissioned treatment planning system (TPS). Three treatment plans were investigated including a simple four-field box treatment, a multiple small field delivery, and a complex IMRT treatment. Dosimeters were imaged within 2h post irradiation, using consistent scanning techniques (360 projections acquired at 1 degree intervals, reconstruction at 2mm). DFOS efficacy was evaluated through

inspection of dose line-profiles, and 2D and 3D dose and gamma maps. DFOS/TPS gamma pass rates with 3%/3mm dose difference/distanceto-agreement criteria ranged from 89.3% to 92.2%, compared to from 95.6% to 99.0% obtained with the commissioned system. The 3D gamma pass rate between the commissioned system and DFOS was 98.2%. The typical noise rates in DFOS reconstructions were up to 3%, compared to under 2% for the commissioned system. In conclusion, while the introduction of a solid tank proved advantageous with regards to cost and convenience, further work is required to improve the image quality and dose reconstruction accuracy of the new DFOS optical-CT system.

Investigations into the feasibility of optical-CT 3D dosimetry with minimal use of refractively matched fluids

Jackson, J., Juang, T., Adamovics, J., Oldham, M.

(2015) Physics in Medicine and Biology, 60 (6), pp. 2217-2230

The purpose of this work was to characterize three formulations of PRESAGE® dosimeters (DEA-1, DEA-2, and DX) and to identify optimal readout timing and procedures for accurate in-house 3D dosimetry. The optimal formulation and procedure was then applied for the verification of an intensity modulated radiation therapy (IMRT) and a volumetric modulated arc therapy (VMAT) treatment technique. PRESAGE® formulations were studied for their temporal stability post-irradiation, sensitivity, and linearity of dose response. Dosimeters were read out using a high-resolution optical-CT scanner. Small volumes of PRESAGE® were irradiated to investigate possible differences in sensitivity for large and small volumes ('volume effect'). The optimal formulation and read-out technique was applied to the verification of two patient treatments: an IMRT plan and a VMAT plan. A gradual decrease in post-irradiation optical-density was observed in all formulations with DEA-1 exhibiting the best temporal stability with less than 4% variation between 2-22 h post-irradiation. A linear dose response at the 4 h time point was observed for all formulations with an R2 value>0.99. A large volume effect was observed for DEA-1 with sensitivity of the large dosimeter being ~63% less than the sensitivity of the cuvettes. For the IMRT and VMAT treatments, the 3D gamma passing rates for 3%/3 mm criteria using absolute measured dose were 99.6 and 94.5% for the IMRT and VMAT treatments, respectively. In summary, this work shows that accurate 3D dosimetry is possible with all three PRESAGE® formulations. The optimal imaging windows post-irradiation were 3-24 h, 2-6 h, and immediately for the DEA-1, DEA-2, and DX formulations, respectively. Because of the large volume effect, small volume cuvettes are not yet a reliable method for calibration of larger dosimeters to absolute dose. Finally, PRESAGE® is observed to be

a useful method of 3D verification when careful consideration is given to the temporal stability and imaging protocols for the specific formulation used.

An investigation of PRESAGE® 3D dosimetry for IMRT and VMAT radiation therapy treatment verification

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(2015) Medical Physics, 42 (5), art. no. 4915530

Purpose: In optical-CT, the use of a refractively matched polyurethane solid-tank in place of a fluid bath has the potential to greatly increase practical convenience, reduce cost, and possibly improve the efficacy of flood corrections. This work investigates the feasibility of solid-tank optical-CT imaging for 3D dosimetry through computer simulation. Methods: A MATLAB ray-tracing simulation platform, ScanSim, was used to model a parallel-source telecentric optical-CT imaging system through a polyurethane solid-tank containing a central cylindrical hollow into which PRESAGE radiochromic dosimeters can be placed. A small amount of fluid fills the 1-5 mm gap between the dosimeter and the walls of the tank. The use of the solid-tank reduces the required amount of fluid by approximately 97%. To characterize the efficacy of solid-tank, optical-CT scanning simulations investigated sensitivity to refractive index (RI) mismatches between dosimeter, solid-tank, and fluid, for a variety of dosimeter (RI = 1.5-1.47) and fluid (RI = 1.55-1.0) combinations. Efficacy was evaluated through the usable radius (r<inf>u</inf>) metric, defined as the fraction of the radius of the dosimeter where measured dose is predicted to be within 2% of the ground truth entered into the simulation. Additional simulations examined the effect of increasing gap size (1-5 mm) between the dosimeter and solid-tank well. The effects of changing the lens tolerance (0.5°-5.0°) were also investigated. Results: As the RI mismatch between the dosimeter and solid-tank increased from 0 to 0.02, the usable radius decreased from 97.6% to 50.2%. The optimal fluid RI decreased nonlinearly from 1.5 to 1.34 as the mismatch increased and was up to 9% lower than the tank. Media mismatches between the dosimeter and solid-tank also exacerbate the effects of changing the gap size, with no easily quantifiable relationship with usable radius. Generally, the optimal fluid RI value increases as gap size increases and is closely matched to the dosimeter at large gap sizes (>3 mm). Increasing the telecentric lens tolerance increases the usable radius for all refractive media combinations and improves the maximum usable radius of mismatched media to that of perfectly matched media for tolerances >5.0°. The maximum usable radius can be improved up to a factor of 2 when lens tolerances are small (<1.0°). Conclusions: Dry solid-tank optical-CT imaging in a telecentric system is feasible if the dosimeter RI is a close match with the solid-tank (<0.01 difference), providing accurate dose measurements within ±2% of true dose to over 80% of the

dosimeter volume. In order to achieve accurate measurements over 96% of the dosimeter volume (representing out to 2 mm from the dosimeter edge), the dosimeter-tank RI mismatch must be less than 0.005. Optimal results occur when the RI of the dosimeter and tank is the same, in which case the fluid will have the same RI. If mismatches between the tank and dosimeter RI occur, the RI of the matching fluid needs to be fine tuned to achieve the highest usable radius.

Towards optical CT scanning of radiochromic 3D dosimeters in mismatched refractive index solutions
Dekker, K.H., Battista, J.J., Jordan, K.J.
(2015) IFMBE Proceedings, 51, pp. 716-719.

The clinical utility of the PRESAGE® solid dosimeter is inhibited by the need for viscous, oil-based refractive index matching liquids during optical CT scan readout. Practically, it would be advantageous to work with lower viscosity, water-soluble matching fluids. The use of non-matching refractive index results in non-uniformly sampled, incomplete CT data, making standard CT filtered backprojection reconstruction infeasible. However, with iterative CT reconstruction, incomplete and non-uniformly sampled data can be used to reconstruct good quality images. Here we present a method to measure the path of primary rays through a dosimeter scanned with intentionally mismatched fluids. We present preliminary results from an experiment that mimics PRESAGE®-like refractive effects in a low viscosity surrounding liquid, using a scanning-laser CT scanner with a large area detector. We show that a uniformly attenuating object can be reconstructed to 3% accuracy within the central 80-85% of the sample in this case.

Verification of micro-beam irradiation
Li, Q., Juang, T., Beth, R., Chang, S., Oldham, M.
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Micro-beam Radiation Therapy (MRT) is an experimental radiation therapy with provocative experimental data indicating potential for improved efficacy in some diseases. Here we demonstrated a comprehensive micro-beam verification method utilizing high resolution (50pm) PRESAGE/Micro-Optical-CT 3D Dosimetry. A small PRESAGE cylindrical dosimeter was irradiated by a novel compact Carbon-Nano-Tube (CNT) field emission based MRT system. The Percentage Depth Dose (PDD), Peak-to-Valley Dose Ratio (PVDR) and beam width (FWHM) data were obtained and analyzed

from a three strips radiation experiment. A fast dose drop-off with depth, a preserved beam width with depth (an averaged FWHM across three beams remains constant (405.3um, sigma=13.2um) between depth of 3.0~14.0mm), and a high PVDR value (increases with depth from 6.3 at 3.0mm depth to 8.6 at 14.0mm depth) were discovered during this verification process. Some operating procedures such as precise dosimeter mounting, robust mechanical motions (especially rotation) and stray-light artifact management were optimized and developed to achieve a more accurate and dosimetric verification method.

Issues involved in the quantitative 3D imaging of proton doses using optical CT and chemical dosimeters

Doran, S., Gorjiara, T., Kacperek, A., Adamovics, J., Kuncic, Z., Baldock, C. (2015) Physics in Medicine and Biology, 60 (2), pp. 709-726.

Dosimetry of proton beams using 3D imaging of chemical dosimeters is complicated by a variation with proton linear energy transfer (LET) of the dose-response (the so-called 'quenching effect'). Simple theoretical arguments lead to the conclusion that the total absorbed dose from multiple irradiations with different LETs cannot be uniquely determined from post-irradiation imaging measurements on the dosimeter. Thus, a direct inversion of the imaging data is not possible and the proposition is made to use a forward model based on appropriate output from a planning system to predict the 3D response of the dosimeter. In addition to the quenching effect, it is well known that chemical dosimeters have a non-linear response at high doses. To the best of our knowledge it has not yet been determined how this phenomenon is affected by LET. The implications for dosimetry of a number of potential scenarios are examined. Dosimeter response as a function of depth (and hence LET) was measured for four samples of the radiochromic plastic PRESAGE, using an optical computed tomography readout and entrance doses of 2.0 Gy, 4.0 Gy, 7.8 Gy and 14.7 Gy, respectively. The dosimeter response was separated into two components, a single-exponential low-LET response and a LET-dependent quenching. For the particular formulation of PRESAGE used, deviations from linearity of the dosimeter response became significant for doses above approximately 16 Gy. In a second experiment, three samples were each irradiated with two separate beams of 4 Gy in various different configurations. On the basis of the previous characterizations, two different models were tested for the calculation of the combined quenching effect from two contributions with different LETs. It was concluded that a linear superposition model with separate calculation of the quenching for each irradiation did not match the measured result where two beams overlapped. A second model, which used the concept of an 'effective dose' matched the experimental results more closely. An attempt was made to measure directly the

quench function for two proton beams as a function of all four variables of interest (two physical doses and two LET values). However, this approach was not successful because of limitations in the response of the scanner.

Feasibility study using MRI and two optical CT scanners for readout of polymer gel and Presage

H Svensson, PS Skyt, S Ceberg, S Doran, LP Muren, P Balling, JBB Petersen and SÅJ Bäck

2013 **J. Phys.: Conf**. Ser. 444 012079

The aim of this study was to compare the conventional combination of three dimensional dosimeter (nPAG gel) and readout method (MRI) with other combinations of three-dimensional dosimeters (nPAG gel/Presage) and readout methods (optical CT scanners). In the first experiment, the dose readout of a gel irradiated with a four field-box technique was performed with both an Octopus IQ scanner and MRI. It was seen that the MRI readout agreed slightly better to the TPS. In another experiment, a gel and a Presage sample were irradiated with a VMAT field and read out using MRI and a fast laser scanner, respectively. A comparison between the TPS and the volumes revealed that the MRI/gel readout had closer resemblance to the TPS than the optical CT/Presage readout. There are clearly potential in the evaluated optical CT scanners, but more time has to be invested in the particular scanning scenario than was possible in this study.

3-D dose verification by cone-beam optical CT scanning of PRESAGE dosimeter

C-S Wuu, SJ Hoogcarspel, K Deh, W-Y Hsu1 and J Adamovics

2013 J. Phys.: Conf. Ser. 444 012044

There is a clear need for an accurate and practical dosimeter that is able to verify 3-D dose distributions from complex radiation treatments. The purpose of this study is to evaluate the dosimetric performance of PRESAGE radiochromic plastic dosimeter in conjunction with a cone-beam optical CT scanner, Vista for 3-D dosimetry. The cone-beam optical CT scanner presented in this study can perform optical readout in less than 30 min, which makes same day dose verification for treatment possible. For dosimetric accuracy, a complete 3-D dose verification procedures were performed, including dose response calibration with a 12 MeV electron beam, a 6 MV photon square field irradiation, as well as a 5-field IMRT irradiation. This study shows that 3-D dose verification with fast optical CT scan of PRESAGE dosimeter is feasible. First-generation optical CT scanner can be used as a gold standard for optical readout of dosimeters.

How to perform an optical CT scan: an illustrated guide

By: S Doran

2013 J. Phys.: Conf. Ser. **444** 012004

Review

Eliminating the need for refractive index matching in optical CT scanners for radiotherapy dosimetry: I. Concept and simulations

S Doran and D NB Yatigammana

Journal of Physics: Conference Series 444 (2013) 012004

There is by now a considerable body of literature concerning the methodology for performing 3-Dradiation dosimetry. As part of the IC3DDose 2010 “refresher course”, I discussed in two of the most widespread image acquisition techniques, Magnetic Resonance Imaging and Optical Computed Tomography (CT), and attempted to distil the existing research into a set of “hints and tips” to enable newcomers to the field to avoid common problems. This article is designed to be complementary to and aims to provide a step-by-step guide to the process of acquiring an optical CT scan, illustrating the key procedures involved .

On the feasibility of optical-CT imaging in media of different refractive index

Leith Rankine[1] and Mark Oldham

Med Phys. 40:051701 (2013)

Purpose: Achieving accurate optical-CT 3D dosimetry without the use of viscous refractive index (RI) matching fluids would greatly increase convenience.

Methods: Software has been developed to simulate optical-CT 3D dosimetry for a range of scanning configurations including parallel-beam, point, and converging light sources. For each configuration the efficacy of three refractive media was investigated: air, water, a fluid closely matched to PRESAGE®, and perfect matching (RI = 1.00, 1.33, 1.49, and 1.501 respectively). Reconstructions were performed using both filtered backprojection (FBP) and algebraic reconstruction technique (ART). The efficacy of the three configurations and the two algorithms was evaluated by calculating the usable radius (i.e., the outermost radius where data were accurate to within 2%), and gamma (Γ) analysis. This definition recognizes that for optical-CT imaging, errors are greatest near the edge of the dosimeter, where refraction can be most pronounced. Simulations were performed on three types of dose distribution: uniform, volumetric modulated arc therapy (VMAT), and brachytherapy (Cs-137).

Results: For a uniformly irradiated dosimeter the usable radius achieved with filtered back projection was 68% for water-matching and 31% for dry-scanning in air. Algebraic reconstruction gave usable radii of 99% for both water and air (dry-scanning), indicating greater recovery of useful data for the uniform distribution. FBP and ART performed equally well for a VMAT dose distribution where less dose is delivered near the edge of the dosimeter. In this case, the usable radius was 86% and 53% for scanning in water and air, respectively. For brachytherapy, the usable radius was 99% and 98% for scanning in water and air, respectively using FBP, and a major decrease was seen with ART. Point source geometry provided 1%–2% larger usable radii than parallel geometry. Converging geometry recovered less usable dosimetry data (up to 10% reduced usable radii) than point and parallel geometries. A further disadvantage of converging geometry was an increased requirement on detector size by up to 18°.

Conclusions: For applications where dose information is not required in the periphery of the dosimeter, some dry and low-viscous matching configurations may be feasible. For all three dose distributions (uniform, VMAT, brachytherapy) the point source geometry produced slightly more favorable results (an extra 1%–2% usable radii) than parallel and converging. When dosimetry is required on the periphery, best results were obtained using close refractive matching and ART. A concern for water or dry-scanning is the increase in required detector size, introducing potential cost penalties for manufacturing.

Novel Method and Apparatus for 3-D Scanning of Translucent Samples for Radiation

By S. Doran

US Patent Application US 2012/0170049 A1

Reconstructing images with Algebraic Reconstruction Technique

Eliminating the need for refractive index matching in optical CT scanners for radiotherapy dosimetry: I. Concept and simulations

Simon J Doran and Dylan N B Yatigammana

Phy Med Biol 57:665-683 (2012)

Optical computed tomography has now become a well-established method for making empirical measurements of 3D dose distributions in radiotherapy treatment verification. The requirement for effective refractive index matching as part of the scanning process has long been an inconvenience for users, limiting the speed of sample throughput. We propose a new method for reconstructing data that takes explicit account of the refracted path of the light rays and demonstrate theoretically the conditions under which there are sufficient data to create a good reconstruction. Examples of the performance of the algorithm are given. For smoothly varying data, reconstructed images of very high quality are obtained, with RMS deviation of under 1% from the original, provided that the irradiated region lies entirely within a critical radius. For the dosimeter material PRESAGE , this critical value is approximately 0.65 of the sample radius.
Regions outside this are not reconstructed successfully, but we argue that there are many cases where this disadvantage is outweighed by the benefits of the technique.

Fast Cone-Beam Optical CT Scanning of a Radiochromic Solid Dosimeter for Clinical 3-D Dose Verification

By S J Hoogcarspel, Y Xu, and C Wuu

From: **Med. Phys.** 38, 3522 (2011) SU-E-T-156

Purpose: There is an urgent need for fast 3-D dose verification for advanced radiotherapy techniques such as IMAT. This study is to evaluate the accuracy and clinical relevance utilizing a fast cone-beam optical CT scanner with a radiochromic solid dosimeter, PRESAGE®. Methods: A first-generation laser optical CT scanner, in conjunction with gels and radiochromic solid dosimeters, has been successfully used for 3-D dose verification of complex treatments such as IMRT and radiosurgery. However, a major limitation with this type scanner is the long scanning

time (8-hours), which makes same-day dose verification for treatment impossible. In this study three radiochromic dosimeters (PRESAGE®) were irradiated with 12Mev electron beam, 6MV photon beam, and 5-field IMRT, respectively. Dose readout was performed using a Vista™ cone beam optical scanner (Modus Medical Devices Inc.). This scanner utilizes a LED diffuse light panel and a lens based CCD camera to capture a series of 2D optical projections through the region of interest while the object is being rotated 360°. Feldkamp filtered back projection was used to reconstruct the 3D dose map, with a spatial resolution of 1×1×1mm. Each dosimeter was scanned both before and after irradiation in order to eliminate artifacts caused by light scattering and dosimeter non-uniformity. Dose distributions were compared with results from a first-generation laser optical CT scanner and Eclipse planning system. Results: The PDDs measured with PRESAGE® and the beam data from Eclipse agree within 3% and 1mm. Comparison of the IMRT dose distributions between PRESAGE® measurements and Eclipse calculation shows 93% Gamma index passing rate (3%, 3mm criteria). The scanning time for a 3-D dose map is less then 30 minutes. Conclusions: The Vista™ cone-beam optical CT scanner and radiochromic dosimeter, PRESAGE®, has shown the potential for fast 3-D dose verification.

Commissioning and benchmarking a 3D dosimetry system for clinical use

Thomas Andrew; Newton Joseph; Adamovics John; Oldham Mark

Medical Physics (2011), 38(8), 4846-57

PURPOSE: A 3D dosimetry system is described which consists of two parts: a radiochromic plastic dosimeter PRESAGE (which responds to absorbed dose with a linear change in optical-density) and the Duke large-field-of-view optical-CT scanner (DLOS). The DLOS/PRESAGE system has recently been commissioned and benchmarked for clinical use and, in particular, for verification and commissioning of complex radiation treatments. METHODS: DLOS commissioning involved determining the dynamic range, spatial resolution, noise, temporal, and other characteristics of the light source and imaging component

A method to correct for stray light in telecentric optical-CT imaging of radiochromic dosimeters

Thomas Andrew; Newton Joseph; Oldham Mark

Physics in medicine and biology (2011), 56(14), 4433-51.

Radiochromic plastic and gel materials have recently emerged which can yield 3D dose information over clinical volumes in high resolution. These dosimeters can provide a much more comprehensive verification of complex radiation therapy treatments than can be achieved by conventional planar and point dosimeters. To achieve full clinical potential, these dosimeters require a fast and accurate read-out technology. Broad-beam optical-computed tomography (optical-CT) systems have shown promise, but can be sensitive to stray light artifacts originating in the imaging chain.

A method to correct for spectral artifacts in optical-CT dosimetry

Thomas Andrew; Pierquet Michael; Jordan Kevin; Oldham Mark

Physics in medicine and biology (2011), 56(11), 3403-16.

The recent emergence of radiochromic dosimeters with low inherent light-scattering presents the possibility of fast 3D dosimetry using broad-beam optical computed tomography (optical-CT). Current broad beam scanners typically employ either a single or a planar array of light-emitting diodes (LED) for the light source. The spectrum of light from LED sources is polychromatic and this, in combination with the non-uniform spectral absorption of the dosimeter, can introduce spectral artifacts arising from preferential absorption of photons at the peak absorption wavelengths in the dosimeter

An investigation of a potential multipurpose readout modality for two and three-dimensional dosimetry using optical computed tomography scanners

MASTERs Thesis– 2011 Lund

Henrik Svensson

http://www.lunduniversity.lu.se/o.o.i.s?id=24965&postid=2273085

Light scattering in optical CT scanning of Presage dosimeters

By Xu, Y.; Adamovics, J.; Cheeseborough, J. C.; Chao, K. S.; Wuu, C. S.

From **Journal of Physics: Conference Series** (2010), 250

The intensity of the scattered light from the Presage dosimeters was measured using a Thorlabs PM100D optical power meter with an optical sensor of 1 mm diam. sensitive area. Five Presage dosimeters were made as cylinders of 15.2 cm, 10 cm, 4 cm diams. and irradiated with 6 MV photons using a Varian Clinac 2100EX. Each dosimeter was put into the scanning tank of an OCTOPUS optical CT scanner filled with a refractive index matching liq. A laser diode was positioned at one side of the water tank to generate a stationary laser beam of 0.8 mm width.

Fast, high-resolution 3D dosimetry utilizing a novel optical-CT scanner incorporating tertiary telecentric collimation

Sakhalkar H S and Oldham M

Med. Phys. 35, 101 (2008)

This study introduces a charge coupled device (CCD) area detector based optical-computed tomography (optical-CT) scanner for comprehensive verification of radiation dose distributions recorded in non scattering radiochromic dosimeters. Defining characteristics include: (i) a very fast scanning time of ~5 min to acquire a complete three-dimensional (3D) dataset, (ii) improved image formation through the use of custom telecentric optics, which ensures accurate projection images and minimiz es artifacts from scattered and stray-light sources, and (iii) high resolution (potentially 50μm) isotropic 3D dose readout. The performance of the CCD scanner for 3D dose readout was evaluated by comparison with independent 3D readout from the single

laser beam OCTOPUS™-scanner for the same PRESAGE™dosimeters. The OCTOPUS™scanner was considered the gold standard technique in light of prior studies demonstrating its accuracy. Additional comparisons were made against calculated dose distributions from the ECLIPSE treatment-planning system. Dose readout for the following treatments were investigated: (i) a single rectangular beam irradiation to investigate small field and very steep dose gradient dosimetry away from edge effects, (ii) a 2-field open beam parallel-opposed irradiation to investigate dosimetry along steep dose gradients, and (iii) a 7-field intensity modulated radiation therapy (IMRT) irradiation to investigate dosimetry for complex treatment delivery involving modulation of fluence and for dosimetry along moderate dose gradients. Dose profiles, dose-difference plots, and gamma maps were employed to evaluate quantitative estimates of agreement between independently measured and calculated dose distributions. Results indicated that dose readout from the CCD scanner was in agreement with independent gold-standard readout from the OCTOPUS™-scanner as well as the calculated ECLIPSE dose distribution for all treatments, except in regions within a few millimeters of the edge of the dosimeter, where edge artifact is predominant. Agreement of line profiles was observed, even along steep dose gradients. Dose difference plots indicated that the CCD scanner dose readout differed from the OCTOPUS™scanner readout and ECLIPSE calculations by ~10% along steep dose gradients and by ~5% along moderate dose gradients. Gamma maps (3% dose-difference and 3mm distance-to-agreement acceptance criteria) revealed agreement, except for regions within 5mm of the edge of the dosimeter where the edge artifact occurs. In summary, the data demonstrate feasibility of using the fast, high-resolution CCD scanner for comprehensive 3D dosimetry in all applications, except where dose readout is required close to the edges of the dosimeter. Further work is ongoing to reduce this artifact.

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OCT Scanning Properties of PRESAGE -A 3D Radiochromic Solid Polymer Dosimeter

J Adamovics, M Maryanski,

Med. Phys. (2004) 31(5) PO-T-269

PRESAGE is a new type of 3D dosimeter composed of clear rigid polyurethane and the radiochromic leuco dye, leucomalachite green. In the polyurethane matrix the leucomalachite green has a maximum absorbance at 633 nm and is therefore compatible with the OCT-OPUS laser CT scanner (MGS Research, Inc., Madison, CT) operating at the principal He-Ne laser wavelength of 633nm. One inherent advantage of PRESAGE is that it does not need to be held in a container, which eliminates the need to match the refractive indices of a container wall and the polyurethane dosimeter. The refractive index of PRESAGE is ca. 1.515, which is matched for OCT scanning with a mixture of organic phthalates. OCT scanning of PRESAGE dosimeters has detected doses on the order of 50 cGy. The two areas that need additional study and are detected during OCT scanning are the variability of the refractive index across the polymer and polymer heterogeneities. The possible causes and consequences of these variations will be presented.