Brachtherapy

High Resolution 3D Dosimetry for LDR Ocular Brachytherapy

AE Rodrigues, SW Yoon, M Oldham, J Adamovics, S Meltsner, ...
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Purpose 3D dosimetric verification for eye plaque dosimetry remains challenging. Typically, clinical quality assurance of the eye plaque is often satisfied with the assay of seeds from the same batch as used in the eye plaque. Eye plaques can be sent pre-built from the manufacturer, which further underscores the need for additional quality assurance, as the seeds in the eye plaque cannot be assayed. The purpose of this study is to explore the feasibility of using a high resolution 3D dosimeter for independent end-to-end test of an eye plaque program and even potentially for patient-specific eye plaque quality assurance. Materials and Methods A clinical plan using an EP2031 eye plaque (Eye Physics) loaded with I-125 seeds (IsoAid Advantage) was used in this study. Dosimetry was experimentally verified with optical CT scans of PRESAGE®, a radiochromic 3D plastic dosimeter doped

On the experimental validation of model-based dose calculation algorithms for 192Ir HDR brachytherapy treatment planning

Pappas, E.P., Zoros, E., Moutsatsos, A., Peppa, V., Zourari, K., Karaiskos, P., Papagiannis, P.
(2017) Physics in Medicine and Biology, 62 (10), art. no. 4160, pp. 4160-4182

There is an acknowledged need for the design and implementation of physical phantoms appropriate for the experimental validation of model-based dose calculation algorithms (MBDCA) introduced recently in 192Ir brachytherapy treatment planning systems (TPS), and this work investigates whether it can be met. A PMMA phantom was prepared to accommodate material inhomogeneities (air and Teflon), four plastic brachytherapy catheters, as well as 84 LiF TLD dosimeters (MTS-100M 1 × 1 × 1 mm3 microcubes), two radiochromic films (Gafchromic EBT3) and a plastic 3D dosimeter (PRESAGE). An irradiation plan consisting of 53 source dwell positions was prepared on phantom CT images using a commercially available TPS and taking into account the calibration dose range of each detector. Irradiation was performed using an 192Ir high dose rate (HDR) source. Dose to medium in medium, , was calculated using the MBDCA option of the same TPS as well as Monte Carlo (MC) simulation with the MCNP code and a benchmarked methodology. Measured and calculated dose distributions were spatially registered and compared. The total standard (k = 1) spatial uncertainties for TLD, film and PRESAGE were: 0.71, 1.58 and 2.55 mm. Corresponding percentage total dosimetric uncertainties were: 5.4-6.4, 2.5-6.4 and 4.85, owing mainly to the absorbed dose sensitivity correction and the relative energy dependence correction (position dependent) for TLD, the film sensitivity calibration (dose dependent) and the dependencies of PRESAGE sensitivity. Results imply a LiF over-response due to a relative intrinsic energy dependence between 192Ir and megavoltage calibration energies, and a dose rate dependence of PRESAGE sensitivity at low dose rates (<1 Gy min-1). Calculations were experimentally validated within uncertainties except for MBDCA results for points in the phantom periphery and dose levels. Experimental MBDCA validation is laborious, yet feasible. Further work is required for the full characterization of dosimeter response for 192Ir and the reduction of experimental uncertainties.

On the feasibility of polyurethane based 3D dosimeters with optical CT for dosimetric verification of low energy photon brachytherapy seeds. Adamson, J., Yang, Y., Juang, T., Chisholm, K., Rankine, L., Adamovics, J., Yin, F.F., Oldham, M. Medical Physics, 2014. 41 (7), art. no. 071705

Purpose: To investigate the feasibility of and challenges yet to be addressed to measure dose from low energy (effective energy <50 keV) brachytherapy sources (Pd-103, Cs-131, and I-125) using polyurethane based 3D dosimeters with optical CT. Methods: The authors' evaluation used the following sources: models 200 (Pd-103), CS-1 Rev2 (Cs-131), and 6711 (I-125). The authors used the Monte Carlo radiation transport code MCNP5, simulations with the ScanSim optical tomography simulation software, and experimental measurements with PRESAGE® dosimeters/optical CT to investigate the following: (1) the water equivalency of conventional (density = 1.065 g/cm3) and deformable (density = 1.02 g/cm3) formulations of polyurethane dosimeters, (2) the scatter conditions necessary to achieve accurate dosimetry for low energy photon seeds, (3) the change in photon energy spectrum within the dosimeter as a function of distance from the source in order to determine potential energy sensitivity effects, (4) the optimal delivered dose to balance optical transmission (per projection) with signal to noise ratio in the reconstructed dose distribution, and (5) the magnitude and characteristics of artifacts due to the presence of a channel in the dosimeter. Monte Carlo simulations were performed using both conventional and deformable dosimeter formulations. For verification, 2.8 Gy at 1 cm was delivered in 92 h using an I-125 source to a PRESAGE® dosimeter with conventional formulation and a central channel with 0.0425 cm radius for source placement. The dose distribution was reconstructed with 0.02 and 0.04 cm3 voxel size using the Duke midsized optical CT scanner (DMOS). Results: While the conventional formulation overattenuates dose from all three sources compared to water, the current deformable formulation has nearly water equivalent attenuation properties for Cs-131 and I-125, while underattenuating for Pd-103. The energy spectrum of each source is relatively stable within the first 5 cm especially for I-125. The inherent assumption of radial symmetry in the TG43 geometry leads to a linear increase in sample points within the 3D dosimeter as a function of distance away from the source, which partially offsets the decreasing signal.

Simulations of dose reconstruction using optical CT showed the feasibility of reconstructing dose out to a radius of 10 cm without saturating projection images using an optimal dose and high dynamic range scanning; the simulations also predicted that reconstruction artifacts at the channel surface due to a small discrepancy in refractive index should be negligible. Agreement of the measured with calculated radial dose function for I-125 was within 5% between 0.3 and 2.5 cm from the source, and the median difference of measured from calculated anisotropy function was within 5% between 0.3 and 2.0 cm from the source. Conclusions: 3D dosimetry using polyurethane dosimeters with optical CT looks to be a promising application to verify dosimetric distributions surrounding low energy brachytherapy sources.

Dosimetric Verification of a Commercial Brachytherapy Treatment Planning System for a Single Entry APBI Hybrid Catheter Device by Presage® and Radiochromic Film

Kent A. Gifford, Khalid Iqbal, Ryan L. Grant, Saeed A. Buzdar, Geoffrey S. Ibbott, **Brachytherapy** Volume 12, Supplement 1 , Page S21, March 2013

An anthropomorphic breast PRESAGE® dosimeter and radiochromic film were used to measure skin dose and dose distributions for a SAVI® 6-1 applicator to verify the accuracy of a commercial brachytherapy treatment planning system. The PRESAGE® materials were poured into a breast mold where it solidified. A treatment planning x-ray CT scan with a slice thickness of 1.25 mm of the breast PRESAGE® dosimeter was acquired using a GE CT scanner (GE Healthcare Technologies, Waukesha, WI). CT data were exported to the Oncentra® Masterplan version, 4.1 brachytherapy TPS (Nucletron, an Elekta company, Stockholm, Sweden) planning workstation. IPSA was used to plan 2 Gy to the PTV_EVAL of the breast dosimeter while avoiding 125% of the prescribed dose to skin. An independent dose distribution verification was performed using GAFCHROMIC® EBT2 film (ISP Corp., Wayne, NJ). The transverse images with dose distribution from DMOS[1] and Oncentra® treatment plan were exported to the CERR, A Computational Environment for Radiotherapy Research program (Memorial Sloan-Kettering Cancer Center, New York, NY), a Matlab-based software. The calculated dose distribution from Oncentra® was compared to the measured distributions from PRESAGE® and EBT2. EBT2 scans were analyzed using Image J software (National Institutes of Health, Rockville, MD). Point skin doses, line profiles, and DVHs for the skin, and PTV_EVAL were compared.

Comparison of methods for the measurement of radiation dose distributions in high dose rate (HDR) brachytherapy: Ge-doped optical fiber, EBT3 Gafchromic film, and PRESAGE radiochromic plastic
Palmer, A. L.; Di Pietro, P.; Alobaidli, S.; Issa, F.; Doran, S.; Bradley, D.; Nisbet, A.

Medical Physics (2013), 40(6), 061707/1-061707/11.
Purpose: Dose distribution measurement in clin. high dose rate (HDR) brachytherapy is challenging, because of the high dose gradients, large dose variations, and small scale, but it is essential to verify accurate treatment planning and treatment equipment performance. The authors compare and evaluate three dosimetry systems for potential use in brachytherapy dose distribution measurement: Ge-doped optical fibers, EBT3 Gafchromic film with multichannel anal., and the radiochromic material PRESAGE with optical-CT readout. Methods: Ge-doped SiO_2 fibers with 6 μm active core and 5.0 mm length

Towards comprehensive characterization of Cs-137 Seeds using PRESAGE® dosimetry with optical tomography

J Adamson, Y Yang, L Rankine, J Newton, J Adamovics, O Craciunescu and M Oldham
2013 J. Phys.: Conf. Ser. 444 012100

We describe a method to directly measure the radial dose and anisotropy functions of brachytherapy sources using polyurethane based dosimeters read out with optical CT. We measured the radial dose and anisotropy functions for a Cs-137 source using a PRESAGE® dosimeter (9.5cm diameter, 9.2cm height) with a 0.35cm channel drilled for source placement. The dosimeter was immersed in water and irradiated to 5.3Gy at 1cm. Pre- and post-irradiation optical CT scans were acquired with the Duke Large field of view Optical CT Scanner (DLOS) and dose was reconstructed with 0.5mm isotropic voxel size. The measured radial dose factor matched the published fit to within 3% for radii between 0.5-3.0cm, and the anisotropy function matched to within 4% except for θ near 0° and 180° and radii >3cm. Further improvements in measurement accuracy may be achieved by optimizing dose, using the high dynamic range scanning capability of DLOS, and irradiating multiple dosimeters. Initial simulations indicate an 8 fold increase in dose is possible while still allowing sufficient light transmission during optical CT. A more comprehensive measurement may be achieved by increasing dosimeter size and flipping the source orientation between irradiations.

Three-dimensional dosimetry of a beta-emitting radionuclide using PRESAGE dosimeters
Grant, R. L.; Crowder, M. L.; Ibbott, G. S.; Simon, J.; Frank, R. K.; Rogers, J.; Loy, H. M.; Adamovics, J.; Newton, J.; Oldham, M.; et al

Journal of Physics: Conference Series (2010), 250,
Three-dimensional dose distributions from liq. brachytherapy were measured using PRESAGE dosimeters. The dosimeters were exposed to Y-90 for 5.75 days and read by optical tomog. The distributions are consistent with ests. from beta dose kernels.

Water equivalency evaluation of PRESAGE® dosimeters for dosimetry of Cs-137 and Ir-192 brachytherapy sources

Tina Gorjiara, Robin Hill, Zdenka Kuncic and Clive Baldock

2010 J. Phys.: Conf. Ser. 250 012093
A major challenge in brachytherapy dosimetry is the measurement of steep dose gradients. This can be achieved with a high spatial resolution three dimensional (3D) dosimeter. PRESAGE® is a polyurethane based dosimeter which is suitable for 3D dosimetry. Since an ideal dosimeter is radiologically water equivalent, we have investigated the relative dose response of three different PRESAGE® formulations, two with a lower chloride and bromide content than original one, for Cs-137 and Ir-192 brachytherapy sources. Doses were calculated using the EGSnrc Monte Carlo package. Our results indicate that PRESAGE® dosimeters are suitable for relative dose measurement of Cs-137 and Ir-192 brachytherapy sources and the lower halogen content PRESAGE® dosimeters are more water equivalent than the original formulation.

D**osimetry of the microSelectron-HDR Ir-192 source using PRESAGE and optical CT**
By Wai P; Adamovics J; Krstajic N; Ismail A; Nisbet A; Doran S
Applied radiation and isotopes : i (2009),67(3),419-22
Optical CT, using a solid polyurethane (PRESAGE) radiochromic dosimeter, has been used to evaluate dose distributions produced by the microSelectron-HDR Ir-192 source. The anisotropy functions obtained through optical CT are in good agreement with Monte Carlo and previously published results especially at polar angle above 20 degrees. The results indicated an evident potential for using solid polymer dosimetry as an accurate method for 3-D dosimetry, although refinements to the existing methods are necessary before the technique can be used clinically.