

mm Al HVL to 6 MV. Films have been irradiated at increasing dose with three different beams: 6MV beam, $TPR(10,20) = 0.684 \pm 0.01$; HVL = 2.00 ± 0.01 mm Al and HVL = 0.20 ± 0.01 mm Al, a very-low-energy beam. The dose output for each beam was determined with an appropriate calibrated ionization chamber, following IPEM and DIN6809-4 standard recommendations. Calibration curves were generated using the same dose range (0 cGy to 850 cGy) for the three energies. Using the 6MV calibration curve as reference, the film response in terms of net optical density was evaluated. The difference in the calibration curve obtained by irradiating the film with 6MV and 2mmAl HVL energy beams is less than 3%, within the calibration uncertainty, in the dose range 400–850cGy. The maximum difference is 4.1% at 150cGy. The optical density of EBT3-V3 film is significantly lower at 0.2 mmAl HVL compared to 6MV, showing differences up to 25%, with a minimum of 16% at 850 cGy. Conclusion: when the EBT3-V3 film is irradiated at doses higher than 400 cGy, the calibration curve for the 2 mmAl beam agrees with the reference beam (6MV) within 3%. A significant under-response (by up to 25%) was seen at 0.2mmAL HVL. EBT3-V3 films are suitable dose detectors when the dose response curve is measured within the range 6MV and 2 mm Al HVL. 6MV calibration curve could be used within this range, with 3% uncertainty.

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Superficial X-ray therapy beam measurements using a liquid-filled chamber array

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Superficial treatment from units such as the Gulmay D3300 investigated in this study are usually measured using a single ionization chamber at the central axis. Dose falls off from the central axis towards the periphery of the field. This falloff is asymmetrical in the anode-cathode axis due to the heel effect. Current clinical practice is to prescribe dose to the central axis, which neglects the varying dose across the treatment field. Therefore, it is important to formulate a methodology to quantify this. This study investigates the viability of the PTW LA-48 Linear Chamber Array with 100 and 140 kVp beam energies with seven applicators by comparing measurements with GAFChromic EBT-3 Film measurements which is validated for use at those beam energies in previous studies. The PTW LA-48 Array has 47 isoctane-filled chambers in series allowing investigation of off-axis dose. Measurements were taken under 5 mm of liquid water using a PTW MP3 Water Tank. Film measurements were taken under 5 mm of solid water and analysed using FilmQA Pro. Both data sets were made relative to the measured central axis dose and compared. The average percentage difference between measurements for each applicator ranged between $-2 \pm 2\%$ to $1.5 \pm 0.5\%$ for 100 kVp and $-2 \pm 1\%$ to $2 \pm 3\%$ for 140 kVp, where the uncertainty is the standard error. These results show that the PTW LA-48 measurements were comparable to the EBT-3 Film measurements and highlight the potential for liquid-filled chamber arrays to be utilised to investigate off-axis dose for superficial X-ray therapy units.

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Commissioning process for high dose rate prostate brachytherapy

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The aim of this study was to outline and examine the commissioning process of a treatment planning system (TPS) dedicated to high dose rate brachytherapy (HDR BT) prostate treatment and the associated equipment. HDR BT treatment facilitates dose escalation to the prostate and involved seminal vesicles in conjunction with external beam treatment while minimising the dose to the rectum, bladder and urethra. In comparison to low dose rate (LDR) BT, there is an increase in precision and control in source positioning and corresponding dose distribution which results in a high tumour control and low toxicity rates. Other advantages include no patient-specific radiation precautions, as patients are not radioactive following treatment, and decreased radiation exposure to clinical staff and the general public. Commissioning and implementation of a quality assurance program of HDR delivery system guarantees optimal treatment of patients. All aspects must be thoroughly tested prior to the delivery of the treatment to patients to ensure the safe delivery of the intended dose. Based on published guidelines developed by the American Association of Physicists in Medicine (AAPM) and the European Society for Radiotherapy and Oncology (ESTRO) all aspects of the treatment planning system software including the image acquisition, dose calculations and data transfer underwent the required acceptance and commissioning testing. The quality assurance testing of the equipment and the imaging system to be used was also carried out. This study provides a framework of the steps required for the commissioning of a HDR interstitial brachytherapy prostate treatment.

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Relative response of eye dosimeters to variations in scattered X-ray energy spectra encountered in interventional radiology

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The most appropriate operational dose metric for monitoring radiation dose to the eye lens has been identified as the personal and directional dose equivalent at 3 mm depth, Hp(3). Other suggested methods include evaluating Hp(3) through Hp(10) or Hp(0.07), and using conversion factors. There are many uncertainties, however, associated with these dosimetry methods. In particular, the energy response for different dosimetry techniques may vary considerably depending on the incident x-ray energy spectrum. For Thermoluminescent Detectors (TLDs), Optical Stimulated Luminescence Detectors (OSLD) and Electronic Personal Dosimeters (EPD), the deviation of the energy response from unity is reported to vary by a factor of 0.9–2.8 across Hp(0.07) and Hp(10) measurements, with overestimations occurring in the 30–60kV range. This range coincides with scattered energy spectra encountered in both interventional radiology and cardiology. Establishing how dosimeter energy dependence affects dose measurement accuracy in the clini-

cal setting, whether Hp(3), Hp(0.07) or Hp(10), has received little attention in the literature; however, the effect has been identified as the dominant source of uncertainty in current eye dosimetry methods. Accordingly, this study aims firstly to measure scattered x-ray energy spectra to staff in Interventional Radiology procedures under varied conditions and system settings. Consequently, the dosimetry accuracy of a series of currently available eye dosimeters, including TLDs (100s, 100Hs), OSLD and Electronic Personal dosimeters (EPDs), and a variety of real-time trunk dosimeters will be presented, with energy dependent correction factors established for each dosimeter type, leading to more precise dose measurement.

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A review of Slope Intercept GFR patient data to validate and optimize the introduction of Single Sample GFR technique

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The Glomerular filtration rate (GFR) is a quantitative measure of kidney function determined from the plasma clearance of a radio-pharmaceutical such as ⁵¹Cr EDTA or ^{99m}Tc DTPA. The British Nuclear Medicine Society 2018 guidelines recommend a single sample GFR (SS-GFR) analysis method replacing the slope intercept method (SI-GFR) of the previous 2004 guidelines. This research explores the feasibility and implications of making the transition from SI to SS GFR, by retrospectively determining the SS GFR on a patient population whose GFR was previously evaluated using SI-GFR. One shortcoming of the SS-GFR method is that a prior approximation of the GFR is necessary for choosing a sampling time for an accurate result. The objectives of this study are to, firstly, assess the agreement and associated errors of the SS-GFR when compared to SI GFR and, further, to optimise the single sample approach. The study examines the reliability of using previous GFR measurement or a biochemically determined eGFR documented in the patient health-care record as a guide to optimum blood sampling time. The use of other GFR predictors is also investigated for patients undergoing DTPA imaging, functional indicators gained from renogram curves such as body surface area (BSA) and sensitivity corrected summed functional phase slopes. Regression analysis will be carried out on renogram parameters to identify the statistically significant predictors ($p < 0.05$) which will be entered into a multivariate model. Statistical agreement between the SI-GFR and SS-GFR is tested using Bland-Altman plots and the associated errors quantified.

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Verification of manufacturer supplied source paths for Elekta ring applicators at Cork University Hospital

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Ring applicators are routinely used in gynaecological brachytherapy to direct a radioactive source through a number of predetermined dwell positions close to the tumour. Literature has shown that the dwell positions of radioactive sources in ring applicators can deviate from their expected positions by several millimetres. Since high dose rate ¹⁹²Ir sources are used, even small deviations can have a large impact on the distribution of dose received by the patient. AAPM Report 59 deems positional accuracy of within 2 mm to be clinically acceptable. This study investigates the level of

agreement between the measured source path and manufacturer supplied source path for Elekta ring applicators of diameters 26 mm, 30 mm and 34 mm. Dwell positions were measured using both the “gold standard” approach of GAFchromic film and a MatriXX ionisation chamber array. We developed processing algorithms using ImageJ. Use of an ionisation chamber array with free, open source software for this application is novel. Our results found insufficient evidence to verify that the actual source path matches the manufacturer supplied source path for any of the applicators. Most source paths were found to be clinically acceptable, however, deviations of the source from the expected path of up to 3.8 mm (MatriXX) and 4.0 mm (film) were recorded. Inter-applicator deviations of up to 1.7 mm (MatriXX) and 2.1 mm (film) were observed. Measurements using the MatriXX were found to be comparable to the standard film-based approaches for source path measurement, offering improvement in speed, ease of use and cost.

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A study on the comparison of the dose distribution of low kV X-ray radiation in generically modulated bone and CT scanned bone

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The INTRABEAM system is a device that uses low kV X-ray radiation in the treatment of cancers. During Kypho-IORT the INTRABEAM delivers a single high dose of radiation to a metastasis in a spinal vertebra, sterilising the metastasis, before the vertebra is stabilised with PMMA. However, much remains uncertain about the dose distribution of low kV X-ray radiation in heterogeneous tissue, such as bone. Current generation planning CTs do not have sufficient resolution to resolve the trabecular architecture. Voxel averaging therefore affects the calculation of bone density values which are typically underestimated. This subsequently affects dose calculations. In this study the GEometry ANd Tracking 4 (GEANT4) code was used to develop a generic model of a spinal vertebra that includes trabecular architecture. The dose distribution of low kV X-ray radiation within this architecture was modelled using a Virtual Source Model (VSM) of the INTRABEAM and compared to the dose distribution of the same radiation in simulated CT scanned bone. The results show that the dose distribution of low kV X-ray radiation in trabecular bone is more complex than previously suggested. A spherical dose distribution is modulated by the trabecular architecture such that the energy deposition in the trabecular walls can reach five times higher than expected, while the energy deposition in the trabecular openings is reduced by upwards of 50%. With further development, this code may be incorporated into future treatment planning software resulting in improvements in the dose distribution calculations for low kV treatments such as Kypho-IORT.

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Dosimetry assessment of patient-specific 3D printable material for HDR surface brachytherapy

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Purpose: 3D printable material water equivalence was investigated within the range of Iridium-192 source energies. The aim is to validate it for superficial brachytherapy treatments.