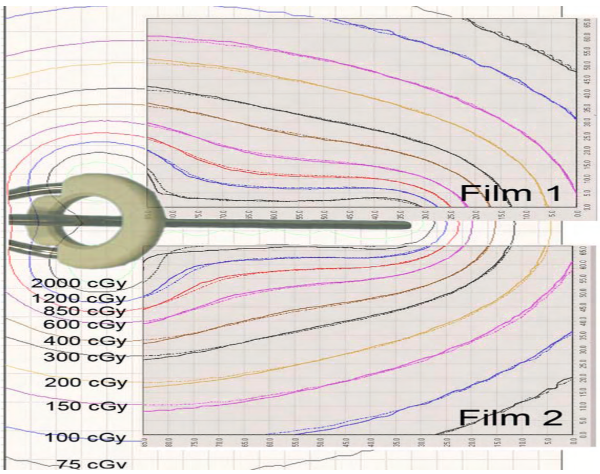
independent components was used (FimQAPro). Dose-maps were compared to treatment plans using isodoses and gamma. Absolute film dose values were used with no re-normalisation of any data. Isolated source doses were compared to TG-43 source model values. The value and sensitivity of gamma for brachytherapy applications was assessed by multivariate analysis of area/position and calculation parameters. Eckert & Ziegler Bebig GmbH HDR multiSource treatment unit, with Co-60 source, and HDRplus treatment planning system (TPS) were used throughout.

Results: Figure 1 shows dose maps from 2 films positioned adjacent to and bisecting the cervix applicator intrauterine (IU) channel, overlaid on TPS isodoses. Agreement in isodoses, 75 cGy to 2000 cGy, is generally within 1.0 mm. A comparison of the 2 symmetric films confirms sufficient reproducibility. Table 1 provides example gamma results for the cervix and shielded vaginal applicators. The passing rate in brachytherapy is sensitive to the defined interest region, in the cervix example ranging from 95% at typical HR-CTV to 100% at a bladder position, for 3% (local) / 2 mm criteria, evaluated over 9 cm^2 regions. The full-region, 144 cm^2, passing rate was ~ 98%.

The validity of the TG-43 general source model for individual supplied HDR sources was successfully verified. Gamma passing rates > 95% at 3% (local) / 2 mm between 5 mm and 50 mm from the source.



Applicator	Evaluation region	Gamma passing rate 3% (local) / 2 mm
Full-insertion cervix applicator	Full film area adjacent to IU, left	97.5%
	Full film area adjacent to IU, right	98.3%
	Typical HR-CTV location	95.2%
	Typical bladder location	100.0%
	Typical rectum location	99.7%
Internally-shielded vaginal cylinder	Full film traversing shield junction	99.7%
	Open region	100.0%
	Shielded region	97.1%

Conclusions: There is an absence of clinically-relevant QC for modern brachytherapy. We have presented a practical, robust method of advanced film dosimetry of treatment applicators, which is more closely aligned to clinical treatments than current QC. Planned and measured isodoses agreed closely, with high gamma passing rates. Film dosimetry is advocated to confirm validity of the general TG-43 model for individual supplied sources. The use and sensitivity of gamma for brachytherapy must be carefully considered; we propose separate calculations in a number of clinically relevant regions.

PO-0965

Clinical investigation of inter seed attenuation effects in prostate I-125 seed implant brachytherapy.

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Purpose/Objective: In permanent seed implant prostate brachytherapy the actual dose delivered to the patient may be less than that calculated by TG43-U1 due to inter-seed attenuation (ISA) and differences between prostate tissue composition and water. In this study the ISA effect is assessed using Monte Carlo (MC) simulation of clinical prostate treatment plans.

Materials and Methods: Simulations of ultrasound based pre-plans and CT based post-plans were performed for 30 patients treated with 6711 seeds, the mean activity used was 0.44U. MC simulation results were compared to TG43-U1 using DVH parameters for the prostate, urethra, rectum and the volume enclosed by the 100% isodose. Use of gamma index values to compare MC simulation results and TG43-U1 was investigated. Areas of the prostate where ISA caused dose to drop below 100% of prescription dose were analysed. Sector analysis of ISA effects was performed dividing the prostate into apex, mid-gland and base segments, with each segment divided into anterior, posterior, left and right quadrants.

Results: For CT post-plans, the mean ISA effect was to reduce prostate D90 by 4.2Gy (3%), prostate V100 by 0.5cc (1.4%), urethra D10 by 11.3Gy (4.4%), rectal D2cc by 5.5Gy (4.6%) and the 100% isodose volume by 2.3cc. For ultrasound pre-plans the mean ISA effect was smaller, reducing prostate D90 by 2.2% and the 100% isodose volume by 1.5cc. For distance to agreement 2mm and dose difference 3% the number of points in the prostate with gamma <=1 was 95.3% for CT based post-plans and 97.8% for US based pre-plans. The number of points with gamma <=1 correlated strongly with ISA effect on DVH parameters (p<0.01). Sector analysis showed that in CT post-plans the majority of points where ISA causes prostate dose to fall below 100% are near the prostate base however this is not true for ultrasound pre-plans as these have more uniform coverage and seed spacing.

Conclusions: ISA causes the delivered dose in prostate seed implant brachytherapy to be lower than the dose calculated by TG43-U1. Because of differences in seed positions between pre-plan and post-plan, the effect of ISA on the post-plan could not necessarily be predicted from the pre-plan. For this group of patients ISA had most impact at the prostate base, an area which is often underdosed even excluded any effects of ISA.

PO-0966

Comparison of analytical and Monte Carlo calculations for heterogeneity corrections in LDR prostate brachytherapy

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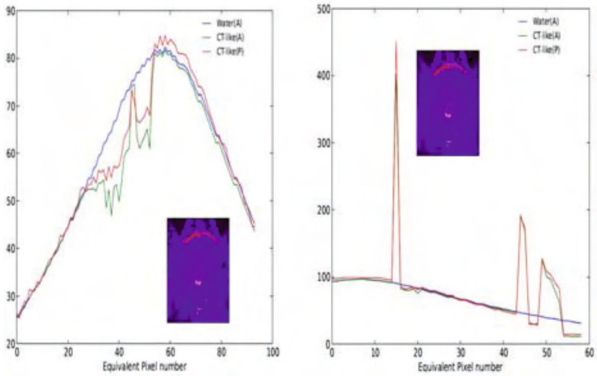
Purpose/Objective: It is well-known that tissue heterogeneities and calcifications have significant influence on low energy brachytherapy such as prostate permanent I-125 implants. The aim of this work is to study the application of a simplified analytic algorithm that could be compatible with commercial Treatment Planning System (TPS) based on TG-43. The algorithm, based on the classic equivalent path length method, has been tested with Monte Carlo (MC) computations using Penelope2009.

Materials and Methods: The analytical model scales the distance from the seed to the calculation point according to the electronic density of the medium relative to water. Then the dose is obtained from TG-43 consensus data stored on a TPS but with the radial dose function obtained for the scaled distance keeping the anisotropy function unaltered. A voxelized phantom obtained from real cases has been used. This case was selected as a benchmark because the patient presented a significant proportion of calcifications inside the prostate. After this step a comparison between MC and the algorithm was performed.

Results: The results given by the algorithm show a remarkable agreement with the complete Monte Carlo simulations taking into account the calcifications in the aforementioned real case. Several other realistic geometries and compositions of the calcification have been checked successfully. In the figure below two different imaging planes can be observed (black arrows in the insets). Blue lines stands for TG-43 based results, green lines for the algorithm, and red ones for MC simulations. More overdose rate times the distance squared and divided by air-kerma strength is given.



Conclusions: The presented analytical dose calculation algorithm is applicable for any type of heterogeneity. The high calculation speed of the algorithm makes it feasible for use in clinical real time-treatment planning and thus for improving treatment quality.

PO-0967

Loose seeds vs. stranded seeds in permanent prostate brachytherapy: dosimetric comparison of intraoperative plans

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Purpose/Objective: To evaluate and compare the dosimetric parameters of intraoperative treatment plans in prostate seed implants performed with loose seed and stranded seed techniques.
Materials and Methods: Permanent prostate brachytherapy with I-125 seeds as a monotherapy for patients with low and intermediate risk prostate cancer was implemented at our institute in 2009, and since then 147 patients have been treated. The first 79 patients were implanted with loose seeds (seedSelect, Nucletron) and the next 68 patients with stranded seeds (IsoSeed, Bebig). Loose seeds (LS) were delivered automatically with the seedSelectron system, while stranded seeds (SS) were placed into the prostate manually. For treatment planning the SPOT PRO 3.1 (Nucletron) software was used for all patients. The number and positions of seeds were calculated with an inverse dose optimization algorithm (IPSA) in the pre-implant plan. Then, the seeds were implanted under transrectal ultrasound guidance, and their real positions were updated in live planning. The prescribed dose was 145 Gy. Dose-volume histograms were calculated and volumetric parameters were used to evaluate the plans. V100 (%), DHI, D90 (Gy) and COIN were determined for the prostate, while D_{max} (%), D0.1cm^3 (%), D10 (%), D30 (%) for the urethra, and D_{max} (%), D0.1cm^3 (Gy), D2cm^3 (Gy), D10 (%) for the rectum. Means and standard deviations were calculated and compared for both intervention groups.
Results: On average, 54 and 47 seeds were implanted in the prostate with individual median seed activities of 0.49 and 0.56 mCi for LS and SS technique, respectively. The median needle number was 15 and 17, correspondingly. The mean prostate volumes were practically identical (33.4 vs. 33.9 cm^3). The dose coverage was similar (V100: 96% vs. 97%, D90: 167 Gy vs.169 Gy) in the two groups, and the dose homogeneity was identical (DHI: 0.39). The conformity of dose distributions was better for LS (COIN: 0.70 vs. 0.65). Regarding the dose to urethra all dosimetric parameters were significantly lower ($p<0.05$) for LS (D_{max}: 138% vs. 154%, D0.1cm^3: 126 vs. 140 %, D10: 125 vs. 136 % and D30: 119 vs. 128 %). The rectum received less dose with the LS technique (D_{max}: 101% vs. 112 %, D2cm^3: 82 Gy vs. 97 Gy, D0.1cm^3 :127 vs. 143 Gy, and D10: 75% vs. 86%) ($p<0.05$ for all).
Conclusions: In permanent prostate seed brachytherapy the dose to urethra and rectum is less with LS technique compared to SS technique in the intraoperative plans. Moreover, the conformity of dose distributions is also better with LS along with the same homogeneity of dose distributions. Probably the more flexible loading pattern for LS technique results in the more favourable dose distributions.

PO-0968

Available guidance, current UK practice, and future directions for HDR brachytherapy quality control

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Purpose/Objective: A survey of high dose rate (HDR) brachytherapy quality control (QC) procedures undertaken at radiotherapy centres in the United Kingdom (UK) is reported [1]. Published recommendations and guidance for HDR QC are also reviewed and compared to current UK practice. Recent changes in clinical brachytherapy techniques and the impact on required QC is discussed. Modern methods to determine optimum quality checking processes are indicated. This work is conducted in the context of the recent 'point/counterpoint' debate in *Medical Physics* that 'QA procedures in radiation therapy are outdated and negatively impact the reduction of errors' [2] and a review of the dosimetric accuracy in HDR [3].

[1] AL Palmer, M Bidmead, A Nisbet. *J Contemp Brachy* 2013 (in press)
[2] HI Amols, EE Klein. *Med Phys* 2011; 38: 5835-5837
[3] A Palmer, D Bradley, A Nisbet. *J Contemp Brachy* 2012; 4: 81-91

Materials and Methods: All UK radiotherapy centres were asked to participate in a survey of their approach and practice for HDR brachytherapy QC. This included guidance used, frequencies and tolerance values for individual QC tests. A comprehensive evaluation of responses was conducted detailing popularity of tests, and the average and range values of testing and tolerance. A literature search was conducted on general guidance, specific QC techniques in both brachytherapy and teletherapy, and on risk-based systems for quality assurance.
Results: Survey data was acquired from 31 UK radiotherapy centres and statistical analysis of responses performed. 45 possible individual QC tests were identified. There was general agreement on measurement frequency and tolerance for key QC tests, e.g. measurement of source position in a straight catheter, checked daily and with a 1.0mm tolerance in most centres. There was disagreement on a number of tests, e.g. the need for regular x-ray imaging of applicators. There was absence of tests that may be deemed necessary for modern brachytherapy practice, e.g. confirmation of planned and delivered dose distributions. There is likely a need to move from a device-centred to a system-centred approach, using risk-based assessment methods to determine required QC testing, with emphasis on clinical processes rather than simple device operation. Table 1 provides sample key results from the work.

Perception of need, within UK, for routine QC	QC test	% occurrence in routine QC schedules	Measurement frequency: Mean value (and range in brackets)	Tolerance value: Mean value (and range in brackets)
Agreed essential	Initial and independent measurements of source strength	100%	At source change (all)	3% (2% to 5%)
	Source dwell timer accuracy	100%	Daily (daily to annually)	1s (0.1s to 2s)
	Source dwell positions in straight catheter	100%	Daily (daily to at source change)	1 mm (1 mm to 2 mm)
No agreement	Repeated source strength through life of source	75%	Monthly (daily to monthly)	3% (0.5% of initial to 5% of cert)
	Source dwell positions in clinical applicators	55%	At commissioning (2-weekly to 12-monthly)	1 mm (1 mm to 2 mm)
	Source transit time	47%	3-monthly (weekly to at commissioning)	Large variations in definition
Low use or absence	X-ray imaging of applicators	32%	At commissioning (3-montly to 12-monthly)	1 mm (all)
	In-vivo dosimetry	Available at 19% of centres	Monthly (monthly to 'as required')	5% (all)
	Dose distribution measurement around applicators	0%	Not performed	Not performed

Conclusions: The only contemporary benchmark survey of HDR QC practice has been undertaken. The outcome of this work is a review of current practice against available recommendations, relevant recent changes in clinical brachytherapy techniques, and the use of modern quality process assessments. Recommendations for appropriate, optimised QC for HDR brachytherapy are made.

PO-0969

Air kerma rate measurements for Ir-192 and Co-60 HDR sources using three different international protocols.

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