broader dose range (double) than the two existing gel compositions used for 3D Gel dosimetry applications. Also, the novel gel composition showed no apparent change in response with post-irradiation time.

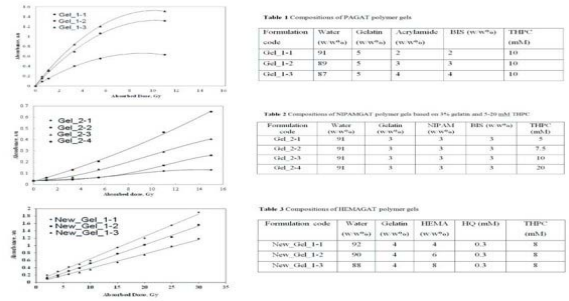

Figure 1 Comparison of dose response (absorbance sampled at 500 nm) curves for the three gel models studied: PAGAT gel model (top); NIPAMGAT gel model (middle); and novel HEMAGAT gel model (bottom).

PD-0383

A phantom suitable for cell survival investigations using flattened and unflattened photon beams

W. Lechner[1], E. Bozsaky[1,2], D. Georg[1,2], W. Dörr[1,2]
[1]*Medizinische Universität Wien Medical University of Vienna, Department of Radiation Oncology, Vienna, Austria*
[2]*Christian Doppler Laboratory for Medical Radiation Research for Radiation Oncology, Vienna, Austria*

Purpose/Objective: Recently, a number of studies investigating the difference in cell survival after irradiation with unflattened (FFF) compared to flattened beams (FF). Most of these studies were, on the one hand, performed under 'normal' oxygen conditions (21 %) and, on the other hand, dose homogeneity was often established using compensators or intensity modulation. The reproducibility of such setups has not yet been investigated. The aim of this study was to design a phantom capable of establishing hypoxic and normoxic conditions, providing a region of homogeneous dose distribution using static fields only and the possibility to precisely monitor the delivered dose to the cells for each experiment.

Materials and Methods: A VersaHD (Elekta, Crawley, UK) linac was utilized, which was commissioned to produce 10 MV FF and FFF beams. Doses of 0.5, 1, 2, 4 and 6 Gy were delivered to HaCaT (human keratinocytes) cells from a gantry angel of 180° using a static 10x10 cm² field. The cells were grown and irradiated in chamber slides, which consist of two wells each with inner dimensions of 2x2 cm². Only one well was used for the cells, the other one was filled with culture medium to provide scatter material. A PMMA insert was manufactured to fit the chamber slide between solid water slabs in a depth of 10 cm. Two holes were drilled through the PMMA insert in order to provide gas exchange, either ambient air for normoxic or nitrogen for hypoxic conditions. Dose homogeneity and monitor units necessary to deliver the specified doses to the cells were assessed using EBT3 films. . In order to determine the reproducibility of the setup of each cell irradiation, a Farmer chamber TM 30006 (PTW, Freiburg, Germany) was positioned downstream the beam line. The described setup is depicted in Fig. 1a. Cell survival was investigated in a clonogenic assay. Based on that, α and ß values of the cell survival curves were calculated for cells irradiated with FF and FFF beams.

Results: The film measurements showed that when using the chamber slides it is possible to establish an isolated region with cells where a dose homogeneity within ± 2% can be achieved even in FFF mode. The Farmer chamber measurements revealed a reproducibility of the dose between the individual cell irradiations within 0.5%. Alpha values of 0.16 and 0.11 were determined of cells irradiated with FF (dose rate ~4 Gy/min) and FFF beams (dose rate ~16 Gy/min), respectively. Both values agreed within their uncertainty. Beta values were 0.05 for both FF and FFF beams.

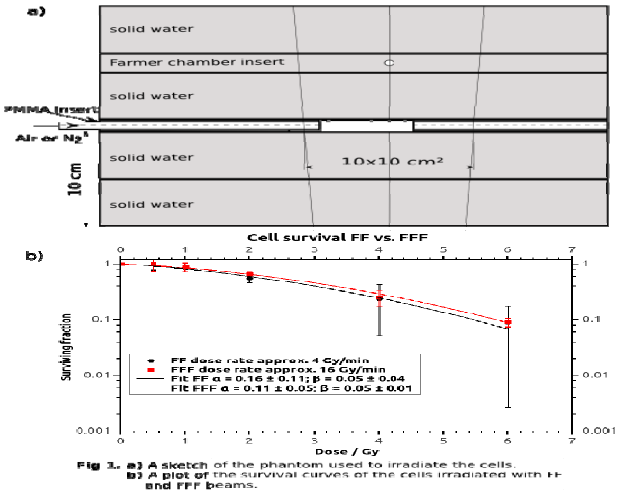

Fig 1. a) A sketch of the phantom used to irradiate the cells. b) A plot of the survival curves of the cells irradiated with FF and FFF beams.

Conclusions: An experimental setup could be established for reproducible cell irradiations in FF and FFF mode with sufficient dose homogeneity, without altering the beam itself or by the use of compensators or intensity modulation. Furthermore, this experimental setup enables simulation of different oxygen conditions. So far, no difference in survival of HaCaT cells was detected between irradiation with FFF or FF beams.

PD-0384

The XX Postal TLD Audit Programme: analysis of 10,660 results

J. Izewska[1], M. Wanklyn[2], P. Grochowska[1], P. Dunscombe[3]
[1]*International Atomic Energy Agency, Division of Human Health, Vienna, Austria*
[2]*King's College London, Medical Engineering and Physics, London, United Kingdom*
[3]*University of Calgary, Oncology, Calgary, Canada*

Purpose/Objective: With the aim of improving the accuracy and consistency of clinical dosimetry in hospitals world-wide, the XX Thermoluminescence Dosimetry (TLD) Postal Audit Program has been operating since 1969. In this study, we explore the dependence of the quality of clinical dosimetry in participating institutions on several key infrastructure characteristics.

Materials and Methods: The Postal Audit Program compares the dose read from the mailed TLD with that stated to have been delivered by the Institution. Agreement to within ±5% is regarded as being acceptable with larger deviations triggering follow-up actions. Of particular interest in this study was the dependence of clinical dosimetry quality on i) age of the treatment machine, ii) ^{60}Co vs linac, iii) number of machines in the participating centre, iv) elapsed time since the last dosimetry system calibration v) whether the audit was the first one or a subsequent one and vi) the dosimetry protocol used (a sub-set of 7182 TLDs). Quality, in this context, is defined as the percentage of results within the XX's criterion of acceptability of ±5%. Also, it is to be noted that the term 'clinical dosimetry' encompasses calibration of the institution's beam, the institution's dosimetry calculations and irradiation of the Postal Audit TLDs as it was clearly not possible to isolate these different contributors to the final result.

Results: Whereas for machines younger than 10 years agreement between measured and stated dose was 90% overall, for those over 30 years old agreement dropped to 70%. However, this picture varied with region. Linac dosimetry was always better than ^{60}Co and multi-machine centres generally performed better than single machine institutions. We interpret this latter observation as a reflection of a more substantial physics infrastructure in larger centres. The data suggest virtually no dependence on the time elapsed since the last dosimetry system calibration at least out to 10 years. Second or subsequent participation in audits reflected higher quality dosimetry (85% of results within the XX's acceptance criterion) than the first audit (77%). The use of $N_{D,w}$ based dosimetry protocols resulted in more accurate dosimetry than the use of the older N_k or N_x protocols (95%, 92% and 79% agreement respectively).
Conclusions: Clearly, over the 45 years that the XX has accumulated these TLD data, practice has changed both in institutions and at the XX's Dosimetry Laboratory. However, it is possible to draw some general conclusions from the analysis. Higher quality dosimetry is generally associated with younger machines, linacs as opposed to ^{60}Co, centres with more than one machine, prior experience with the XX's audit programme and the use of an $N_{D,w}$ based protocol.

PD-0385

Characterization of a microDiamond dosimeter in clinical scanned carbonion beams

G. Verona-Rinati[1], M. Marinelli[1], G. Prestopino[1], C. Verona[1], M. Ciocca[2], A. Mirandola[2], A. Mairani[2], L. Raffaele[3], G. Magro[4]
[1]"Tor Vergata" University, Industrial Engineering, Rome, Italy
[2]Fondazione CNAO, Unit of Medical Physics, Pavia, Italy
[3]INFN - Laboratori Nazionali del Sud, Catania, Italy
[4]INFN - Università degli Studi di Pavia, Physics, Catania, Italy

Purpose/Objective: To evaluate the dosimetric properties of the synthetic diamond dosimeter PTW 60019 (microDiamond) in high-energy scanned clinical carbon ion beams.
Materials and Methods: The measurements were performed at the National Center for Oncological Treatment (CNAO) synchrotron facility. The detector response was tested under actively scanned carbon ion beams ranging from 115 to 380 MeV/u. All measurements were performed in a water phantom. The detector performance was firstly evaluated in terms of response stability, dependence on beam energy and ion type (carbon ions and protons), linearity with dose, dose rate and angular dependence. The depth dose curve of a 280 MeV/u carbon ion beam, obtained by the microDiamond detector was compared to the one measured using a PTW Advanced Markus ionization chamber, and to numerical simulation from FLUKA Monte Carlo code. Dose measurements in spread-out-Bragg-peaks (SOBP) were also performed and the results were compared to the data from the treatment planning system (TPS).
Results: A response reproducibility within about 1% was found. Deviations of the calibaration factor below 3.5% with respect to the reference Co-60 source were observed for the whole set of beam qualities investigated (including protons). The detector response showed a good linear behavior and its sensitivity was found to be dose rate independent, with a variation below 1.3% in the evaluated dose rate range. Very good agreement between the measured Bragg peak curves, with respect both to the ones obtained by the Advanced Markus chamber and to simulated ones were observed, demonstrating a substantial LET independence of the microDiamond response. Very good results were also obtained from SOBP measurements, with a difference below 1% between measured and TPS-calculated doses.
Conclusions: The results of the present study showed that the microDiamond detector is suitable for clinical carbon ion beams dosimetry.

PD-0386

Multi centre comparative dose accuracy of Flattening Filter Free beams for SBRT lung cancer treatment

D.I. Thwaites[1], P. Juneja[1], S. Blake[1], J.R. Sykes[1], J. Barber[2], R. Bromley[3], S. Fisher[4], M. Bailey[5], S. Deshpande[6], G. Cho[7], C. Brink[8], C.R. Hansen[9]
[1]University of Sydney, Institute of Medical Physics, Sydney, Australia
[2]Nepean Cancer Care Centre, Department of Radiation Oncology, Sydney, Australia
[3]Royal North Shore Hospital, Northern Sydney Cancer Centre, Sydney, Australia
[4]Prince of Wales Hospital, Department of Radiation Oncology, Sydney, Australia
[5]Illawarra Cancer Care Centre, Department of Radiation Oncology, Wollongong, Australia
[6]Liverpool & Macarthur Cancer Therapy Centres, Department of Radiation Oncology, Sydney, Australia
[7]Chris O'Brian Lifehose, Department of Radiation Oncology, Sydney, Australia
[8]University of Southern Denmark, Institute of Clinical Research, Odense, Denmark
[9]Odense University Hospital, Laboratory of Radiation Physics, Odense, Denmark

Purpose/Objective: Flattening filter free (FFF) beams are becoming the new gold standard modality for clinical stereotactic body radiotherapy (SBRT). Beneficial characteristics compared to conventional flattened fields (FF) include higher dose rate, reduced lateral changes in beam hardening, reduced leakage, and less out-of-field dose and these have the potential to improve treatment plans. The two main accelerator manufacturers have chosen to implement FFF with different energy definitions and are using quite different MLC designs, which might also influence the achievable plan quality, as might the use of different treatment planning systems (TPS) with different MLC segmentation algorithms. This study investigates the possibility of creating FFF plans with high dose delivery accuracy across the different vendors, energies, and TPSs used for planning.
Materials and Methods: Ten lung patient cases were provided to seven different cancer treatment centres for SBRT planning using FF and FFF beams. The different centres' linac/TPS combinations were: Varian-Eclipse, Varian-Pinnacle, Novalis-Eclipse, Elekta-Pinnacle and Elekta-Monaco. All planning followed the same protocol. The prescribed minimum dose was 48Gy/4fr for tumours located less than 1.5cm from the thorax wall, 50Gy/5fr for tumours located within 2cm of the main bronchial tree, and 54Gy/3fr for free lying tumours in the lung. Half circle VMAT arcs were used for all plans avoiding the contra lateral lung. All treatment plans were delivered and measured using the Sun Nuclear ArcCheck phantom and evaluated using a 3% and 3 mm gamma analysis between planned and measured doses. Beam on times were recorded for the treatment beams. All DVH metrics were tested for significant differences with a paired two-sided Wilcoxon-signed rank test, with a significance level of 5%.
Results: All the linac-TPS combinations show high dose accuracy across the ten patients, with a mean pass rate of 98.1% and 97.4% for FF and FFF treatment plan respectively (see table). For the Elekta-Pinnacle combination the FFF plans have lower pass rates than FF plans, which might be related to the relative calibration of the ArcCheck phantom