

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

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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 calibration 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

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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

being performed in low dose rates. The MU used for the FFF plans are higher in the Varian/Novalis-Eclipse combination; this is not seen for Elekta -Pinnacle. In general Eclipse used more MU than Pinnacle. The beam-on times are significantly reduced and the largest gain is seen for Elekta-Pinnacle.

	FF		FFF		p
	mean	SD	mean	SD	
All					
Beam on [sec]	304	78	132	59	<0.001
MU	2912	732	3022	763	0.009
Pass rate [3%,3mm]	98.1	2.1	97.4	1.8	0.003
Elekta-Pinnacle					
Beam on [sec]	312	72	109	25	<0.001
MU	2783	653	2796	598	0.60
Pass rate [3%,3mm]	98.9	1.9	97.7	1.6	0.001
Varian/Novalis-Eclipse					
Beam on [sec]	306	79	175	59	<0.001
MU	3040	799	3249	855	0.005
Pass rate [3%,3mm]	97.6	1.8	97.3	2.0	0.27

Conclusions: FFF can be used for SBRT planning and delivery of accurate dose, independent of the specific combination of accelerator vendor and treatment planning system. The different combinations have different specific issues. Future perspective is to add the TomoTherapy-Hi Art combination to the study.

Proffered Papers: Clinical 2: Breast

OC-0387

The UK HeartSpare Study (Stage II): Multicentre evaluation of a voluntary breath-hold technique

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Purpose/Objective: To confirm the heart-sparing ability and feasibility of the voluntary breath-hold (VBH) technique in a multicentre setting.

Materials and Methods: Following surgery for early breast cancer, patients with any heart inside the 50% isodose on free-breathing radiotherapy planning-CT scans with standard tangential fields, underwent a second planning-CT scan using the VBH technique. Separate radiotherapy treatment plans were prepared based on free-breathing and VBH CT scans. Mean heart, left anterior descending coronary artery (LAD) and lung doses were calculated for each plan. Daily electronic portal imaging (EPI) was performed and scanning/treatment times were recorded. The primary endpoint was the percentage of patients who achieved a reduction in mean heart dose with VBH. Population systematic (Σ) and random errors (σ) were estimated and within-patient comparisons between techniques used Wilcoxon signed-rank tests.

Results: 101 patients from 10 UK centres were recruited. Data for the first 43 patients has been analysed and showed that 41 (95%) achieved a reduction in mean heart dose with VBH. Mean cardiac doses (Gy) for free-breathing and VBH techniques were: heart 1.9 and 1.1, LAD 12.1 and 5.7, maximum LAD dose 34.5 and 24.8. Pooled EPI-based displacement data showed Σ of 1.2-1.7mm and σ 1.6-2.1mm. Median CT and treatment session times were 20 and 22 minutes respectively.

Conclusions: Preliminary data suggest multicentre implementation of VBH is both effective at heart-sparing and feasible. Results from the remaining 58 patients are being analysed, and complete data (including inter-centre comparisons) will be presented in April 2015.

OC-0388

Risk of pacemaker implantation subsequent to radiotherapy for early-stage breast cancer in Denmark, 1982-2005

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Purpose/Objective:

Background

Adjuvant radiotherapy reduces the risk of recurrence and death for early-stage breast cancer. However in planning radiotherapy, dose to the heart should be considered since recent data suggest an increasing risk of ischemic heart disease with increasing dose to the heart. Conduction abnormalities have been reported after mediastinal radiation for Hodgkin's disease, but the risk of conduction disorders and arrhythmias does not appear to be increased subsequent to breast cancer radiotherapy. Such conduction abnormalities constitute a quite heterogenous group covering mild as well as severe disorders.

Purpose

The aim of this study was to examine the risk of severe conduction abnormalities evaluated by implantation of a pacemaker, subsequent to breast cancer radiotherapy.

Materials and Methods: From the database of the Danish Breast Cancer Collaborative Group, we identified women treated with radiotherapy for early-stage breast cancer in Denmark from 1982 to 2005. By record linkage to the Danish Pacemaker and ICD Registry information was retrieved on pacemaker implants subsequent to radiotherapy. The rate ratios (RR) of pacemaker implantation were estimated by Poisson regression for left versus right sided breast cancer with stratification for calendar year of breast cancer diagnosis, age at diagnosis and time since diagnosis (all in five-year groups). 95% confidence intervals (CI) and two-sided significance tests were calculated.

Results: Among 18,129 women treated with radiotherapy for early-stage breast cancer, 179 women had a pacemaker implanted subsequent to radiotherapy, 90 in 9,315 left sided and 89 in 8,993 right sided breast cancers. The unadjusted RR was 1.02 (0.76-1.36 95% CI, p=0.91) and the RR adjusted for year, age and time since diagnosis was 1.06 (0.79-1.42 95% CI, p=0.71).

Conclusions: Adjuvant radiotherapy as practiced in Denmark for early stage breast cancer does not increase the risk of severe conduction abnormalities in the heart.