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Purpose or Objective: Target position is variable during fractionated prostate radiotherapy, mainly due to rectal changes. Margin reduction is preferable with the advancements of modulated techniques and IGRT. However, geometric uncertainty can persist in the absence of an intervention to minimise rectal motion. The purpose of this study is to retrospectively evaluate the effectiveness of three rectal emptying strategies in maintain rectal stability and reducing target motion during prostate radiotherapy.

Material and Methods: Four cohorts of consented prostate patients (total n=37) underwent different rectal strategies: daily phosphate enema; low-fibre diet and microlax microenema and no intervention (control). Using retrospective CBCT data, (8 CBCTs per patients), inter-fraction PTV motion relative to bony anatomy was measured using automatic bone anatomy registration, followed by an automatic Structure Volume of Interest (SVOI) match. Changes in rectal diameter (RD) at the base, mid and apex of the prostate and rectal volume (RV) were measured using the CBCT data. Frequency of prostate geometric miss was assessed, with a miss defined as any PTV shift in any direction.

Results: PTV displacement was significantly reduced in the anteroposterior (AP) direction in the microlax group ($p=0.004$), and in the superoinferior (SI) direction in the phosphate enema group ($p=0.013$) when compared with the control group (Table 1). The frequency of geometric miss was lowest in the microlax group. RD variability at the base of prostate was significantly smaller in the microlax and phosphate enema groups compared to the control group stats, and variation in RV was smallest in the microlax group. PTV motion and rectal variability were largest in the control group.

Table 1: Mean (μ), Systematic (Σ), and Random (δ) PTV displacements (mm) in the anteroposterior (AP), superoinferior (SI) and left-right (LR) directions for each group. Negative values indicate posterior, inferior and left PTV displacements from bony anatomy.

	Daily Phosphate Enema n=9			Microlax Microenema n=8			Low-Fibre Diet n=10			No Intervention (Control) n=10		
	AP	SI	LR	AP	SI	LR	AP	SI	LR	AP	SI	LR
μ (mm)	-1.2*	0.3*	-0.1	-0.7*	-0.6	0.3	-1.1*	-1.3	-0.2	-2.6*	-1.9*	0.3
Σ (mm)	0.8	1.6	0.6	0.6*	0.4*	0.6	1.0	1.1	1.1	1.6*	1.9*	0.7
δ (mm)	1.4	1.0	0.5	0.8*	0.9	0.6	1.5	1.7	0.7	2.0*	1.6	0.9

*Significant difference ($p<0.05$) when compared with the control group statistics.

Conclusion: Microlax microenema is an effective intervention in maintaining rectal stability, and PTV motion during prostate radiotherapy, in patients with large RD≥4(cm) on planning CT.

OC-0560
Plan of the day approach in post prostatectomy radiation therapy

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Purpose or Objective: Our primary aim is to investigate the frequency of using smaller margins for post prostatectomy radiotherapy (RT) in conjunction with daily soft tissue image guided radiotherapy (IGRT). Our secondary aim is to assess the feasibility of implementing an adaptive, 'plan of the day', treatment approach by selecting an appropriate plan on a daily basis which will highly conform to the target and minimise rectal and bladder toxicities.

Material and Methods: Retrospectively identified 19 post prostatectomy patients. Soft tissue matching guidelines were created and split into two categories; patients with or without surgical clips. Soft tissue match was performed on cone-beam CT (CBCT) in offline review program by two radiation therapists and reviewed by two radiation oncologists. The frequency of geographic miss was measured using a planning target volume (PTV) small with a 5 mm clinical target volume (CTV) expansion and PTV large with 10 mm (15 mm anteriorly) CTV expansion. To implement a 'plan of the day' treatment approach, a post prostatectomy soft tissue training module was developed to educate the radiation therapists to perform daily soft tissue alignment. Radiation therapists will then apply an adaptive RT regime that selects from a plan library to account for internal organ inconsistencies of the bladder and rectum.

Results: A total of 135 CBCTs were reviewed on 19 radical post prostatectomy patients including those with lymph node involvement. Retrospective soft tissue match analysis determined that PTV small covered the target for 84% of CBCTs while the PTV large covered the target for 16%. There was no geographic miss outside PTV large in this retrospective analysis. In the matches that resulted in the selection of PTV large, 12% of CBCTs were due to variations in bladder filling and 4% from rectal filling.

Conclusion: PTV small is suitable for use on most CBCTs with PTV large selected for only a small portion of CBCTs. Very small bladders caused a greater amount of bladder and small bowel to fall in the target and increases the chance of side effects but rarely causes a geographic miss. Over filling bladders on CBCTs was undesired as it caused internal pelvic tilt in the superior portion resulting in a selection of the plan with PTV large. A dangerous combination is present if there are inconsistencies to both the bladder and rectum filling causing the CTV prostate bed region to tilt and fall outside of the target. With a high frequency of using PTV small, and a better understanding of the effect of bowel and bladder filling, implementation of 'plan of the day' is feasible. This will result in a highly targeted treatment delivery in conjunction with soft tissue IGRT that will reduce toxicities and increase local control.

Poster Viewing : 12: Physics: Dose measurement and dose calculation III

PV-0561
Validation of an optimised MC dose prediction for low energy X-rays intraoperative radiation therapy

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Purpose or Objective: Low energy X-rays Intra-Operative Radiation Therapy (XIORT) is increasingly used in oncology, predominantly for breast cancer treatments with spherical applicators [1], but also for skin or gastrointestinal cancer [2] with surface and flat applicators. This study aims to validate a fast and precise method [3,4] to calculate Monte Carlo (MC) dose distributions with an optimized phase space file (PSF) obtained from a previously stored database of monochromatic PSF and depth dose curves (DDP) for different INTRABEAM® (Carl Zeiss) applicators. To validate this procedure, we compared dose computed with the PSF with measurements in phantoms designed to prove actual XIORT scenarios.

Material and Methods: PSF were optimized from experimental DDP in water and were employed to calculate dose distributions, first in water, then in validation phantoms

such as air gaps or bone inhomogeneities, for all flat, surface and spherical applicators. Measurements with Gafchromic EBT3 films were performed. Irradiated films were scanned with an EPSON Expression 10000XL flatbed scanner (resolution 72 ppi) after a polymerization time of at least 24 h, and the three-channel information corrected for inhomogeneity [5] was used to derive dose. Calibration films were irradiated from 0 Gy to 5 Gy for surface and flat applicators and from 0 Gy to 20 Gy for spherical applicators. Simulations and experimental data were compared in detail.

Results: MC simulations are in good agreement with experimental data, at the 3%-1 mm level (10% dose threshold) for most setups, well within what is needed for XIORT planning. Accuracy of the comparison was mostly limited by the difficulty in assuring geometrical positioning within 1 mm or less of the physical phantoms. An example of dose distribution on a heterogeneous phantom of PMMA and bone for a 3 cm flat applicator is shown in **figure 1**.

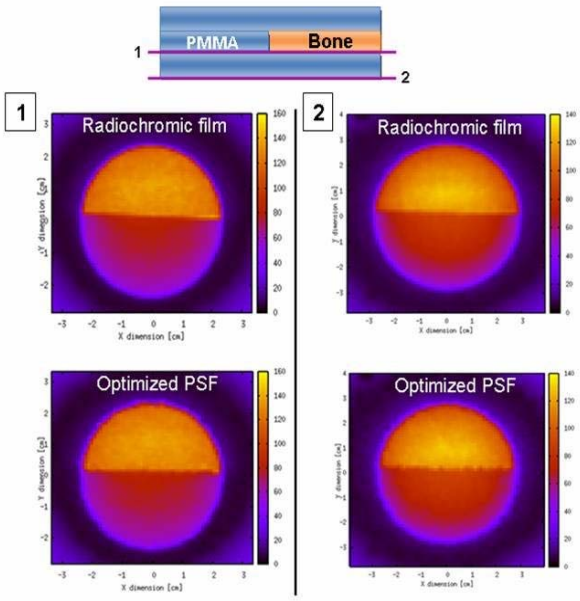

Figure 1. Experimental (top) and simulated (bottom) dose distributions of a PMMA-bone phantom with a 3 cm diameter flat applicator. More than 90% voxels pass the 3%-1mm gamma test.

Conclusion: Preliminary results show that the optimized Monte Carlo dose calculation reproduces dose distributions measured with different applicators, accurately enough for XIORT planning. The method is flexible and fast, and has been incorporated in Radiance® [6], a treatment planning system for intraoperative radiation therapy developed by the GMV company.

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PV-0562

Hadron-therapy monitoring with in-beam PET: measurements and simulations of the INSIDE PET scanner

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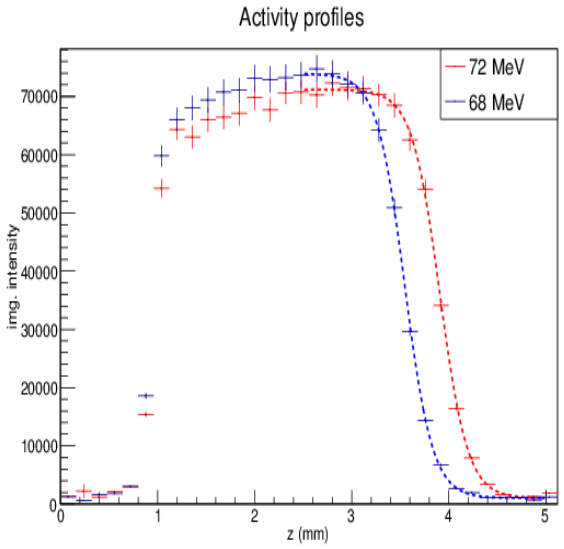
Purpose or Objective: In-beam PET exploits the ß+ activation induced in the patient's body by the hadron-therapy (HT) particle beam to perform treatment monitoring and dose-delivery accuracy assessment. The INSIDE collaboration is building an in-beam PET and tracker combined device for HT. In this work we focus on the preliminary PET measurements performed at the CNAO (Italian Hadron-therapy National Center) synchrotron facility and on Monte Carlo simulations.

Material and Methods: The PET module block is made of 16x16 Lutetium Fine Silicate scintillator elements 3.2x3.2x20 mm³ each, coupled one-to-one to a Silicon Photomultiplier matrix, read out by the TOFPET ASIC. The scanner will feature two 10x20 cm2 planar heads, made by 10 modules each, at a distance of 25 cm from the iso-centre. Preliminary tests investigated the performance of one module per head at nominal distance. Monoenergetic proton pencil beams of 68, 72, 84 MeV and 100 MeV were targeted to a PMMA phantom placed inside the FOV of the two detectors. The CNAO synchrotron beam has a periodic structure of 1 s beam delivery (spill) and 4 s interval (inter-spill). Acquisition was performed both in- and inter-spill. A 250 ps coincidence window is applied to find the LORs and reconstruct the image with a MLEM algorithm. Monte Carlo (MC) simulations are used in HT for detector development and treatment planning. In case of 3D online monitoring, they could also be used to compare the acquired image, which is a measurements of the activity, with the expected distribution, and hence to assess the treatment accuracy. Taking into account the detection and digitisation processes, it is also possible to reconstruct the simulated image. MC simulations, performed with FLUKA, were used to assess the expected performance and also compared to the measured activity profiles.

Results: Acquisition has been successfully performed in both inter-spill and in-spill mode. The inter-spill and in-spill Coincidence Time Resolution (CTR) between the two modules, measured without a fine time calibration, is 459 ps and 630 ps σ, respectively. The larger in-spill value is expected and related to background uncorrelated events. The images profile along the beam axis for the 68 and 72 MeV beam energies, which have a range short enough to be stopped by the phantom inside the FOV (5x5x5 cm³), show the characteristic distal activity fall-off. The expected proton range difference in PMMA for 68 and 72 MeV (3.64 mm) is compatible with the experimental measurement (3.61±0.10 mm), obtained by fitting with sigmoid functions the fall-off of the image profiles (fig. 1). The same behaviour is found in simulated images.



Conclusion: Tests with proton beams and prototype detector modules has confirmed the feasibility of the INSIDE in-beam PET monitoring device. Simulations are in good agreement with data and could be used to calculated the expected activity distribution measured by the PET scanner.