PO-0856

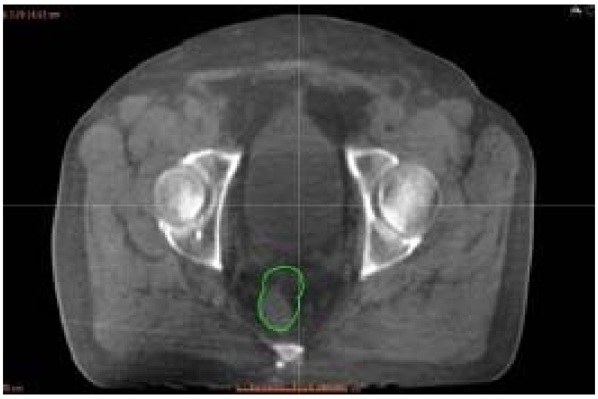
A retrospective study of image guided adaptive radiation therapy in prostate cancer

M. Guasp Tortajada[1], R. García-Mollá[1], L. Vidueira-Martínez[1], N. De Marco-Blancas[1], J. Bonaque-Alandí[1], M. Albert-Antequera[2], A. Santos-Serra[1], J. López-Tarjuelo[1]
[1]*Consorcio Hosptialario Provincial de Castellon, Servicio de Radiofisica y Protección Radiológica, Castellón de la plana, Spain*
[2]*Consorcio Hosptialario Provincial de Castellón, Servicio de Oncología Radioterápica, Castellón de la plana, Spain*

Purpose/Objective: Image Guided Adaptive Radiation Therapy (IGART) uses the Deformable Image Registration (DIR) between Computed Tomography (CT) and Cone-Beam CT (CBCT) images to calculate the delivered dose to the patient during treatment. Using this method we carried out a retrospective study of prostate cancer patients in order to study the weekly variations of delivered dose and evaluate the full treatment projecting on CT the delivered dose previously calculated on CBCT images.

Materials and Methods: Five patients with prostate cancer were selected for a retrospective IGART study. VMAT treatments were planned on CT simulation images with RayStation 4.0 Treatment Planning System (TPS). For every patient, three of the five weekly CBCT studies they had were retrieved. For each CBCT, a Rigid Registration (RR) was made, setting CT and CBCT as primary and secondary images, respectively. Subsequently, a DIR by Hybrid Deformable Registration algorithm was run in order to map the CT's reference structures (ROIs) -external body contour, femoral heads, rectum, prostate and seminal vesicles (SV)- onto CBCT. A radiation oncologist reviewed the mapped structures and modified the non-matching structures by editing them. When some structures were modified was necessary to run a new DIR using these structures as control ROIs. Finally, VMAT plan was calculated on each CBCT and the resulting doses were projected to CT, achieving the total dose delivered on CT. The corresponding dose for the two non-retrieved weekly CBCT studies was estimated using the Raystation IGART module.

Results: One patient was rejected because the field of view (FOV) cut the patient´s surface. The accuracy of DIR for moving structures such as rectum was lower than for fixed structures. Therefore, it was necessary to review the rectum contour and run again a new DIR using this structure as a control ROI. With respect to the external body contour, the weight loss suffered by the patient due to the diet during treatment introduced overdoses which were not computed in the initial dosimetry. One patient showed overdoses in rectum (5.6% and 4.7% for D25 and D20, respectively), whereas another patient showed a 4% overdose in D20. In both cases, the limits prescribed by radiation oncologist were exceeded. On the other hand, the variation of dose in fixed structures such as femoral heads was insignificant. Finally, one patient showed a 7.3% overdose in V98 for SV and 3.7% in V100 for the prostate. In general, a slight tendency to overdose was observed in patients who showed greater weight loss.



Patient	D25	D20	D15
*P1**	*5.6%*	*4.7%*	*2.6%*
*P2**	*0,04*	*3.6%*	*1.6%*
P3	*-2.1%*	*-1.8%*	*-0.4%*
P4	*0.6%*	*0.3%*	*-0.4%*

Conclusions: Shape and volume of some organs, i.e. rectum, fluctuate during the treatment, resulting in a failure to meet the initial prescription doses. The implementation of a weekly IGART protocol study could detect such changes and allows an offline correction through the adaptive treatment.

PO-0857

Are the dosimetric verification results of spot scanned IMPT fields dependent on field specific parameters?

P. Trnkova[1], A. Bolsi[1], F. Albertini[1], D.C. Weber[1], A.J. Lomax[1]
[1]*Paul Scherrer Institute (PSI), Centre for Proton Therapy, Villigen PSI, Switzerland*

Purpose/Objective: A detail analysis of 2437 IMPT fields that were clinically used for patient treatment between 2007 and 2013 at PSI Gantry 1 was performed [1]. The aim of this study was to find out a possible correlation between the results of dosimetric verifications and specific field characteristics.

Materials and Methods: Dosimetric verifications were performed for every IMPT field prior to patient treatment. For every field a steering file was generated containing all the treatment unit information necessary for treatment delivery: beam energy, beam angle, dose, size of air gap, nuclear interaction (NI) correction factor, number of range shifter plates, number of spots with their position and weight. This information was extracted and compared to the results of dosimetric verification of each field which was a measurement of two orthogonal profiles using an orthogonal ionization chamber array in a movable water column.

Results: The data analysis has shown that the difference between measured and calculated dose depends critically on the number of spots and maximal range. Figure 1 displays the dose degradation as a function of the mean range and mean number of spots. An increase of the dose degradation was observed with smaller number of spots (i.e. smaller tumour) and smaller ranges (i.e. superficial tumours). Noteworthy, more than 94% of all verified fields were within defined clinical tolerances. Figure 1 does not reflect the frequency of each measured dose value. The results of the verification do not depend however on the prescribed dose, NI correction or the size of the air gap. There is no dependency of the transversal and longitudinal spot position precision on the beam angle.

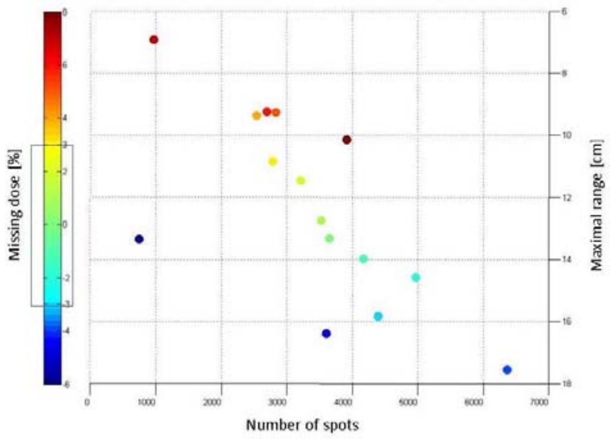


Figure 1: Dose dependency on the number of spots and maximal range. Positive values of the parameter “missing dose” indicate that the measured dose was lower than calculated. Negative values indicate that the measured dose was higher. The clinical acceptable tolerance of ± 3 % of prescribed dose is highlighted on the colour scale. Number of spots and maximal range are mean values over all measurements resulting in the same value of “missing dose”.

Conclusions: The detail analysis of field specific verifications has shown that the dose calculation as well as proton therapy delivery at PSI is reliable and precise. The dependence of the dose measurement on the tumour size and location in depth indicates that a correct definition of output factors is essential for the precise treatment delivery.

[1] Trnková P, Gomà C, Mumot M, Lomax T: *Patient specific verifications of spot scanned IMPT fields at the Paul Scherrer Institut: 5 years of experience*; 2nd ESTRO FORUM, 20.-23.4.2013, Geneva, Switzerland

PO-0858

Perturbation effects of Carbon Fiber-PEEK screws on radiotherapy dose distribution

R. Bar-Deroma[1], E. Borzov[1], A. Nevelsky[1], S. Daniel[1]
[1]*Rambam Health Care Campus, Radiation Oncology, Haifa, Israel*

Purpose/Objective: Radiation therapy in conjunction with surgical implant fixation is a common combined treatment in case of bone metastases. However, metal implants generally used in orthopedic implants perturb radiation dose distributions. Carbon-Fiber Reinforced (CFR) PEEK material has been recently introduced for production of intramedullary screws and plates. In this work, we investigated the perturbation effects of stainless steel, titanium and carbon fiber screws on radiotherapy dose distributions by means of Monte Carlo (MC) simulations for a 6 MV photon beam.

Materials and Methods: The EGSnrc code package was used for the MC simulation of a 6 MV beam from the Elekta Precise Linear accelerator. Stainless steel, titanium and carbon fiber plates of 1, 3, and 6 mm thickness were used for attenuation and backscatter measurements using a 10x10cm^2 field at SSD=100cm. For the same setup, MC dose calculations were performed. Comparison of measured and calculated doses was performed in order to verify the validity of the MC simulation results. Next, dose calculations for metal and CFR-PEEK screws (manufactured by Carbo-Fix Orthopedics LTD, Israel) were performed. The screw axis was either parallel or perpendicular to the beam axis. Dose perturbation was assessed for both situations.

Results: For the plates, the results of our Monte Carlo calculations for all materials were found to be in good agreement with the measurements. This indicates that the MC model can be used for calculation of dose perturbation effects caused by the screws. The dose at the entrance surface of the plates was increased (backscatter effect) by 22% for stainless steel, 18% for titanium and less than 1% for CFR- PEEK. There was only minor dependence (less than 1%) on the thickness of the plate. For the same plates, the dose at the exit surface was reduced by 10, 13 and 17% for steel and by 8, 10 and 13% for titanium for the thickness of 1, 3 and 6mm correspondingly. For the CFR-PEEK plates, the dose was increased by less than 2%. For the CFR-PEEK screws, the dose perturbation was less than 5% compared to more than 30% perturbation for the metal screws.

Conclusions: CFR-PEEK implants have good prospect for use in radiotherapy because of less dose alteration and possibility of more accurate treatment planning. This could favorably influence treatment efficiency and decrease possible over- and underdose of adjacent tissue. The use of such implants has potential clinical advantage in the treatment of neoplastic bone disease.

PO-0859

Real-time detection of deviations in VMAT and IMRT beam delivery using a head-mounted detector

R.A.M. Canters[1], J.M.A.M. Kusters[1], J. Oellig[2], J.P. Carrasco[2], H. Huizenga[1]
[1]*Radboud University Medical Center, Radiation Oncology, Nijmegen, The Netherlands*
[2]*iRT systems GmbH, Koblenz, Germany*

Purpose/Objective: Correct delivery of the planned treatment is of vital importance in radiation therapy. To be able to monitor beam delivery online, the Integral Quality Monitor (IQM, iRT Systems GmbH) was developed. Mounted on the linac head it enables real-time, per-segment evaluation of the delivered beam [1,2].

In this study we tested the sensitivity for potential errors in a variety of VMAT and IMRT beams as a beta test in the last development stage of the IQM.

Materials and Methods: We incorporated various forced deviations/errors in four treatment plans (stereotactic lung, lung (VMAT), larynx (VMAT), and head & neck (IMRT)):

- An unintentionally performed re-optimization of the beams after plan approval by the radiation oncologist
- Incorrect number of monitor units (MU) in two segments (±20 MU for a stereotactic beam, ±10 MU for other beams). The beam MU remained the same.
- Incorrect leave positioning (retraction by 1 cm) in a single segment, located at the start, halfway, or at the end of the VMAT beams.

The clinical beams, without incorporated errors, are used as a reference.