iORT staff and could provide a provisional plan that includes also DVH and MU calculation.

**EP-1583**

An automated Monte Carlo plan verification system for spot-scanning proton therapy

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**Purpose or Objective:** Monte Carlo (MC) recalculation of spot-scanning proton therapy treatment plans can provide an independent verification of monitor units required for delivery, and reduce the time treatment rooms need to be reserved for patient specific QA. We describe the development of such a MC verification system for a clinical facility.

**Material and Methods:** Realistic clinical beam models were developed by matching simulations (using GATE/GEANT4) to measurements made in a clinical beamline. They consist of a tuned physics list, a lookup table relating each of the 115 nominal beam energies to a tuned spot energy (mean and standard deviation) and phase space parameters which allow spot sizes to be properly modeled for any combination of energy and nozzle extension. For all beam energies simulations accurately reproduce both integral depth dose profiles (~97% of data-points pass a local gamma analysis at 2%/2mm) and lateral profiles measured in air and in solid water (with a 0.2 mm maximum difference). The model was further validated against a series of simple test plans which were optimized in the clinical Treatment Planning System (TPS) to produce uniform dose volumes at various depths in water. The automated MC system can process, simulate and analyse treatment plans without user input once it receives the TPS files.

**Results:**

The system was tested for a three field (11k spot) base of skull treatment plan computed in a patient CT dataset. Simulations were split into 40 calculations over a 10 quad-core CPU cluster, requiring <30 minutes to achieve dosimetric uncertainties (within the 90% isodose volume) of <1%. The figure demonstrates the broad agreement between the TPS (left) and the MC simulation (right). The local gamma pass rate between the two (bottom) is 97% at 4%/4mm (green voxels pass, red / blue voxels fail). This should be interpreted in the context of this being a highly inhomogeneous target site: Differences occurred only in heterogeneous regions where the TPS’s analytical dose calculation would be expected to model dose deposition less accurately than MC systems. For example, the MC simulations predict a lower dose around the sinus air cavities than the TPS.

**Conclusion:** We have demonstrated that the MC verification system can accurately reproduce the dose distribution predicted by a clinical TPS. Further validation work is ongoing using a variety of plans and phantom measurements. Once clinically commissioned, the system can be used as an independent dose checker, reducing on-set verification time.

**EP-1584**

Experimental validation of Tomotherapy to VMAT plan conversion using RayStation Fallback Planning

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**Purpose or Objective:** To establish the workflow & methodology and to perform an experimental validation of treatment plan conversion from Tomotherapy HD machine (Accuray) using dynamic jaws to a True Beam (Varian) Linac.

For this purpose, the RayStation (RS) TPS using fallback planning (RFP) is currently tested. An end-to-end set of phantom configurations of increasing complexity are presented. The ultimate goal is to validate this process in order to minimize the impact of machine downtime on patient treatments.

**Material and Methods:** Four phantom based treatment plans were generated in the Tomotherapy Planning Station. These plans were mimicked with RFP for the TrueBeam using X6-FFF dual-arc VMAT. The first three cases planned on the Cheese Phantom (Std. Imaging) consisted of 1 to 4 target dose levels and 3 OARs, using heterogeneous inserts for the last one. The 4th case was an integrated boost H&N treatment with 3 target dose levels planned on an anthropomorphic phantom (H&N, IBA). Original Helical Tomotherapy (HT) and RS fallback plans were delivered respectively on each machine.

Ion chamber (A1SL, Std. Imaging) and Gafchromic EBT3 (ISP) films were used to measure absolute and planar doses. First, for both machines beam delivery vs. treatment plan was evaluated as a baseline for absolute dose, gamma (γ) passing rate (criteria 3%/3mm) and overall uncertainties. Secondly, in order to ensure that the difference between the two calculated dose distributions (TPS_TOMO / TPS_RAYSTATION) matched the differences between the two measured film dose distributions (Film_TOMO / Film_RAYSTATION), a γ difference (5%/5mm) was performed.

**Results:** First, gamma evaluation was (99.1±0.6)% for HT and (99.5±0.4)% for RS fallback plans while absolute dose differences between calculations and ion chamber measurements were respectively 0.9% for HT and -0.7% for RS on average for all end-to-end tests. Secondly, average γ difference between calculated doses TPS_TOMO / TPS_RAYSTATION was (99.5±0.4)%.
Conclusion: Raystation fallback planning is an advanced feature that allows switching patient plans between alternative treatment machines and techniques. This could be useful to reduce impact of machine downtime on patient treatments. However, this process could introduce potential risks as distinct TPS and beam deliveries are involved. The results presented here show that a difference between calculated HT and mimicked RS fallback plans match the measured differences found throughout the end-to-end tests. Results based on a 5%/5mm tolerance show that we can expect at most 0.3% agreement from the difference between original and fallback plans displayed by the RS TPS. Further work will involve the study of clinical plans on various tumors sites.

EP-1585
PRIMO software as a tool for Monte Carlo treatment quality control in IMRT: a preliminary study
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Purpose or Objective: Monte Carlo (MC) approach is considered the gold standard method to perform absorbed dose calculations in external radiotherapy[1], because it provides the most detailed and complete description of radiation fields and particle transport in tissues. Several codes are available and recently a new MC Penelope based code and graphic platform named PRIMO was developed [2]. PRIMO has a user-friendly approach, a suitable and competitive characteristic for clinical activity. Nevertheless, advanced features such as IMRT are not introduced yet. This work is a preliminary study for the PRIMO software as a tool for MC based quality control of IMRT treatment.

Material and Methods: The simulated beam parameters of a Varian CLINAC 2300 were adjusted based on measurements in a water tank for 6 MeV energy and 10x10 cm² field. The water tank was divided in 81x81x155 voxels with dimensions of 2x2x2 mm³. The Gamma Function (GF) was used for agreement assessment and a phase-space was obtained above the MLC. A solid water phantom with a PTW OCTAVIUS® 722 2D ionization chamber array inserted was imaged by a CT scan and used in PRIMO. A dynamic IMRT plan was calculated by the Eclipse™ TPS and irradiated. The LINAC DynaLog files were analysed and the dynamic delivery was divided into series of static fields in PRIMO. MATLAB was used to analyse the PRIMO output and to create images of dose distributions at specific locations. The simulated dose at the ion chamber matrix position in the phantom was compared with the matrix measurement using the 2D GF through the PTW Verisoft program.

Results: The best agreement for the beam parameters of the LINAC numerical model was obtained with initial electron energy of 5.9±0.2 MeV and beam divergence of 1.5°. The gamma function analysis (2%, 2mm) showed that 97% of the points was lower than 1, confirming the good agreement with the experimental data. For the IMRT plan, the measured and simulated dose distributions at the ion chamber matrix (fig 1A-B) show good agreement, as the gamma points lower than 1 were 96% (fig 1C).

Conclusion: This preliminary study shows that an IMRT plan was successfully simulated through PRIMO with acceptable concordance with the experimental results. Even though further studies on more complex treatments are still required, the results confirm PRIMO as a promising tool for IMRT simulation in clinical environment.

EP-1586
Characterization of a new EPID-based system for in-vivo dosimetry in VMAT treatments
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Purpose or Objective: The aim of this paper is to evaluate the EPID detector sensitivity and specificity for in vivo dosimetry of VMAT treatments to identify dosimetric and geometric errors and anatomical variations.

Material and Methods: Measurements were performed by using TrueBeam STx accelerator equipped with TPS Raystation (Varian, Palo Alto, CA) and PerFraction (PF) software (Sun Nuclear Corporation, Melbourne, FL). PF is a commercial EPID-based dosimetry software, which allows performing transit dosimetry, to provide an independent daily verification of the treatment. Performance of the EPID detector and of the PF software on anthropomorphic phantom was studied, simulating 17 perturbations of the reference VMAT plan. Systematic variations in dose values (1%-5% output variation), shifts (2,5-11 mm in anterior direction), anatomical variations (adding bolus over phantom), and MLC positioning (locked leaf position for different arc extensions) were applied. The difference in local and global gamma pass rate (%GP) between the no-error and error-simulated measurements with 1%/1mm, 2%/2mm and 3%/3mm tolerances was calculated. The clinical impact of these errors was also analyzed through the calculation of the difference between the reference DVH and the perturbed DVH (%DE). We defined as clinically meaningful a variation higher than 3% between calculated and perturbed doses. A value of %GP equal to 95% and 90% and %DE equal to 3% were used as thresholds to calculate sensitivity and specificity.

Results: Repeatability and reproducibility of no-error measurements were excellent with %GP=100% for all gamma