Results

The response of the system was linear with dose from 1 to 990 MU (R^2=1) and consistent with dose rate varying from 70 to 500 MU/min (m/σ=0.06%). Measured dose was repeatable (m/σ=0.07%) and reproducible (m/σ=0.2%). For H&N treatment plan, iViewDose system detected a shift of 1 mm on a single bank (γ_{3D} percentage decreased from 91.7% to 67.6%), a 2° collimator rotation (γ_{3D} percentage decreased to 76.8%) and 1% MU increase (γ_{3D} percentage decreased to 84.6%).

For first in vivo fraction, γ_{3D} percentage was 82.3%, and decrease to 80.0% for all fractions (average for all patients). The 4 ART patients showed a mean γ_{3D} percentage of 87.6%. For 6 of the non-ART patients the γ_{3D} was deteriorated during the treatment course. CBCT images analysis highlighted several phenomena: shoulder relaxation, patient anatomical changes (tumor shrinkage, weight loss) (Fig 1). Based on planning CT-CBCT registrations, a replanning was triggered for the 6 patients. Re-planning improved the γ_{3D} percentage from 58.8% to 86.8% (average on 5 fractions before and after re-plan).

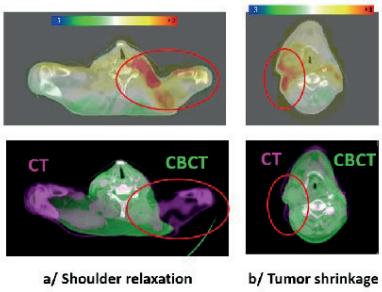


Fig 1. 2D gamma index maps from iViewDose software and corresponding registration CT/CBCT slices for 2 critical clinical cases: a/ shoulder relaxation b/ tumor shrinkage

Conclusion

This study shows the iViewDose capability to detect LINAC and patient potential errors. A daily analysis of EPID-based transit dosimetry adds the dose guided dimension to an adaptive radiotherapy process and accuracy can potentially improve with reconstruction on CBCT images. The clinical impact of this tool warrants further investigation in the context of an ART workflow.

PO-0890 EPID for QA and pre-treatment verification of electron beams in absolute dose using EpiDream method

A. Sors[1], P. Dudouet[1,2], D. Franck[2], M. Macé[1], P. Boucarut[1], C. Boutry[1]

[1]*Clinique du Pont de Chaume - Groupe Oncorad Garonne, Service de Radiothérapie, Montauban, France*

[2]*Clinique Pasteur - Groupe Oncorad Garonne, Service de Radiothérapie, Toulouse, France*

Purpose or Objective

The objective of the study was to evaluate the use of EPID for electron beams quality assurance (QA) and pre-treatment verification with a new approach in absorbed dose to water reconstruction: the EpiDream method [1].

Material and Methods

The study was performed on Varian LINAC, equipped with EPID AS1000 imager for electron beams energies of 6, 9, 12, 15 and 18 MeV. For each energy reference water depth (zref), EPID was calibrated with EpiDream application in order to obtain the dose to water matrix from the Grey Level (GL) image. EPID integrated images were corrected of dark field and acquired using AM Maintenance system (Varian) at the detector source distance (DSD)=(100+zref) cm for different parameters: applicator sizes (6×6-20×20 cm^2), delivered MUs (3-300 MU), dose rate (100-300 MU/min). For a 15×15 cm^2 applicator size, comparison was performed between water radial and transverse profiles measured with a 0.125cm^3 ionization chamber (IC) (PTW31010), in water at zref for SSD=100 cm and dose profiles extracted from EpiDream matrices. For gantry angle of 90°-270°, EpiDream matrices were compared with PROFILER2 (Sun Nuclear, Melbourne, FL) profiles obtained at DSD 100+zref. Rescaling of each measured profile was performed using a Kriging interpolation method with a 0.02 mm step. Analyse was performed considering: flatness and symmetry parameters, penumbra and field size. EPID images of 10 irregularly clinical block electron fields were acquired for all energies mentioned above. A gamma analysis was performed between EpiDream matrices and corresponding TPS (eMC v13.6, Varian) 2D dose matrices, using criteria of 2%2mm absolute dose for beam QA and 3%3mm for irregular clinical fields with threshold of 15%.

Results

Kriging interpolated profiles comparisons show that EpiDream profiles are substitutable to IC and PROFILER2 profiles. From the range of 15 to 300 MU, for 10x10 cm^2 applicator size, the mean gamma index value for 6-9-12-15-18MeV was respectively: 96.6%(σ=1.6%), 99.9%(σ=0.1%), 100%(σ=0.16), 99.8%(σ=0.6%), 99.8%(σ=0.1%).For clinical fields, the gamma index values for 6-9-12-15-18 MeV ranged from 97.6% to 100%.

Conclusion

The EpiDream method allows to perform electron beams QA in 2D absolute dose using EPID for all gantry angles by maximizing measurement reproducibility and optimizing time dedicated to QA process. Our results show that pre-treatment verification of electron beams in absolute dose is possible using EPID combined with EpiDream method.

[1] Boutry, C., Sors, A., Fontaine, J., Delaby, N. and Delpon, G. (2017), Technical Note: A simple algorithm to convert EPID gray values into absorbed dose to water without prior knowledge. Med. Phys. doi:10.1002/mp.12587

PO-0891 Enhancing efficiency of proton macro Monte Carlo dose calculation by an adaptive step size algorithm

R. Kueng[1], F. Stürmlin[2], D. Frei[1], M.F.M. Stampanoni[3], P. Manser[1], M.K. Fix[1]

[1]*Inselspital- Bern University Hospital- and University of Bern, Division of Medical Radiation Physics and Department of Radiation Oncology, Bern, Switzerland*

[2]*Swiss Federal Institute of Technology ETH, Department of Physics, Zurich, Switzerland*

[3]*University of Zurich and Swiss Federal Institute of Technology ETH, Institute for Biomedical Engineering, Zurich, Switzerland*

Purpose or Objective

To implement an adaptive step size algorithm to provide fast and accurate dose calculations by improving the efficiency of the proton macro Monte Carlo (pMMC) method for voxelized geometries.

Material and Methods

The in-house developed local-to-global macro MC method for proton dose calculation was extended to further improve efficiency of proton transport and energy deposition in voxelized geometries. The Geant4 MC

source: https://doi.org/10.7892/boris.123807 | downloaded: 10.4.2024

toolkit was used for full local simulations of homogeneous layers (slabs) for a range of clinically relevant materials, energies and slab thicknesses. Exit phase space parameters including energy loss and lateral displacement were scored and stored in a database. An adaptive step size algorithm was developed for the global pMMC transport of protons through a voxelized geometry by sampling parameters from adequately large slabs of the database. Adaptive choice of an adequate slab size in dependence of material interfaces and density variations in the proton's vicinity was investigated and optimized for efficient transport, while keeping dosimetric accuracy. Particle tracking of the macro step (proton track) was approximated with a hinge step and accurate energy deposition in a voxelized grid was achieved by a semi-empirical approximation of stopping power increase over the proton track. The dose calculation algorithm was validated for accuracy and benchmarked for efficiency against full MC simulation for pencil and broad beams with various energies impinging on a number of homogeneous and inhomogeneous academic phantoms as well as a head and neck patient CT.

Results

Slab size choice limited by material interfaces in proton direction as well as in lateral direction were shown to yield an efficient proton transport in voxelized geometries. Restriction of slab size to ensure a maximum density variation of 5% with respect to the density at the starting point of a proton track provided an excellent trade-off between accuracy and efficiency of the proton transport. For the homogeneous and inhomogeneous academic phantoms, dose differences of within 1% or 1 mm compared to full Geant4 MC simulation were found, while achieving an efficiency gain of up to a factor of 500. For the head and neck patient CT, dose differences were within 1% or 1 mm with an efficiency gain factor of 130.

Conclusion

An adaptive step size algorithm for proton macro Monte Carlo was implemented and evaluated. The dose calculation provides the accuracy of full MC simulations, while achieving an efficiency gain factor of 130 for a complex patient CT.

PO-0892 Dosimetric evaluation of the gantry sag effect

E. Borzov[1], A. Nevelsky[1], T. Sharon[1], R. Bar-Deroma[1], I. Orion[2]

[1]*Rambam Health Care Campus - Faculty of Medicine, Oncology, Haifa, Israel*

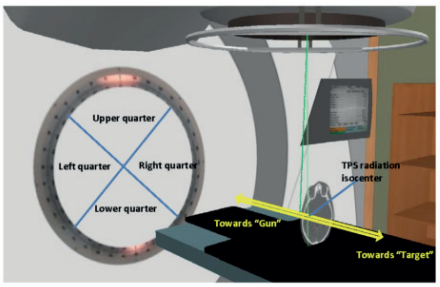
[2]*Ben-Gurion University of the Negev, Nuclear Engineering, Beer Sheva, Israel*

Purpose or Objective

The gantry sag introduces a largely reproducible variation of the radiation field center around the radiation isocenter. The purpose of this work is to assess the change of the dose distribution caused by the gantry sag in clinical stereotactic plans with coplanar and non-coplanar dose delivery techniques.

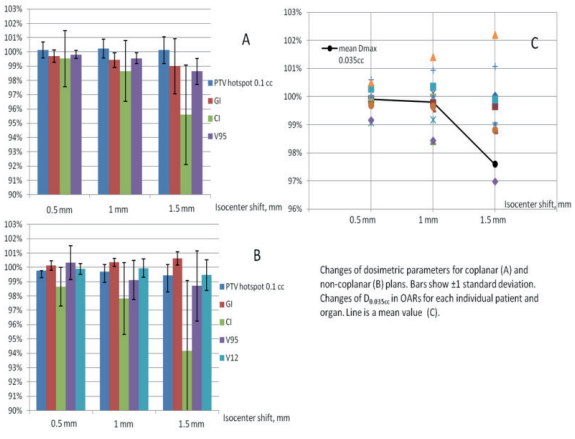
Material and Methods

Two equal groups of ten SRS patients with intracranial tumors were selected for the study. The first group consisted of patients planned with VMAT technique using full coplanar arc. The second group included patients planned using four non-coplanar arcs. The PTV volumes were less than 2.5 cc in all selected cases. The linear accelerator used in this study was Elekta Versa HD equipped with Agility MLC and 6 MV FFF photon beam. Treatment plans were created in Monaco treatment planning system. The model describing gantry sag in the TPS consisted of the next stages and assumptions. First, all segments from the original plan were divided into four groups according to the corresponding gantry angles: the upper, the lower, the left and the right quadrants (Fig1). Then segments from the upper quadrant were shifted towards "Gun", segments from the lower quadrant were shifted towards "Target" while segments in the left and right quadrants were left at their original positions. Apart from the shift, all other segment parameters (number of MU, shape, gantry angle etc) were kept unchanged. Lastly, dose distribution for the modified plan with shifted segments was recalculated on the original CT set. The magnitude of the shift was 0.5 mm, 1 mm and 1.5 mm in each direction, which corresponds to 1 mm, 2 mm and 3 mm of gantry isocenter diameter.To estimate the changes in dose distribution between the original and modified plans the following parameters were tracked: maximum dose in PTV ($D_{max(0.1cc)}$), PTV coverage (V_{95Rx}), conformity index (CI), gradient index (GI). In this study, organs located at a distance of 0 to 5 mm from PTV were assigned as organs at risk (OAR). The change of a point dose in OAR ($D_{0.035cc}$) was also tracked. For the second group of patients the parameter of V_{12Gy} of brain tissue was analyzed.



Results

The mean relative change of $D_{max(0.1cc)}$, V_{95Rx}, V_{12Gy} and GI was within -2.5% / +1% range for both techniques. The exception was the CI value for 1.5 mm shift where the difference increased up to -4.5% and -6% for non-coplanar and coplanar plans respectively. $D_{0.035cc}$ in OAR was changed within ±1% for 0.5 mm, ±2% for 1 mm, and ±3% for 1.5 mm shift. The results are shown in Fig2.



Changes of dosimetric parameters for coplanar (A) and non-coplanar (B) plans. Bars show ±1 standard deviation. Changes of $D_{0.035cc}$ in OARs for each individual patient and organ. Line is a mean value (C).

Conclusion

The results demonstrate that the detrimental effect on the dosimetry of gantry sag is overestimated in the