Results: The volumes of the single-cycle ITVs vary up to 20% around their mean. Averaged over all four datasets, the median CTV V95% for the ITV00, ITV25, ITV50, and ITV75 are 98.7%, 97.6%, 97.2%, and 94.3% respectively. In the same order, median D5-D95% are 9.4%, 10.1%, 10.6%, and 12.0%. The median ipsilateral mean lung doses are 14.8%, 13.8%, 13.2%, and 12.4%.
Conclusion: Breathing variations can have a significant impact on the ITV definition. Our probabilistic ITV definition can effectively account for variable motion, resulting in acceptable target coverage and substantial dose reduction to the involved lung. The ITV50 approach provided the best compromise between the two clinical objectives.

Quality assurance for the adaptive workflow on the MRI linac

Type: Physics

Presenting Author:
Lotte Wilke
Authors:
L. Wilke, S. Ehrbar, M. Bogowicz, J. Krayenbühl, N. Andratschke, M. Guckenberger, S. Tanadini-Lang

Institutions:
Universitätsspital Zürich
Department:
Klinik für Radio-Onkologie

Aims: The new MRidian MR Linac enables online adaptive treatment for daily changing anatomy of the patient. For these modulated treatments, no measurement of the treatment plan can be performed prior to treatment. Besides performing a secondary calculation within the system, we set up a chain of additional tests to ensure a safe treatment.
Methods: For all patients the original treatment plan as well as all adapted plans were measured on an IMRT verification phantom (Delta 4, Scandidos). During the adaptive process, we did a point dose verification in an independent Software (Radcalc). Additionally, we calculated a value that is representative of the integral dose delivered to the patient and compared this value to the original plan. To ensure that the electron densities are correctly assigned to the new MRI, we compared the equivalent pathlength of the original and the adapted plan.
Results: For the first 10 Patients, all measurements of the original plan passed the gamma-analysis with a 3%/3 mm criterion of on average 99.9% (range 99.6–100%). The adapted plans had equally good passing rates (average 99.8%, range 97.2–100%). For 89% of the plans the independent point dose calculation agreed within 10% with the original plan one (average 5.9%, range 0.3–21.4%). Values above 10% were connected to a lung treatment, where the scatter is incorrectly taken into account in the point dose calculation. The value representing the integral dose also agreed within 10% between the original plan and the treated adapted plan (average 4.0%, range 0.26–9.45%). The effective pathlength differed less than 2 cm from the original plan except for one case, where the change was traced back to a change in anatomy.
Conclusion: We set up a QA chain for the online adaptive planning on the MRIdian MR Linac which ensures a save treatment of the patient.

Influence of magnetic field transport parameters on accuracy and efficiency of electron transport in EGSnrc

Type: Physics

Presenting Author:
Gian Guyer
Authors:
G. Guyer[1], R. Kueng[1], W. Volken[1], M. F. M. Stampanoni[2], P. Manser[1], M. K. Fix[1]

Institutions:
[1]Inselspital, Bern University Hospital and University of Bern, [2]ETH Zürich and PSI, Villigen

Department:
[1]Division of Medical Radiation Physics and Department of Radiation Oncology, [2]Institute for Biomedical Engineering

Aims: In context of MR guided radiotherapy, accurate and efficient dose calculation and therefore describing the propagation of electrons in a magnetic field is essential. The aim is to quantify the influence of the EGSnrc magnetic field transport parameters on the electron transport in a magnetic field in a local spherical geometry and a macroscopic phantom.
Methods: The EGSnrc 2019 version provides two different macros for handling magnetic fields: the EMF macro and a novel enhanced EEMF macro. Both are applied to calculate the deflection angle of 15 MeV electrons in a sphere (3 mm radius) due to a perpendicular 1.5 T magnetic field in vacuum and water with varying maximal electron step size. The deflection angles are compared to theoretical calculations. Next, the same parameters are used to calculate the dose in a water phantom with a 1 cm air slab in 1 cm depth for a 15 MeV electron pencil beam with a magnetic field of 1.5 T perpendicular to the incident beam direction. The resulting dose distributions are investigated by comparing relative dose differences in the air slab.
Results: For the EMF, varying the step size shows substantial differences in the deflection angle with an error up to 19% compared to the theoretical calculation. The EEMF shows only differences of up to 0.2%. The EMF shows dose differences of up to 6% in air but only 0.3% for a small step size. For the EEMF, the dose differences in air are up to 0.2% for all step sizes. The EMF computation time is 30% faster than the EEMF for the same step size but increases exponentially with decreasing step size.
Conclusion: The novel EEMF shows more accurate results for electron transport in a magnetic field when compared to EMF with the same step size. Although EMF can yield as accurate results as EEMF with a small step size, due to efficiency, EEMF should be preferred over EMF.

Dynamic trajectory radiotherapy versus HyperArc: treatment plan comparisons for tumors in the brain

Type: Physics

Presenting Author:
Peter Manser
Authors:
P. Manser, S. Mueller, D. Frei, W. Volken, D. Terribilini, D. Frauchiger, A. Joosten, D. Henzen, E. Herrmann, D. M. Aebersold, M. K. Fix

Institutions:
Inselspital, Bern University Hospital, and University of Bern
Department:
Division of Medical Radiation Physics

Purpose: HyperArc applies a pre-defined set of non-coplanar arcs for treatments of brain tumors, while dynamic trajectory radiotherapy (DTRT) additionally includes dynamic couch and collimator rotations during beam on to increase degrees of freedom for the selection of beam directions. The aim of this work is to investigate the potential benefit of DTRT compared to HyperArc for brain tumors.
Materials & methods: Five clinically motivated brain cases are included in this study. The target volumes range from 3 to 270 cm^3 and are located at different areas in the brain with according organs at risk (OARs). A framework utilizing the Eclipse Scripting Research API was used to determine gantry-table and gantry-collimator paths based on contoured structures. These paths served as input for the multi-leaf sequence optimization using a research version of the VMAT optimization algorithm in Eclipse. Additionally, a HyperArc treatment plan was generated for each of the five cases. Resulting dose distributions for DTRT and HyperArc plans were compared based on DVH parameters. The deliverability of DTRT dose distributions was confirmed by gafchromic film measurements.

Results: Comparing DVHs for the target shows that coverage is similar for all brain cases. On average over all five cases mean doses for parallel OARs and near maximum doses for serial OARs improved for DTRT treatment plans by 5.5% and 5.0% relative to the prescribed dose, respectively. Measured and calculated doses show a gamma passing rate >99.5% for 2%/2 mm criteria and a threshold of 10%.
Conclusions: Depending on the case and on the OAR considered, the DTRT treatment plan generally performs better or similar compared to the HyperArc plan. The results demonstrate that DTRT has a great potential to reduce dose to OARs, while target coverage is preserved compared to HyperArc. This work was supported by Varian Medical Systems.

A lean but still robust plan quality assurance program for stereotactic radiotherapy. Our experience with a redundant workflow

Type: Physics

Presenting Author:
Enrico Barletta
Authors:
E. Barletta[1,2], H. Haerle[1], A. Clivio[2], O. Sommer[1], H. Nguyen[2], C. Negreanu[1]

Institutions:
[1]Kantonsspital Winterthur, [2]Rüti Zürich-Ost-Linth AG, Rüti ZH
Department:
[1]Department of Radiation Oncology, [2]Zentrum für Radiotherapie

Aims: Stereotactic treatments are an established treatment concept in Radiotherapy (RT). In recent years, the application of this technique has expanded substantially. This is mainly due to the development of the Image Guided RT (IGRT) techniques, which allow for a secure administration in organs not considered in the past for stereotactic RT, because of lack of positioning precision.

With the widening of the application field, the new arising challenge is to speed up the Plan Quality Assurance (QA) procedures without reducing safety. Film Dosimetry is still nowadays the gold standard for Plan QA in this field, but it is time-consuming and error prone.

The aim of this work is to compare different stereotactic RT QA methods with respect of precision and time optimization.
Methods: Ten stereotactic RT plans were retrospectively verified with five different methods, namely: Film Dosimetry (FD), Portal Dosimetry (EPID), dose verification by ionization chamber in a solid phantom, PTW Octavius 4D SRS (O4D) and Varian Mobius 3D offline recalculation. The results were analyzed in terms of precision and time requirements.
Results: Using FD as a benchmark, the comparison of the different QA techniques shows substantial agreement in the results, in particular for the O4D Phantom. The O4D results, strengthened by the other faster verification measurements, offer the same level of robustness in accepting or rejecting a stereotactic RT plan as with FD.
Conclusion: This study highlights the possibility of carrying out lean Plan QA verification procedures without a loss of accuracy. Performing redundant measurements increases the time of raw measurements, but allows to substantially shortening the total waiting time before accepting or rejecting a stereotactic RT plan in comparison with FD.

Extended EPID commissioning for reliable plan verification of volumes well below 1cc

Type: Physics

Presenting Author:
Anisoara Socoliuc Toquant
Authors:
A. Socoliuc Toquant, K. Buchauer, H. Schiefer, L. Plasswilm

Institutions:
Kantonsspital St. Gallen
Department:
Klinik für Radio-Onkologie

Aims: Among different methods for patient QA, one practical approach is the accelerator's EPID. Purpose of this work is to extend the 3 cm commissioned size to stereotactic volumes well below 1cc and demonstrate the clinical usefulness.
Methods: Portal Dosimetry commissioning data were acquired on 6FFF and 10FFF STX True Beams for static fields between 40×40 and 1×1 cm. This includes the generation of a relative output factor table (OF) of the mean central pixel value determined during EPID irradiation. Extra- and intracranial stereotactic complex VMAT plans with target volumes between 0.15 and 13 cc (collimation range 0.6–3 cm) were verified before and after the OF adjustment. The output factors were adjusted to bring measurement and prediction to agreement. Correlations between parameters specific to dynamic plan delivery and dosimetric QA results were under investigation.
Results: For field sizes below 3×3 cm large differences between calculated PDIP and measured EPID fluences are noticed. Surprisingly, 10FFF showed less pronounced dosimetric disagreements compared to 6FFF, where for fields of 1×1 cm the discrepancy was up to 36%. With the modifications of output factors the fluence differences from prediction to measurement went well below 0.5%. A net average increase in gamma passing rate, for 3%–1 mm evaluation criteria, from 95.7 to 98% was obtained. As comparison, film-based plan verification lead to an average gamma-passing rate of 99.1% for a subset of SRS cases. Despite different modulation complexity scores, leaf and jaw opening statistics for the intracranial stereotactic plans, a clear correlation to the plan gamma-passing rate could not be established. In contrast, lung stereotactic plans showed correlation that is more pronounced.
Conclusion: Adjustment of the EPID prediction algorithm allows patient QA also for plans with effective field sizes below 1×1 cm. The verification results are on par with other verification methods used in our clinic.

Results of a feed-back learning process for RapidPlan knowledge based planning

Type: Physics

Presenting Author:
Antonella Fogliata
Authors:
Fogliata A.[1], Cozzi L.[1,2], Reggiori G.[1], Stravato A.[1], Lobefalo F.[1], Franzese C.[1], Scorsetti M.[1,2]

Institutions:
[1]Humanitas Research Hospital and Cancer Center, Milan, Italy, [2]Humanitas University, Milan, Italy
Department:
[1]Radio-oncology

Aim: The knowledge based planning KBP capability to harmonize plan quality depends on the quality of the model, configured with selected plans and defined optimization objectives to estimate the DVH for organs at risk. This work will determine if the performance of a KBP model (RapidPlan, Varian, RP) could be improved with a feedback learning process, i.e. if plans generated by a RP model could be used as new input to re-train the model and achieve better performances.
Methods: Clinical VMAT plans from 83 patients presenting head and neck cancer were selected to train a RP model, RP-1. The same 83 patients were re-planned using the RP-1 model; the resulting plans were used as input to train a novel model, RP-2. The same optimization objectives were selected in the two models. The models quality was assessed through: the coefficient of determination R^2, describing how