CT based lymph nodes radiomics to predict 12-months event-free survival in stage IIIA NSCLC; SAKK 16/00

Type: Physics

Presenting Author:
Diem Vuong
Authors:
D. Vuong[1], M. Bogowicz[1], S. Denzler[1], C. Oliveira[1,2], R. Foerster[1], F. Amstutz[1], H. S. Gabryś[1], J. Unkelbach[1], S. Hillinger[3], S. Thierstein[4], L. Basler[1], E. Eboulet[4], S. Peters[5], M. Pless[6], M. Guckenberger[1], S. Tanadini-Lang[1]

Institutions:
[1,3]University Hospital Zurich, [2]Queen's University, Kingston, Ontario, [4]Swiss Group for Clinical Cancer Research (SAKK) Coordinating Center, Bern, [5]Centre Hospitalier Universitaire Vaudois, Lausanne, [6]Kantonsspital Winterthur
Department:
[1]Department of Radiation Oncology, [2]Department of Oncology, Cancer Center of Southeastern Ontario, [3]Department of Thoracic Surgery, [5]Department of Oncology, [6]Department of Medical Oncology

Aims: Radiomics is a growing research field but is often limited to single institution imaging data. The sensitivity of radiomics features to e. g. scanning settings present in multi-centric imaging data is disadvanteous for robust radiomic models. We built a robust CT lymph nodes radiomics model to predict 12-months event-free survival (EFS) trained on a multi-centric imaging dataset and validated it on an external homogeneous dataset.
Methods: 74 NSCLC patients were selected from a Swiss multi-centric prospective randomized phase 3 trial (IIIA/N2, SAKK-16/00,neo-adj. radio/chemoradiotherapy prior surgery, 14 sites). Patients received CT scans with similar imaging protocol (non-contrast, FBP,standard kernel). ROI was a combined lymph nodes structure. 1404 radiomic features were fed into a principal component analysis. Surrogate features representing 95% data variance were included in a 12-months logistic regression using LASSO. 5-fold cross validation was used to study the performance. The final model was validated on a separate internal dataset ($n=32$, IIIA/N2/IIIB). Performance measure was area under the roc curve (AUC).
Results: The final model (3 features) had a performance of AUC = 0.722(95%CI = 0.60–0.84) and 0.78(0.59–0.97) for training and validation, resp.
Conclusion: A 12-months EFS CT radiomics model from combined lymph nodes structure was built for NSCLC patients. This model could be validated on homogeneous single-institution data with good performance.

Efficiency and safety improvements for proton treatment plan QA by automation

Type: Physics

Presenting Author:
Till Böhlen
Authors:
Böhlen TT[1], Rosas S[1], Lowe M[2], Bizzocchi N[1], Lomax AJ[1], Weber DC[1], Hrbacek J[1]

Institutions:
[1]Paul Scherrer Institut, Villigen, [2]University of Manchester
Department:
[1]Centre for Protontherapy

Background: Meticulous treatment planning QA is essential to deliver safe and high-quality proton treatments. Repetitive and extensive plan QA binds significant amounts of resources in clinical routine and is prone to human error. This work presents and evaluates tools developed at our clinic to extend, automatize and standardize the physicists' and clinicians' plan review.
Method & materials: Using the scripting capabilities of the commercial TPS Eclipse™ (Varian), two plugins for plan QA were developed. A Plan Checker plugin verifies parameters and properties of plans. The comprehensive checks cover the planning CT, the structure set, and the plan itself and generate more than 150 different colour-coded messages which are classified according to their severity (INFO, PASSED, TO CHECK, WARNING, ERROR). Checks encompass amongst others: correct labelling (e. g. switching of left and right of organs), plan approval by authorized personnel, correct patient orientation, correct field tolerance tables, reasonable air gaps, HU overrides, plan and beam model parameters, the degree of field modulation, normalization, plan and field maxima and their positions, etc. A second tool evaluates clinical objectives for a given plan or plan sum and indicates by colour-coding if they are met. It allows for easy template generation and can obtain data from the clinicians' prescription. Plan uncertainty can be additionally evaluated.
Results: Both tools extend and standardize the clinically performed plan checks while leading to a considerable time-reduction when performing the physicists' and clinicians' plan review. At the same time they lead to a reduction of repetitive, human error-prone work in clinical routine.
Conclusions: TPS plugins which automatize parts of the plan QA allow to create flexible plan checks and can be tailored to institutional needs and practices. They can contribute to increase safety, standardization and efficiency for proton therapy treatment planning.

Development of an in-house VMAT treatment planning

Type: Physics

Presenting Author:
Alisha Dütschler
Authors:
A. Duetschler[1], S. Mueller[1], P. Manser[1], D. M. Aebersold[1], M. F. M. Stampanoni[2], M. K. Fix[1]

Institutions:
[1]Division of Medical Radiation Physics and Department of Radiation Oncology, Inselspital, Bern University Hospital, and University of Bern, [2]Institute for Biomedical Engineering, ETH Zürich and PSI, Villigen
Department:
Division of Medical Radiation Physics

Aims: Volumetric modulated arc therapy (VMAT) is the current state-of-the-art treatment technique for radiotherapy. Commercial optimizers are used to generate clinical VMAT plans, however, their implementation provides a limited flexibility for the user. In order to overcome this limitation, a new treatment planning process (TPP) was developed.
Methods: The in-house developed TPP is based on Monte Carlo calculated beamlet dose distributions. A hybrid column generation and simulated annealing based direct aperture algorithm (HDAO) directly optimizes the MLC leaf positions and monitor units of discrete control points describing the arcs for VMAT. Deliverable VMAT plans for an academic situation and a clinically motivated bladder, head and neck and prostate case were generated with the new TPP and compared to plans optimized with the commercial Eclipse photon optimizer (version 13.6).
Results: The HDAO plan for the academic situation showed a decrease in mean dose by 19.1% for the single OAR and a decrease in the PTV homogeneity of 3.0% when compared to the Eclipse plan. The PTV coverage, the maximal dose to serial OARs and the dose to normal tissue are similar for the HDAO and Eclipse plans for the clinically motivated cases. However, the mean dose in parallel OARs is on average 8.6% smaller for HDAO plans compared to Eclipse plans. The delivery time for HDAO and Eclipse optimized plans is equal.

Conclusion: A TPP was successfully developed for deliverable VMAT plans. Comparisons with Eclipse optimized plans suggest similar plan quality with some benefits for parallel OARs for the investigated cases. The flexible and new TPP allows the implementation of further functionalities in future projects.

This work was supported by Varian Medical Systems.

End to end dosimetric and geometric accuracy of a magnetic resonance guided linear accelerator

Type: Physics

Presenting Author:
Luisa Sabrina Stark
Authors:
L. S. Stark, M. Baumgartel, S. Ehrbar, J. Krayenbühl, M. Zamburlini, M. Chamberlain, N. Andratschke, M. Guckenberger, L. Wilke and S. Tanadini-Lang

Institutions:
University Hospital Zurich
Department:
Radio oncology

Purpose: Magnetic resonance guided linear accelerators (MR-Linac) allow for online imaging during the treatment and enable gating on the tumor position. To assess the overall dosimetric and geometric accuracy of the MRIdian MR-Linac (Viewray), end-to-end tests with three different phantoms were performed for static and moving targets.
Methods and materials: Six different treatment plans were measured in the static inhomogeneous thorax phantom (CIRS) using a Farmer chamber. Radio chromic film measurements were performed in the Lucy 3D QA phantom (Standard Imaging) for an IMRT plan with 11 fields. The gating performance of the MR-Linac was evaluated in the longitudinal direction in the dynamic thorax phantom (CIRS) using a 10-field IMRT plan. Stripes of radio chromic films were inserted into a target rod moving longitudinally with an amplitude of 15 mm within a body-like support structure. The gross tumor volume (GTV) was enlarged by 3 mm to define the gating window.
Results: Mean dose deviation in the CIRS phantom was 0.7%±0.4% compared to the planning system. The accuracy was equally good in water, lung and bone tissue surrogate. For static treatments the gamma evaluation of films in the Lucy phantom was repeated showing passing rates of 97% and 98.5% for a 5%/1 mm criteria and a passing rate of 100% for a 5%/1.5 mm criteria. The gated dose distribution showed a longitudinal offset of 1 mm relative to the static treatment and an offset of 1.5 mm compared to the planned dose distribution. The measured dose maximum was 2% lower in the gated treatment compared to the static treatment and 4% lower than the planned dose.
Conclusion: The MRIdian showed a high geometric and dosimetric accuracy which allows for precise stereotactic body treatments and accurate gating for moving targets.

Modeling and measuring clinical electron beams in magnetic fields: investigating the potential of future MR-guided electron therapy

Type: Physics

Presenting Author:
Reto Kueng
Authors:
R. Kueng[1], B. M. Oborn[2,3], N. Roberts[2], T. Causer[2], S. Mueller[1], M. F. M. Stampanoni[4], P. Manser[1], P. J. Keall[4], M. K. Fix[1]

Institutions:
[1]Inselspital, Bern University Hospital, and University of Bern, [2,3]University of Wollongong, Wollongong NSW, [4]University of Zurich and Swiss Federal Institute of Technology (ETH), Zurich, [5]Sydney Medical School, University of Sydney

Department:
[1]Division of Medical Radiation Physics and Department of Radiation Oncology, [2]Centre for Medical Radiation Physics, [3]Illawarra Cancer Care Centre, [4]Institute for Biomedical Engineering, [5]ACRF Image X Institute

Aims: Future integrated MR guided radiotherapy systems might profit from the availability of an electron beam mode. The aim is to model and experimentally confirm the dosimetric impact of magnetic fields on clinical electron beams for different beam energies, magnetic field strengths including two relative orientations in a water equivalent phantom.
Methods: A multiple source Monte Carlo (MC) beam model was commissioned for a Varian Clinac 2100 C linear accelerator and applied to simulate the particle transport including a magnetic field with the Geant4 MC toolkit. A permanent magnet device was used to generate a strong magnetic field up to 0.7 T encompassing a solid water phantom. Gafchromic EBT3 film was placed in the phantom for dose measurements of 6, 12 and 20 MeV electron beams in a perpendicular and parallel magnetic field orientation and a zero magnetic field reference setup.
Results: Film data confirmed MC predictions of substantial deflection of the electron beam in a perpendicular magnetic field due to the Lorentz force for all three initial energies compared to reference measurements. For a parallel magnetic field, a dose enhancement up to 100% (6 MeV beam, 0 vs. 0.7 T magnetic field) was observed in the dose profiles at different depths in the phantom.
Conclusions: An experimental and corresponding in-silico framework to measure and simulate clinical electron beams in magnetic fields of different strengths and relative orientations was established and successfully tested.

Implications of respiratory motion variability for the ITV approach in PBS proton therapy

Type: Physics

Presenting Author:
Miriam Krieger
Authors:
Miriam Krieger[1,2], Alina Giger[3], Damien C Weber[1,4,5], Tony Lomax[1,2], Ye Zhang[1]

Institutions:
[1]Paul Scherrer Institute, [2]ETH Zürich, [3]University of Basel, [4]University Hospital Zürich, [5]Inselspital Bern
Department:
[1]Centre for Proton Therapy, [2]Department of Physics, [3]Center for medical Image Analysis & Navigation, [4]Department of Radiation Oncology, [5]Department of Radiation Oncology

Introduction: Motion management is a key component for pencil beam scanned (PBS) proton therapy. Currently, treatment planning and target definition for mobile tumours are still based on a single 4DCT without considering variable breathing. We aim in this analysis to assess the dosimetric impacts of motion variability, and propose a probabilistic ITV definition to account for respiratory variabilities.
Methods: CTs from two lung patients were warped using deformation vectors extracted from 4DMRI datasets of two volunteers, resulting in four pseudo-4DCT datasets covering 40 breathing cycles each. A percentage map was defined by overlaying the first 20 single-cycle ITVs. Threshold percentages (x = 0%, 25%, 50%, or 75%) were selected to define probabilistic ITVx).

Two-field PBS proton treatment plans were optimised on the four ITVs, and 4D dose distributions were calculated using the second 20 breathing cycles. In order to minimise the influence of interplay effect, 9 × volumetric rescanning was applied.