Conclusion: We can improve treatment-plan quality for lung SBRT treatments by providing the planner with a quality parameter associated with the dose gradient around the PTV. This index does not depend on GTV volume and position and is suited to compare all patients treated for SBRT without making corrections for size and position of the tumor and is suitable for multiple tumors.

OC-0464
Integration of fMRI and MEG functional maps into a Cyberknife planning system: a feasibility study
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Purpose or Objective: In recent years Magnetoencephalography (MEG) and Functional Magnetic Resonance Imaging (fMRI) have imposed as non-invasive methods providing localization of eloquent brain areas for pre-surgical planning. With the advent of radiosurgery, the impact of these neuroimaging techniques in preventing neurological morbidity is under investigation in the clinical conditions for which radiotherapy is the treatment of choice. This study aimed to develop a method of integrating MEG and fMRI maps into a Cyberknife system to optimize dose planning.

Material and Methods: A patient with a recurrent brain metastasis affecting both the left pre-central and the post-central gyrus underwent functional imaging of the hand motor cortex two weeks prior its scheduled radiosurgery treatment. MEG data were acquired with a 306 sensors whole-head system while the patient performed self-paced motor activation of right hand and index finger. Epochs were extracted in the window ranging from -3 to +3 seconds with respect to the movement onset and then averaged. Source of the motor-related activity was assessed by means of swLORETA algorithm. A day after MEG acquisition, fMRI was performed using a 3T MR Philips Achieva scanner. Motor activation of right hand and index finger was obtained through a block designed paradigm. Stimulation modality and duration both for MEG and fMRI were chosen to maximize time course signal to noise ratio. Magnetoencephalography and fMRI maps were integrated into a Cyberknife system for treatment planning optimization, considering the boolean sum of activations as organ at risk.

Results: Localization of the hand motor cortex was obtained for both functional investigation methods within close proximity of the lesion. Integration of the fMRI data into the Cyberknife system was easily achieved through the customary Cyberknife import protocol. More problematic was the integration of the MEG images, and for the purpose a customized Dicom import software had to be developed.

Conclusion: Nowadays, the availability of advanced neuroimaging techniques is playing a more and more important role in radiosurgical planning strategy. The authors developed an effective method to co-register fMRI and MEG data sets in a Cyberknife treatment planning system. This additional information can improve dose sparing of eloquent areas, and MEG information in particular might be valuable when BOLD effect is disturbed by pathological vascularization.

OC-0465
Quality of treatment plans in hybrid IMRT and VMAT for prostate radiotherapy
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Purpose or Objective: The strong directional characteristics of step-and-shoot IMRT beams, and the ability to turn off the beam between segments, may be used to advantage when avoiding critical structures. Consequently, there may be a benefit in delivering selected parts of VMAT plans using IMRT beams. This study investigates such a hybrid approach for the case of prostate radiotherapy.

Material and Methods: Five prostate patients were retrospectively studied. The AutoBeam treatment planning system produced hybrid IMRT / VMAT plans with a prescribed mean dose of 74 Gy in 37 fractions to the smallest of three target volumes, PtV74Gy, PtV71Gy and PtV60Gy. Inverse planning consisted of fluence optimisation using iterative least squares, sequencing, and aperturre optimisation. The plans consisted of a single 220° arc with 111 segments arranged in groups of 20°. For each patient, five hybrid IMRT / VMAT plans were constructed, with 0%, 25%, 50%, 75% and 100% of the segment groups sequenced for IMRT, respectively, and the remainder of the segment groups sequenced for VMAT, maintaining the same number of beam segments in all cases. Thus, 0% IMRT corresponded to conventional VMAT and 100% IMRT corresponded to an 11-beam IMRT plan. IMRT groups were selected on the basis of fluence variation in each group, the most complex fluence maps being selected for IMRT delivery at the central gantry angle of the group. Treatment plans were evaluated in terms of PTV dose uniformity (root-mean-square variation) and coverage, critical structure dose, objective value and benchmark and performance validation.

Results: All plans are clinically acceptable, but increasing the IMRT percentage improves PTV coverage (p < 0.01 for 50% or more), reduces the volume of rectum irradiated to 65 Gy (p < 0.01) and increases the monitor units needed (p < 0.001) (Table 1). Delivery time also increases substantially, which is clinically relevant due to prostate motion being partly dependent on treatment time. All plans show accurate delivery of dose.

Conclusion: Hybrid IMRT / VMAT can be efficiently planned and delivered as a single beam sequence. Beyond 25% IMRT, the delivery time becomes unacceptably long, outweighing the benefit of the improved plan quality, but 25% IMRT is an attractive compromise. These hybrid plans can be accurately delivered.

OC-0466
Dynamic Wave Arc: initial characterisation, dosimetric benchmark and performance validation
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Purpose or Objective: Dynamic Wave Arc (DWA) is a clinical approach designed to maximize the versatility of Vero SBRT system by synchronizing the gantry-ring noncoplanar movement with D-MLC optimization. The purpose of this study was to verify the delivery accuracy of DWA approach for SBRT treatments and to evaluate the potential dosimetric benefits.

Material and Methods: A preclinical version of RayStation v4.7 (RaySearch Laboratories, Sweden) was used to create patient specific wave arc trajectories. DWA is an extended form of VMAT with a continuous varying ring position. The main difference in the optimization modules of VMAT and DWA is during the angular spacing, where the DWA algorithm does not consider the gantry spacing, but only the Euclidian norm of the ring and gantry angle that cannot exceed 4°. Thirty-one patients with various anatomical tumor regions were selected from the Vero patient database. It was decided to select some pathologies with a high incidence (prostate and oligometastases) and some more challenging cases from the perspective of organ-at-risk sparing i.e. centrally-located small-cell lung cancer (NSCLC) tumors and locally-advanced pancreatic cancer (LAPC). DWA was benchmarked against the current clinical approaches and co-planar VMAT to establish the clinical importance of DWA among other treatment approaches. Each plan was evaluated with regards to the target coverage, dose to OAR, MU efficiency and treatment delivery time. The delivery accuracy was evaluated using the Delta4 2D diode array that takes in consideration the multi-dimensionality of DWA.

Results: For prostate and oligometastases, the results showed that all modalities provide comparable plan quality, with no significant difference for PTV coverage or OAR sparing, but with a steeper dose gradient outside the target for DWA. The delivery time per lesion was significant reduced with DWA (Table 1). For centrally-located NSCLC (Figure 1), DWA and VMAT increased target coverage and conformity. The structures that significantly benefited from using DWA were proximal bronchus (Dmax 24.72Gy, 20.57Gy and 22.7Gy) and esophagus (16.6Gy, 12.57Gy and 14.76Gy) for 8-10CRT beams, DWA and VMAT, respectively. The other OARs presented comparable values. In the LAPC cases, DWA achieved similar PTV coverage, along with a significantly improved GTV coverage and improved low dose spillage (p<0.01). The delivery time and the number of MU needed to deliver the dose were significantly lower for DWA versus IMRT. The DWA plans presented a good agreement between measured and calculated dose, with an mean γ (3%,3mm) passing rate of 98.17%, 98.72%, 99.2% and 98.1% for the prostate, oligometastatic cases, centrally-located NSCLC and LAPC, respectively.

Conclusion: Hybrid IMRT / VMAT can be efficiently planned and delivered as a single beam sequence. Beyond 25% IMRT, the delivery time becomes unacceptably long, outweighing the benefit of the improved plan quality, but 25% IMRT is an attractive compromise. These hybrid plans can be accurately delivered.