Figure shows the absolute change in the D_{mean} for the anal sphincter (left y-axis) and relative change in the V_{64Gy} for the rectal wall (right y-axis) expressed as a function of the relative increase in the homogeneity index *HI* of the dose distribution in the PTV.
Conclusions: By increasing the inhomogeneity of the targeted dose to the PTV in prostate RT plans the dose delivered to the rectal wall and anal sphincter, as measured by respectively the clinical relevant parameters V_{64Gy} and D_{mean}, can be reduced considerably.

ELECTRONIC POSTER: PHYSICS TRACK: TREATMENT PLAN OPTIMISATION

EP-1228

Advantages and limitations of multi-criteria optimization (MCO) for prostate IMRT planning.

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Purpose/Objective: To validate multi-criteria optimization (MCO) in RayStation (v2.4, RaySearch Laboratories, Stockholm, Sweden) against standard intensity modulated radiation therapy (IMRT) optimization in Oncentra (v4.1, Nucletron BV, Veenendal, the Netherlands) and to characterise dose differences due to conversion of navigated MCO plans into deliverable leaf apertures.
Materials and Methods: Step and shoot radiotherapy treatment plans were created for ten prostate cancer patients using either standard IMRT optimization or MCO. Pareto fronts of average rectal dose versus target homogeneity were computed for each patient case and planning technique. The standard IMRT plans were generated by direct step and shoot optimization. The weight for the rectum objective was incrementally altered to trade this criterion against homogeneity. The corresponding trade-off for the MCO plans managed through a user interface that permits continuous navigation between plans optimized with respect to fluence. Navigated plans were made deliverable at incremental steps along a trajectory between maximal homogeneity and maximal rectal sparing and exported to Oncentra where final dose was re-calculated. Plan quality was assessed by comparison of the clinically acceptable plan with minimal rectal dose generated by each planning technique. Dosimetric differences between navigated and deliverable MCO plans were also quantified.
Results: MCO planning for all patient cases resulted in improved rectal sparing and superior target homogeneity compared to standard IMRT optimization. The improvements were, however, to some extent at the expense of less conformal dose distributions. The dose deviations due to conversion of the navigated to deliverable MCO plans increased as higher priority was placed on rectal avoidance. Discrepancies between final dose calculated by collapsed cone in RayStation and pencil beam in Oncentra were quantified and found to be minimal.
Conclusions: Similar or better IMRT plans can be created for prostate cancer patients using MCO compared to standard IMRT optimization. Limitations exist within MCO regarding conversion of navigated plans to deliverable apertures, particularly for plans that emphasize avoidance of critical structures.

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Energy-minimization vs. dose-volume inverse optimization: a phantom study.

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Purpose/Objective: Radiation dose is defined as energy deposited per unit mass (Gy = J/kg). If dose is multiplied by mass on a voxel-by-voxel basis, and a summation over all voxels within a volume of interest (VOI) is performed, then the total energy imparted on that VOI would be obtained. Energy minimization approaches are commonly used in the solution of many physics problems. However, little attention has been paid to this fundamental approach for treatment plan optimization in radiotherapy. Here we present a framework for IMRT optimization based on total energy minimization, and make comparisons to the 'standard of care', realized through dose-volume-histogram-based (DVH)optimization.
Materials and Methods: A DVH-based quadratic objective function is compared to a total energy minimization objective function. using a digital phantom-patient.The phantom is built from four 10x10x10 cm^3 cubical volumes of interest (VOIs). The central VOI has a density of 1.0 g/cm^3 and includes a cylindrical (3 cm in diameter, 3 cm in length) target (PTV). The other three VOIs form (on top and two sides of the central cube) an organ at risk (OAR) with three different densities: 0.8 ($OAR_{0.8}$), 0.2 ($OAR_{0.2}$),and 0.5 ($OAR_{0.5}$) g/cm^3. Two sets of deliverable plans are generated with DVH- and energy-based optimization schemes: a) a 2-beam plan with 2 IMRT segments, and b) a 3-beam plan with 3 IMRT segments. In the 2-beam plan the PTV is irradiated with an AP beam through $OAR_{0.8}$ and an orthogonal beam through $OAR_{0.2}$. In the 3-beam plan an additional orthogonal beam through $OAR_{0.5}$ is added. DVH and energy optimizations were performed for both sets of plans, aiming to deliver a 100 cGy to 95% of the PTV, while minimizing the dose to the OAR as much as possible.
Results: The mean, the integral, and the coverage doses, as well as the MUs to the OAR and the PTV from DVH- and energy-optimized 2- and 3-beam plans are summarized in the table below. For comparable PTV coverage,the energy optimized plan in the 2-beam case results in lower OAR dose by 8.6%,while the deposited energy to the OAR is lower by 18.5%. Similarly, in the 3-beam scenario the energy optimized plan results in mean and integral dose reduction to the OAR by 9.8% and 26% respectively. The plan MUs in the 2- and 3-beam scenarios differ by less than 2%.

	2-beam/2-segment plan ($OAR_{0.8}$ + $OAR_{0.2}$)		3-beam/3-segment plan ($OAR_{0.8}$ + $OAR_{0.2}$ + $OAR_{0.5}$)	
	DVH	**Energy**	**DVH**	**Energy**
PTV D_{95} [cGy]	100	100	100	100
Mean Dose OAR [cGy]	11.4	10.5	10.1	9.2
Integral Dose OAR [J]	0.109	0.092	0.155	0.123
MUs	153	156	161	159

Conclusions: In a heterogeneous media total energy minimization and DVH-based inverse optimization differ for the simplest setup of 2 and 3 orthogonal beam IMRT plans, with 2 and 3 segments respectively. The reported findings are for IMRT plans, where the fluence maps are converted to MLC step-and-shoot leaf trajectories, and therefore the computed doses are from actual deliverable plans. For an equivalent PTV coverage the average doses to surrounding critical structures, intended to be spared, are lower by almost~10% with energy optimization. Energy optimization resulted in even more dramatic reduction of the integral dose in excess of 20%.

EP-1230

Optimizing HDR brachytherapy dose distributions with respect to dosimetric indices and homogenei

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Purpose/Objective: Recent research has shown that the optimization model hitherto used in HDR brachytherapy correspond weakly to the dosimetric indices used to evaluate the quality of a dose distribution. Alternative models that include such dosimetric indices explicitly have been presented; however including the dosimetric indices explicitly yields intractable models that cannot be solved to optimality. We will present an alternative approach.
Materials and Methods: We use surrogates to the dosimetric indices based on applying the concept of conditional value-at-risk to the dose-volume-histogram (DVH), instead of the exact indices. This yields a linear model that is easy to solve to optimality, and where constraints are easy to interpret and modify to obtain satisfactory dose distributions.
Results: We show by experimental comparisons that our proposed model corresponds well with the dosimetric indices and that the quality of generated dose distributions is equivalent to those generated by the standard model.
Conclusions: Our proposed model is a viable surrogate to optimizing dosimetric indices that quickly and easily yields high quality dose distributions and is more intuitive and easier to steer for the phycisist than current penality based models

EP-1231

Assessment of the robustness of volumetric modulated arc therapy for lung radiotherapy