

Purpose: To introduce a hybrid VMAT/IMRT optimization strategy that combines the delivery efficiency of VMAT with the superior intensity modulation possible with IMRT.

Methods: A beamlet-based inverse planning system was enhanced to combine the advantages of VMAT and IMRT into one comprehensive system. In the hybrid system, IMRT plans are created with many beams and optimized to convergence, taking note of the beam intensity map variation (BIMV) at each angle. Second, all beams are converted to VMAT segments and optimized for a set number of cycles. Then, the previous BIMV values and current cost function gradients with respect to the beamlets are used to define a gradient modulation factor (GMF). Beams with the highest GMF are converted from segments to beamlets and optimization proceeds with the mixed variable set until convergence or until additional beams are selected for conversion. This strategy was characterized on phantom and clinical cases. Comparisons were made between the hybrid plans, standard IMRT plans, and VMAT plans.

Results: In a simple phantom, a hybrid VMAT/IMRT plan with 3 converted beams achieved superior dosimetric quality and required 30% fewer MU compared to 7-beam IMRT. The hybrid plan also had a 20% reduction in final cost compared to VMAT. In a pancreas case, a 3 converted beam hybrid plan had improved and equivalent dosimetric quality compared to VMAT and 7-beam IMRT, respectively. The hybrid and VMAT plans were more delivery efficient than IMRT.

Conclusion: A hybrid VMAT/IMRT strategy was implemented to find the best compromise between gantry-angle and intensity-based degrees of freedom. This optimization method will allow patients to be simultaneously planned for dosimetric quality and delivery efficiency without switching between delivery techniques. Phantom and clinical examples suggest that the conversion of only 3 VMAT segments to modulated beams results in a good combination of quality and efficiency.

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