AbstractID: 5574 Title: Incorporation of modulation range constraints into a gradient search algorithm for IMRT optimization

Purpose: Hardware-sensitive optimization for IMRT results in more conformal dose distributions; however, most planning systems neglect hardware constraints, most likely due to the complexity of incorporating them into gradient search algorithms. An important limitation of delivery systems is the modulation range, which we demonstrate can be incorporated as a hard constraint into gradient search algorithms.

Method and Materials: We used a commercial treatment planning system (TPS) for calculation of dose-deposition coefficients, which were exported to optimization software that we developed. For a beam j comprised of beamlets i, we reformulated the optimization problem such that the fluence of beamlet i, ϕ_i, is the product of the weight of beam j and the transmission of beamlet i, $\phi_i = w_j t_i$. A gradient search algorithm determined the optimal values of w_j and t_i subject to the constraints $w_j \geq 0$ and $T_{minimum} \leq t_i \leq 1$. The resulting fluence distributions were exported back to the TPS for MLC leaf sequencing and dose calculation. We applied the method to a phantom simulating head and neck re-irradiation, a situation that requires very low fluence values to protect the spinal cord. Using the same cost function parameters, we varied the minimum transmission constraint. After optimization, leaf sequences for dynamic MLC delivery were determined and the dose calculated. All plans were normalized such that 95% of the target received the prescription dose.

Results: Target mean and maximum doses were essentially identical for all transmission constraint values. The maximum spinal cord dose was 33% of the prescription dose for no transmission constraint. The minimum value, 30.8%, occurred for an 8% transmission constraint.

Conclusion: Modulation constraint is a good approximation of hardware transmission limits and could be readily incorporated into existing TPSs. Furthermore, initial results suggest that transmission constraint beyond the intrinsic hardware limitation may be beneficial.