Purpose: Use of inverse planning to improve conformal treatment plan quality has concentrated on optimization of beamlet-based IMRT plans. The few direct aperture-based optimization methods are all based on optimizing a beamlet-based plan, followed by sequencing which identifies the many apertures to be optimized. In contrast, direct segment optimization (DSO), described here, directly optimizes conformal and few-segment plans using inverse planning. This work compares DSO-optimized plans versus beamlet IMRT and forward-planned 3DCRT plans for a series of clinical sites.

Methods: Our in-house beamlet-based inverse planning system has been enhanced to support DSO with an improved and reimplemented perturbational version of the Edge/Octree calculation algorithm and a multi-layer search strategy. DSO optimizes MLC segment shapes, weights and/or jaw positions for multiple field plans (including VMAT). In our inverse planning infrastructure, beamlet, multi-segment and conformal plans can all be optimized using the same cost functions, dose points, and plan evaluation metrics, making quantitative comparisons between techniques straightforward. Inverse planned DSO 3DCRT plans are compared to forward planned 3DCRT and beamlet IMRT plans for brain, liver, lung, and other sites.

Results: For many tested patient geometries, DSO achieves equivalent plan quality to the beamlet IMRT plan optimized with the same cost function, though there are certain situations where IMRT is expected to (and does) perform better. The DSO plans use significantly fewer MU, require less treatment time, are less sensitive to motion, and do not require pre-treatment IMRT QA checks, so they may be significantly easier to implement in the clinic.

Conclusions: Optimization of 3DCRT and multi-segment plans using DSO results in plan evaluation metrics virtually equivalent to beamlet IMRT plans optimized with the same cost function and beam directions, for many geometries. DSO may potentially lead to important efficiency savings for many clinical protocols.

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