Purpose: To quantify organ-specific objective function weights in a multi-objective optimization formulation of prostate IMRT treatments; to demonstrate that optimized weights can be used to generate clinical plans with fewer objective functions more efficiently than current practice.

Methods: Starting with a simple prostate IMRT inverse planning formulation involving four weighted OAR objectives, we developed an inverse optimization model (IOM) to determine optimal weights for each objective. The objectives were: penalize bladder and rectum voxels with dose above 50 Gy, and minimize maximum dose to the left and right femoral heads. Tumor objectives were modeled as hard constraints. A historical, clinical prostate treatment plan was input to the IOM, and optimized objective function weights were output. The clinical plan was generated in Pinnacle using 15 objective functions. The IOM was formulated as a linear optimization problem and solved using the CPLEX optimization solver. Using the optimized weights and the original inverse planning formulation, a new treatment plan was generated and then compared to the clinical plan.

Results: The optimized weight on the rectum objective was almost exactly three times the bladder objective weight. The weights for the femoral heads were negligible. A new treatment plan generated using the optimized weights and four objectives was nearly identical to the clinical plan. All required clinical dosimetric criteria were satisfied by the new plan.

Conclusions: A treatment planning formulation with optimized objective function weights can generate plans that are nearly identical to clinical plans that were generated using many more objective functions. With optimized weights and fewer objectives, it may be possible to significantly reduce the need for parameter tuning and trial-and-error approaches in treatment planning. While parameter tuning may be unavoidable, inverse optimization can be used to significant reduce the size of the parameter space that needs to be searched.