AbstractID: 8314 Title: Optimized planning of a high dose rate prostate brachytherapy treatment using constrained nonlinear programming.

Purpose:
To describe an efficient prostate HDR optimization strategy using constrained nonlinear programming.

Method and Materials:
Calculation points, contours and source positions were exported from a clinical prostate HDR implant case to a PC running MatLab. A matrix **Dij** is computed for the dose rate to each calculation point **i** from each dwell position **j**. The dose **d = Dij*t** for dwell time **t** was calculated using the TG-43 formalism. Both the prostate and urethra are planned for a uniform dose **d0** with equal weights. The MatLab optimization toolbox is used to compute the minimum of an arbitrary nonlinear cost function *f*(**t**) = ∑abs(**d0 – d**)^n subject to linear inequality constraint **Dij*t** $\geq$ **d0** with **t** values between any lower and upper bound. We investigated the effects of performing an unbounded optimization and setting negative dwell times to zero; linear (n=1) versus quadratic (n=2) cost function with positive dwell times; and lowering the upper bound. These methods were compared to manual optimization performed by an expert user.

Results:
Utilizing a quadratic cost function, nearly perfect target coverage is obtained with acceptable urethral dose when negative dwell times are allowed. Setting negative dwell times to zero seriously compromises dose homogeneity. The effect of applying a linear cost function as well as that of lowering the upper dwell time bound is to significantly increase the hot spots. A quadratic cost function with positive dwell times and upper dwell time limit of nine times the mean provided a clinically optimal treatment plan. Compared to manual plans, optimized plans had superior target coverage, lower inhomogeneity and were calculated in minutes instead of hours.

Conclusion:
Constrained nonlinear programming is an effective tool to optimize prostate HDR treatment planning. A relatively high upper dwell time limit with a quadratic cost function yielded the best clinical results.