Evaluation of OAR Sparing in Prostate Radiotherapy Plans Optimized with Database Dose Predictions

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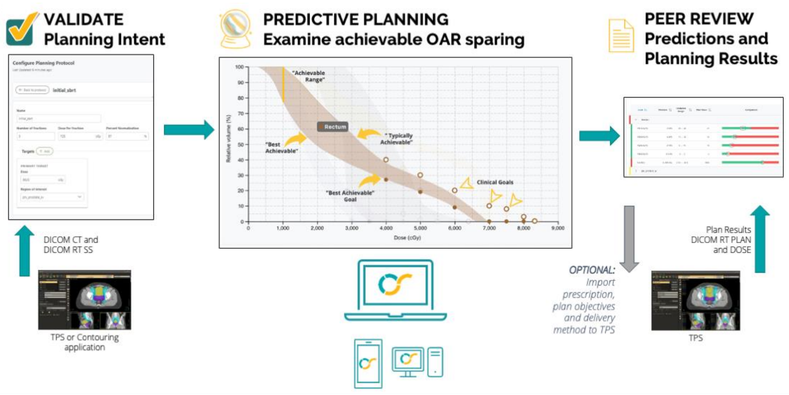
Purpose: To evaluate the quality of prostate radiotherapy plans optimized using objectives from artificial intelligence (AI)-based dose predictions

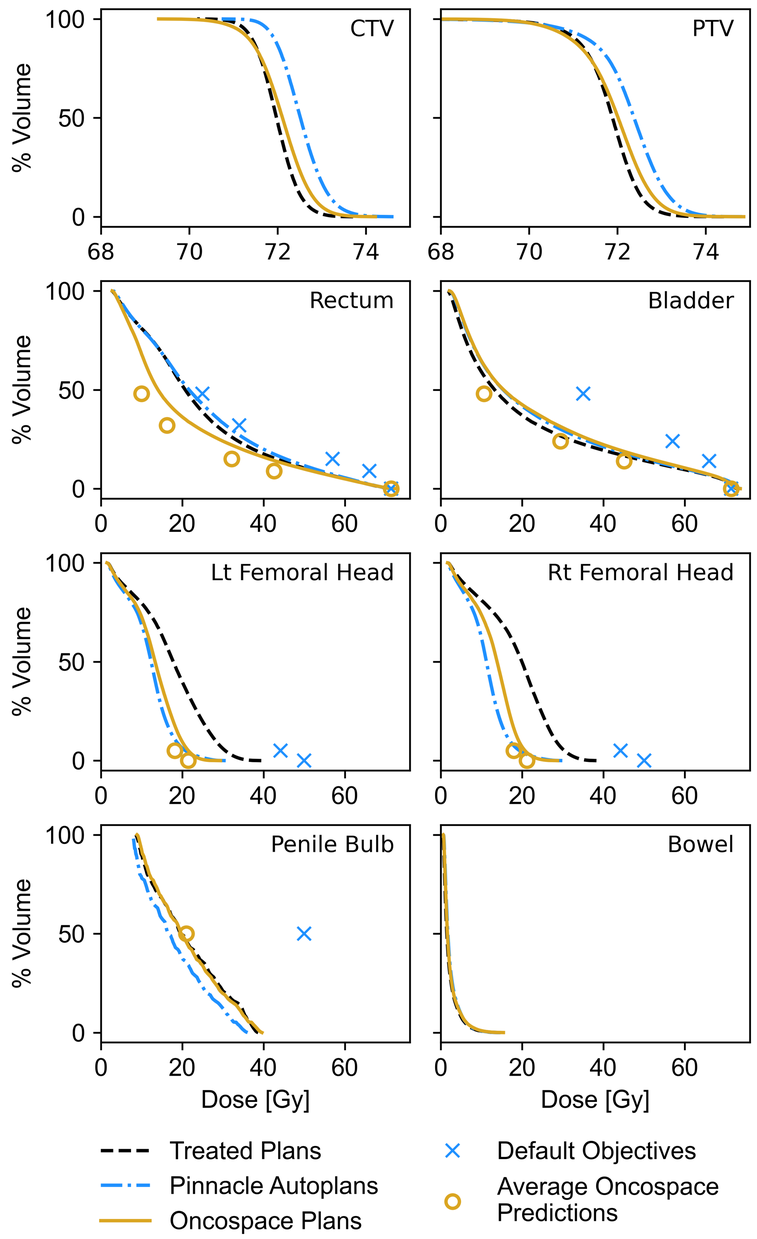
Methods:

- 40 recent prostate plans were identified for 8 physicians and 7 dosimetrists (70 Gy/28 fractions).
- Optimization goals were inconsistent for clinically treated plans, so Pinnacle's Autoplanning tool was repeated using default objectives.
- To create Oncospace plans, contoured structures were exported to the Oncospace web application for AI-based predictions.
  - Oncospace predictions are based on a large database of prior clinical plans.
  - Geometric orientation between targets and organs at risk (OAR) are computed using novel shape relationship features.
  - A random forest AI model relates these shape relationship features to OAR doses.
  - The AI model predicts the lowest reasonably achievable dose objectives for new patients.
- Predictions were imported into Pinnacle's IMRT optimization workspace. Plans were optimized in an automated three-step process:
  1. Initial optimization for 60 iterations, with convolution dose at 30 iterations
  2. Dynamic adjustment of weights, followed by optimization #2 for 30 more iterations
  3. Addition of hot/cold spot structures, followed by optimization #3 for 30 more iterations
- Clinical plan quality metrics were computed for all plans, and the percentage of plans meeting department criteria were tabulated.

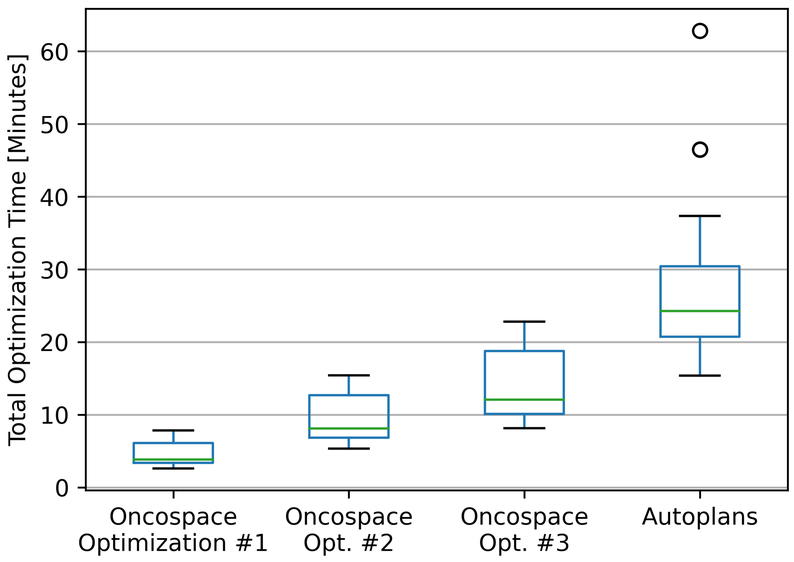
Figure 1: Oncospace Workflow



Results 1: Dose-Volume Histogram Comparison



Results 2: Calculation Times



Results 3: Plan Quality Metrics

Percentage of plans (N=40) in tolerance for clinical plan quality metrics. V(D): Volume receiving the given dose; D(V): Dose to the given volume. Conformity: Ratio of 100% isodose volume to PTV volume. Spilloff: Ratio of 50% isodose volume to PTV volume

Structure	Plan Quality Metric	Treated Plans	Pinnacle Autoplans	Oncospace Plans
CTV	V(100%) > 99%	100.0%	100.0%	100.0%
PTV	V(100%) > 98%	97.5%	100.0%	100.0%
	V(95%) > 99%	100.0%	100.0%	100.0%
	D(0.035 cc) < 107%	97.5%	72.5%	42.5%
	Conformity < 1.2	100.0%	100.0%	100.0%
	Spilloff < 5.0	97.5%	100.0%	97.5%
Rectum	V(35.35 Gy) < 35%	100.0%	95.0%	95.0%
	V(57.45 Gy) < 17%	100.0%	100.0%	95.0%
	V(66.30 Gy) < 10%	100.0%	100.0%	97.5%
	D(0.035 cc) < 105%	100.0%	87.5%	72.5%
Bladder	V(35.35 Gy) < 50%	97.5%	97.5%	97.5%
	V(57.45 Gy) < 25%	97.5%	97.5%	97.5%
	V(66.30 Gy) < 15%	100.0%	97.5%	95.0%
	D(0.035 cc) < 105%	97.5%	27.5%	45.0%
Lt Femoral Head	V(44.2 Gy) < 5%	100.0%	100.0%	100.0%
Rt Femoral Head	V(44.2 Gy) < 5%	100.0%	100.0%	100.0%
Penile Bulb	Mean Dose < 50 Gy	100.0%	97.5%	92.5%
Bowel	V(13.25 Gy) < 830 cc	100.0%	100.0%	100.0%
	V(39.75 Gy) < 195 cc	100.0%	100.0%	100.0%
	V(45.95 Gy) < 0.035 cc	100.0%	95.0%	92.5%

Conclusions: Autoplans and Oncospace plans both demonstrate clinically acceptable OAR sparing but may require further optimization to improve target homogeneity. Given that optimization takes less time than Autoplanning, and that Oncospace plans reduce rectum and femoral head dose compared to clinical plans, AI-based dose predictions help to improve both planning efficiency and clinical plan quality.

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