

Quantitative and qualitative evaluation of an automated planning solution for prostate radiotherapy

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Purpose/Objective:

Volumetric modulated arc therapy (VMAT) is widely used in radiotherapy (RT) treatment planning, yet manual treatment planning (MP) remains labor-intensive and skill-dependent. To address this, we propose a fully automated treatment planning (AP) approach for prostate cancer treatments, aiming to streamline planning while maintaining quality.

Material/Methods:

Our pipeline takes as input a contoured planning CT, the targeted linac machine and the prescription dose. It uses a deep learning model trained on 123 clinical cases for dose prediction and direct aperture VMAT plan optimization. A clinical evaluation study was performed on another 25 cases. The RT plans generated were calculated using a Collapsed Cone Convolution engine and the obtained RT doses were compared with the reference doses from MP.

First, a quantitative evaluation was performed based on dose-volume histogram (DVH) points and plan parameters metrics (monitor units (MU) and modulation complexity score (MCS)). Paired Wilcoxon signed-rank test was used to assess significant differences between the MP and AP plans (with $p < 0.05$ considered statistically significant).

Secondly, a double blinded plan comparison study was organized, showing side-by-side the RT doses from AP and MP plans. Three experts (from major European and US cancer centers) evaluated plan acceptability and preference.

Results:

Results of the quantitative evaluation showed that the AP doses to PTV_80Gy were similar to those of MP (< 0.5 Gy absolute dose difference) and without statistically significant differences in the median (D50%) and maximum (D2%) doses (Table 1). AP reduced toxicity to organs-at-risk (OARs), notably a 6 Gy decrease in D5% to the right femoral head. Significant differences between MP vs AP were also observed in the number of MU (589.67 ± 57.39 vs 658.48 ± 72.52) and MCS (0.19 ± 0.03 vs 0.17 ± 0.03).

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Qualitative evaluation found both AP and MP plans clinically acceptable (87% and 85%, respectively). AP was preferred in 18/25, 13/25, and 22/25 cases by three experts, revealing varying clinical priorities

Conclusions:

Our automated pipeline produces plans comparable to manual ones, deemed clinically acceptable and sometimes superior. Differences in expert preferences highlight variations in clinical practice across centers and countries.

	DVH parameter	Acceptance criteria	Manual plans (mean±SD)	Automatic plans(mean±SD)	p-value<0.05
PTV_80Gy	D98%	≥72Gy	74.77±0.64	74.33±0.54	*
	D50%	=80Gy	80.25±0.45	80.17±0.29	
	D2%	≤85.6Gy	82.15±0.66	82.17±0.42	
Rectum	Dmax	≤76Gy	74.93±1.01	74.97±1.22	
	D50%	≤60Gy	23.52±4.77	22.47±4.11	
Bladder	Dmax	≤80Gy	79.46±0.55	79.63±0.65	
	D50%	≤70Gy	35.55±16.8	34.09±16.28	
Femoral head L	D5%	≤55Gy	33.84±6.68	28.86±4.72	*
Femoral head R	D5%	≤55Gy	34.42±7.02	28.74±4.58	*

Table1. Dosimetric study results. With * are highlighted the statistically significant differences between MP and AP (p<0.05)