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Evaluating knowledge-based planning performance for challenging cases: Prostate bed VMAT with nodal involvement and significant OAR overlaps

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Purpose: Knowledge based (KB) planning is a recent auto-planning technique that generates quality plans using contour geometry/DVH-based models calculated from a library of pre-selected patient plans. For sites that require repetitive manual tweaks and adjustments, knowledge based planning shows its value by producing comparable quality plans in significantly less time. One such site is prostate bed with nodal involvement – these cases are often challenging due to deep overlap between PTV and organs at risk (OAR). Here we investigate the performance of a commercial knowledge based treatment planning system - Varian Rapidplan (RP) - for 3 difficult cases where PTV overlaps both rectum and bladder by >40%.

Methods: Treatment planning system used is Eclipse version 15.6. Model Configuration was used to build a library of training plans consisting 57 prostate bed patients previously treated with Volumetric Modulated Arc Therapy (VMAT). Plans were generated between 2017-2019 and screened for Model Configuration DVH estimation criteria such as regression plot outliers, outlier statistics and dosimetric quality. To test our Rapidplan model's ability to handle overlaps, three dosimetrically-challenging patients with similar overlap volumes by three separate planners were identified (Bladder/PTV overlap of 42%, 51% 54% and Rectum/PTV overlap of 51%, 57%, 41%). These patients were retrospectively re-planned using Rapidplan and results compared with original plans.

Results: Dosimetry parameter comparison between manual and KB planning are shown in Table 1 below. Isodose and DVH comparisons are shown on the right in Figures 1a to 3b. For patient A, manual plan PTV coverage is better – however, this came at the expense of less OAR sparing. For patient B and C, the reverse is true – RP had better coverage but OAR doses are generally higher. Overall, dosimetric differences between the 2 techniques are < 3%.

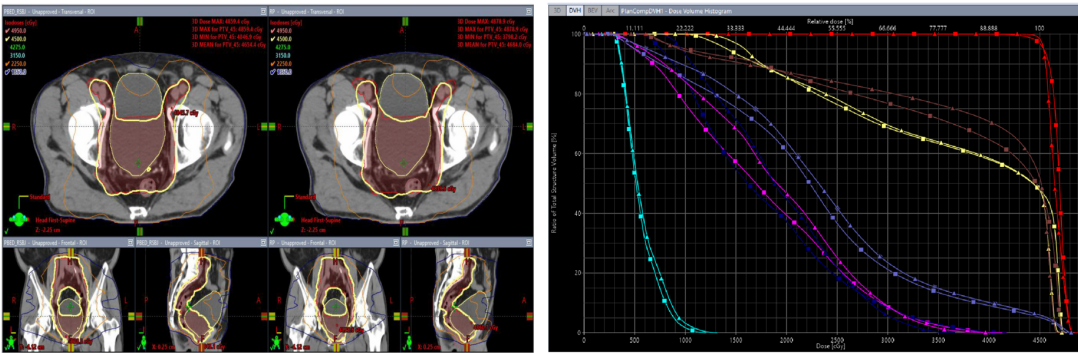


Figure 1a

Figure 1b

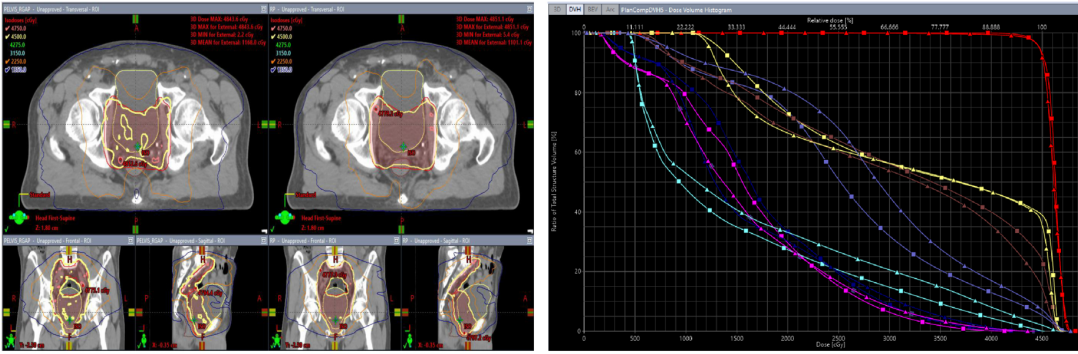


Figure 2a

Figure 2b

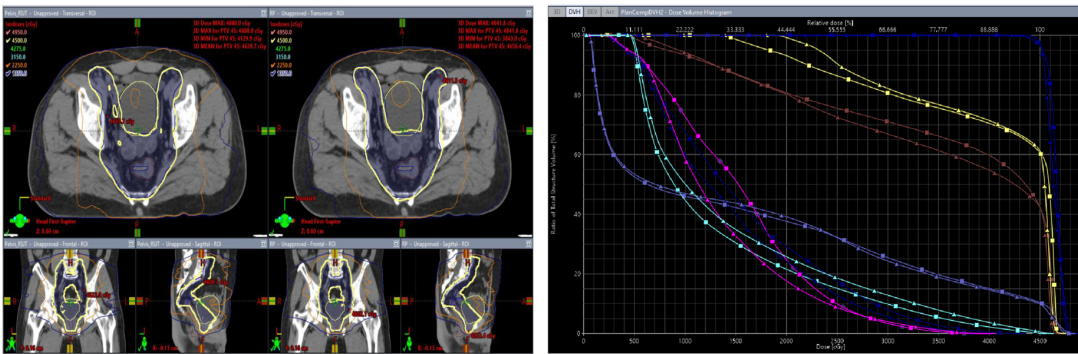


Figure 3a

Figure 3b

Figure 1a: Patient A – 42% bladder overlap, 51% rectum overlap. 3 View plan comparison of manual plan vs Rapidplan. 45Gy in bold yellow isodose line, 50% in orange. Figure 1b: Patient A DVH manual plan (diamond) vs Rapidplan (square) comparison. Figure 2a: Patient B - 51% bladder overlap, 57% rectum overlap. Figure 2b: Patient B DVH comparison. Figure 3a: Patient C - 54% bladder overlap, 41% rectum overlap. Figure 3b: Patient C DVH comparison.

Conclusion: Rapidplan achieved similar PTV coverage and OAR sparing as manual planning in all 3 cases. Manual planning had slightly better dose statistics overall – however, this typically required significantly longer optimization time (<10 minutes for Rapidplan vs 30-40 minutes manual). Rapidplan results can be further enhanced with multi-criteria based optimizers (Varian's MCO) without adding significant planning time. Rapidplan results could also be improved as more challenging cases are added to modelling library patient list in the future.

	Patient A		Patient B		Patient C	
	Manual	RP	Manual	RP	Manual	RP
PTV V45 (%)	98.4	96.9	91.8	93.1	96.5	96.6
PTV Dmax (Gy)	48.6	48.8	48.4	48.5	48.8	48.4
Rectal Wall V40 (%)	70.8	64.7	35.4	40	54.8	59.7
Rectal Wall V30 (%)	80.4	76.8	53.8	56.2	66.9	71
Rect Wall Dmax (Gy)	47.3	47.6	47.1	46.9	47.4	47.1
Bladder Wall V40 (%)	58.4	58	46.7	46.7	71.4	70.4
Bladder Wall V30 (%)	69.6	68.6	56.2	56.2	82.2	80.6
Bladder Wall Dmax (Gy)	47.4	47.7	47.1	47.4	47.6	47
Large Bowel Dmax (Gy)	47.7	48.6	48.4	47.4	48.5	47.5
Small Bowel V48 (cc)	1	0.03	>0.01	>0.01	0.7	>0.01
Small Bowel Dmax (Gy)	48.5	48.2	47.9	48.1	48.5	48.1
Lt Femoral head V30 (%)	5.7	8.3	11.1	8.8	5.6	7.9
Lt Femoral Head Dmax (Gy)	36.6	41.7	43.6	44.9	40.3	43.7
Rt Femoral Head V30 (%)	8.9	8.7	8.2	6.3	4	3.4
Rt Femoral Head Dmax (Gy)	41.3	41.8	44.3	42.2	40.5	39.6

Table 1: Dosimetry comparison between manual and KB planning for patients A, B and C.