Evaluating Treatment Plan Quality between Manual Planning and Auto-Planning in Patients with Prostate and Seminal Vesicle Irradiation

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Introduction

Auto-Planning is a tool that automates and facilitates inverse optimization of treatment plans. Benefits of Auto-Planning are based on planning efficiency improvements and standardization of plan quality. With this in mind, the purpose of this treatment planning study is to dosimetrically assess the quality of Auto-Planning plans generated for patients receiving treatment to the prostate and seminal vesicles for low-/intermediate-risk prostate cancer. The primary objective is to compare the quality of Auto-Planning treatment plans against previously approved clinical treatment plans.

Methods and Materials

- Twenty (n=20) patients previously treated to the prostate and seminal vesicles using a VMAT technique were replanned with Auto-Planning. All patients were planned in Pinnacle^3 (Version 9.10) using single or dual SmartArc plans with either 6 or 10 MV photon energies.
- Plan settings were equivalent for each patient for both clinical and Auto-Planning. Plans were prescribed to 7920cGy and normalized such that 95% of the PTV received at least 100% of the prescription dose.
- A template for Auto-Planning was initially developed using the dose constraints to critical structures from QUANTEC. A final template was adjusted based on the preliminary test results of six patients.
- Patients were evaluated for PTV and organ at risk (OAR) parameters for the bladder, rectum, sigmoid, penile bulb, and femoral heads.
- Metrics used for PTV comparison were $D_{2cc,}$ homogeneity (HI = D_{2cc} / D_{Rx}), conformity (CN), and dose fall-off (R_x = $V_{x\%}$ / V_{PTV}) for the 70%, 50%, and 30% isodose lines.
- OAR metrics included D_{2cc} and D_{MEAN} along with specific volume based constraints for the bladder and rectum per QUANTEC.

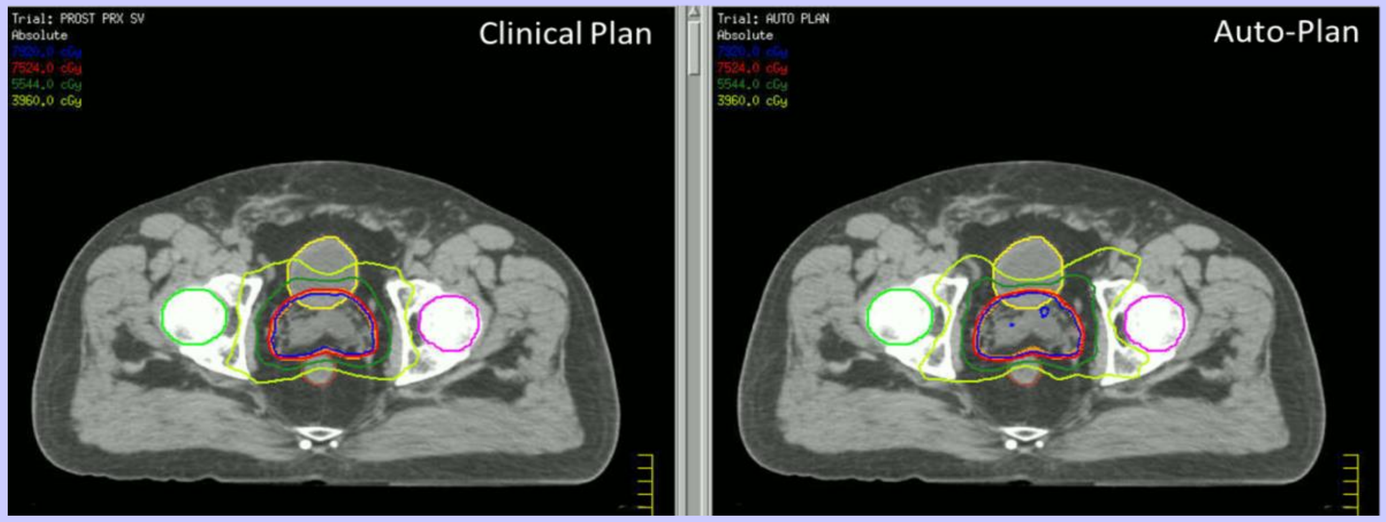
Results

For the PTV, a decrease in the mean percentage difference of 2.9% ($p<0.05$) was noted in the R_{30}. An increase in HI of 1.2% ($p<0.05$) and total plan MUs of 20.2% ($p<0.05$) was noted for Auto-Planning. No statistically significant differences were noted for the other PTV parameters. For OARs, statistically significant reductions in the D_{MEAN} of all structures, decrease in the D_{2CC} of the sigmoid of 8.6% ($p<0.05$), and decrease in the V_{65Gy} of 1.8% ($p<0.05$) and V_{50Gy} of 9.0% ($p<0.05$) for the rectum were noted with Auto-Planning. Statistically significant increases in the mean percentage difference in the D_{2cc} of 1.5% ($p<0.05$) and V_{80Gy} of 33.6% ($p<0.05$) for the bladder, and D_{2cc} increase of 1.2% ($p<0.05$) for the rectum was shown.

Conclusion

The study showed that Auto-Planning produces plans of comparable quality to clinical plans based on the evaluated metrics for the sample of patients studied. Clinical plans showed better homogeneity and fewer total plan MUs. Auto-Planning had lower average doses (D_{MEAN}) for all critical structures.

Figure 1: Axial slice of a sample patient being treated to the prostate and seminal vesicles using a SmartArc technique. Both clinical (*left*) and Auto-Planning (*right*) plans are shown along with their respective isodose lines.



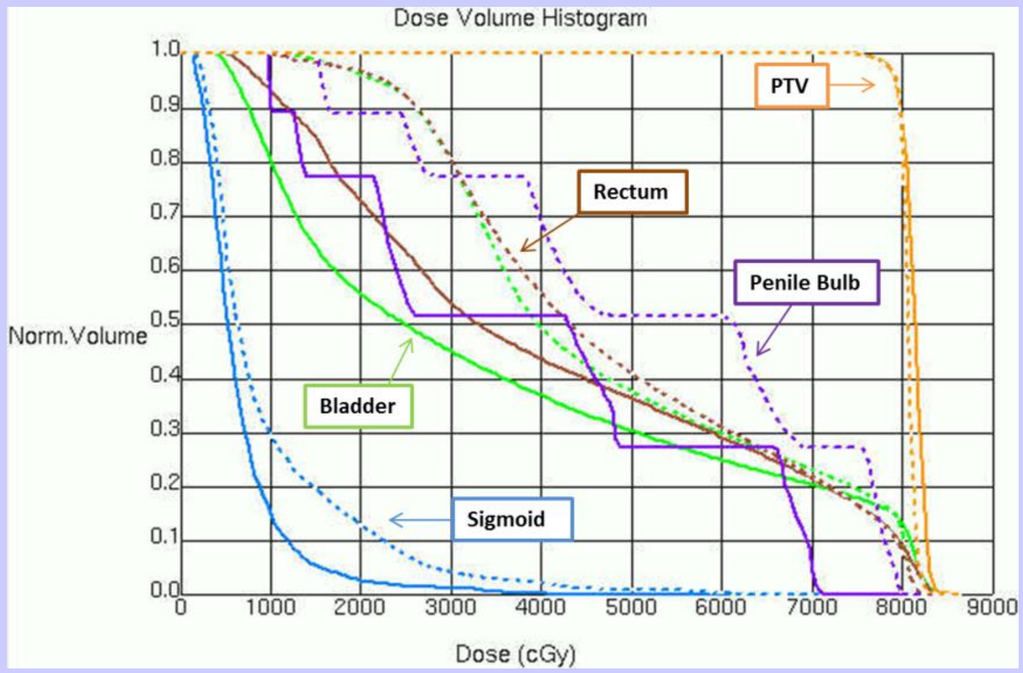


Figure 2: Normalized DVH of a sample patient shows comparable coverage of the PTV and sparing of OARs.

Clinical Plan ----------

Auto-Plan ——————

Table 1: Mean percentage difference between clinical and Auto-Planning plans for the specified OARs is shown. (negative values denote a lower value parameter for Auto-Planning)

OARS	D_{2CC}	D_{MEAN}	$V80_{Gy}$	$V75_{Gy}$	$V70_{Gy}$	$V65_{Gy}$	$V50_{Gy}$
Bladder	1.5% ($p<0.05$)	-6.8% ($p<0.05$)	33.6% ($p<0.05$)	-7.0% (NS)	-10.0% (NS)	-11.1% (NS)	
Rectum	1.2% ($p<0.05$)	-1.4% ($p<0.05$)		5.0% (NS)	1.7% (NS)	-1.8% ($p<0.05$)	-9.0% ($p<0.05$)
Sigmoid	-8.6% ($p<0.05$)	-0.2% ($p<0.05$)					
Penile Bulb		-21.9% ($p<0.05$)					
Femur (R)	-6.3% (NS)	-13.0% ($p<0.05$)					
Femur (L)	-13.9% ($p<0.05$)	-16.7% ($p<0.05$)					

* NS – Not statistically significant.