Evaluating Treatment Plan Quality and Dosimetric Differences between Pinnacle^3 Auto-Planning and Manual Treatment Planning in Brain Cancer Patients

B Zehren, M.S., K Rasmussen, Ph.D., D Baacke, B.Sc., RL Crownover, M.D., Ph.D., N Kirby, Ph.D., N Papanikolaou, Ph.D., AN Gutierrez, Ph.D., M.B.A.

Department of Radiation Oncology, University of Texas Health Science Center at San Antonio, San Antonio, TX 78229

Introduction

Treatment plans for brain cancer patients tend to be complex in nature. There are many organs at risk (OAR) that can have significant consequences if over-irradiated. Additionally, the Planning Treatment Volume (PTV) could be wrapped around more than one OAR, thus making it difficult to maintain coverage of the PTV while sparing healthy tissue. The Pinnacle3 Auto-Planning feature allows for PTV coverage while minimizing the dose to OARs. The purpose of this study was to compare and evaluate the quality of treatment plans for brain tumors using Pinnacle3 Auto-planning versus manual treatment planning.

Methods and Materials

- Nineteen (n=19) patients previously planned using dual arc 6 MV VMAT technique in in Pinnacle^3 TPS (Version. 9.10, Philips Medical, Fitchburg WI) then replanned using the Pinnacle^3 Auto-Planning feature with two SmartArc beams utilizing a full arc.
- An Auto-Planning template was created with the same beam geometry, isocenter, and dose grid as the clinical plan. This method created Planning Risk Volumes (PRVs), which are 3mm expansions of the OAR.
- All plans were normalized so that 95% of the PTV received 100% of the prescription dose.
- Metrics for comparison used were $D_{2\%}$, $D_{98\%}$, homogeneity index (HI = $D_{2\%}$ - $D_{98\%}$ / D_{mean}), conformity index (CN), and fall-off (R_{25} = $PIV_{25\%}$/PTV, where $PIV_{25\%}$ = isodose volume of 25% prescription dose) for the PTV and D_{max} (0.03cc) and D_{mean} for OARs.
- Statistical differences were evaluated using a paired-sample Wilcoxon signed rank test with significance level of 0.05

Results

PTV:

- No statistically significant differences in the HI or the R_{25} fall-off
- CN showed an improvement of 7.15% ($p<0.05$) with the Auto-Plan over the manual plan

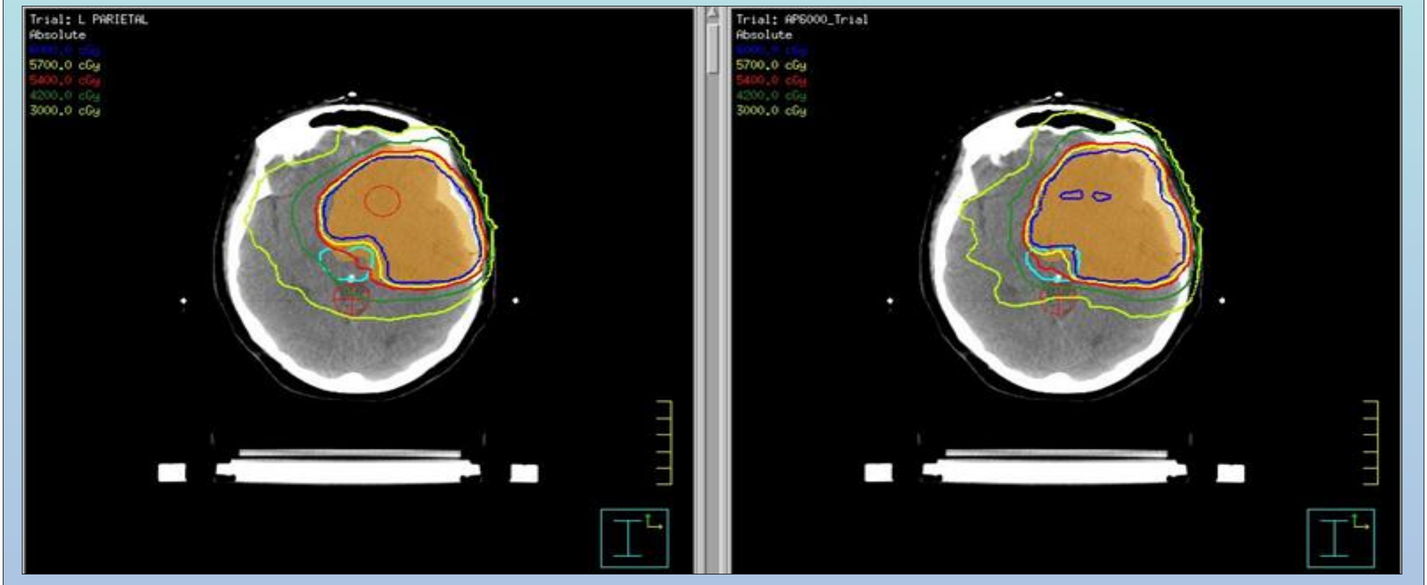
OARs:

- Auto-Plan showed a significant reduction in both the D_{max} and D_{mean} to a majority of the structures.
- Higher D_{max} to the brain stem and a higher to D_{mean} to the optic chiasm
- No statistically significant differences between the D_{max} to the brain, D_{mean} of the spinal cord or D_{max} and D_{mean} to the eyes.

Conclusion

Treatment planning employing auto-planning produces similar, if not better plan quality as compared to previously delivered clinical plans for VMAT based brain irradiation based on the metrics evaluated in this study. The use of auto-planning makes the planning process less time consuming and less planner dependent.

Figure 1: An axial slice of a sample patient that has been planned manually (left) and using Pinnacle^3 Auto-Planning (right) are shown along with respective isodose lines.



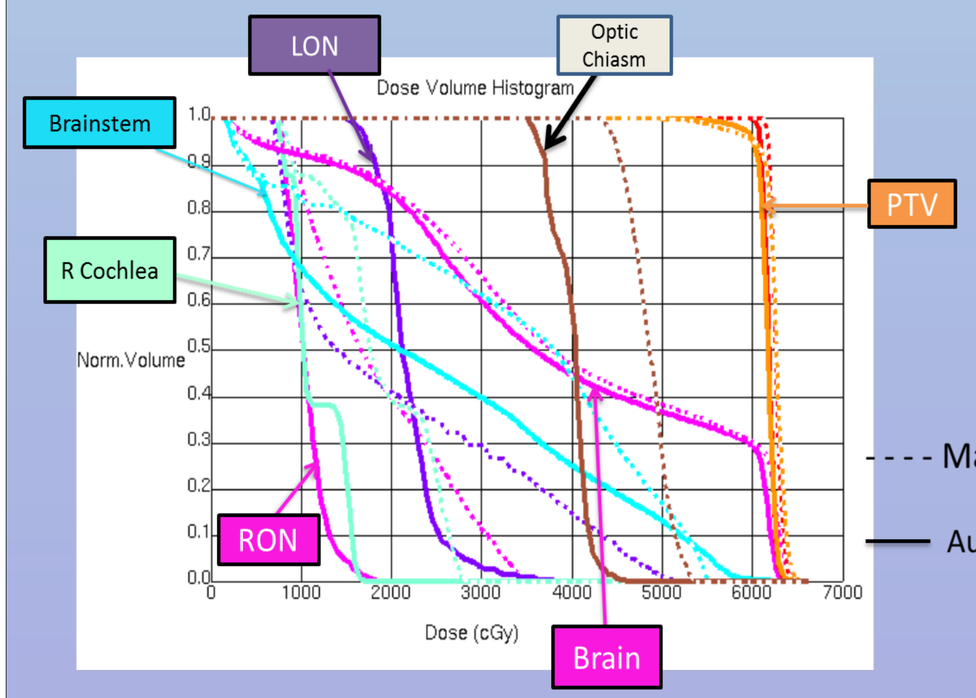


Figure 2: Cumulative, normalized DVH for sample patient shows both comparable coverage to the PTV and significance differences in OARs

Table 1: Dosimetric summary between manual plans and auto-plans for OARs. Mean percentage differences for selected organs of manual plans to auto-plans (positive values denotes higher parameter value for manual plans) NS - Not statistically significant.

OAR	D_{max}	D_{mean}
Brain	-1.1% (NS)	-7.7% ($p<0.05$)
Brain Stem	4.2% ($p<0.05$)	-12.8% ($p<0.05$)
Optic Chiasm	-23.7% ($p<0.05$)	36.2% ($p<0.05$)
R Optic Nerve	-57.2% ($p<0.05$)	-33.6% ($p<0.05$)
L Optic Nerve	-39.3% ($p<0.05$)	-21.5% ($p<0.05$)
R Cochlea	-55.1% ($p<0.05$)	11.3% ($p<0.05$)
L Cochlea	-46.7% ($p<0.05$)	-49.5% ($p<0.05$)
Spinal Cord	-14.1% ($p<0.05$)	-6.2% (NS)
R Eye	-13.5% (NS)	7.9% (NS)
L Eye	-19.8% (NS)	9.3% (NS)