The impact of arc spacing angles on plan quality in VMAT plans

Joshua Nguyen; Ashley Valdez; Leanna Ta; Qun Wang; Donald Hancock, B.S., C.M.D; Jared Ohrt, M.S., DABR; Lori Simmons, M.S., C.M.D.

University of Texas at MD Anderson Cancer Center School of Health Professions

THE UNIVERSITY OF TEXAS MD Anderson Cancer Center

Introduction

Volumetric-modulated arc therapy (VMAT) beams deliver dose as the gantry rotates in a continuous arc. A smaller gantry spacing between control points (CPs) requires more CPs per arc which can potentially improve the accuracy to the dose calculation but can also increase optimization time and computational resources needed for planning.

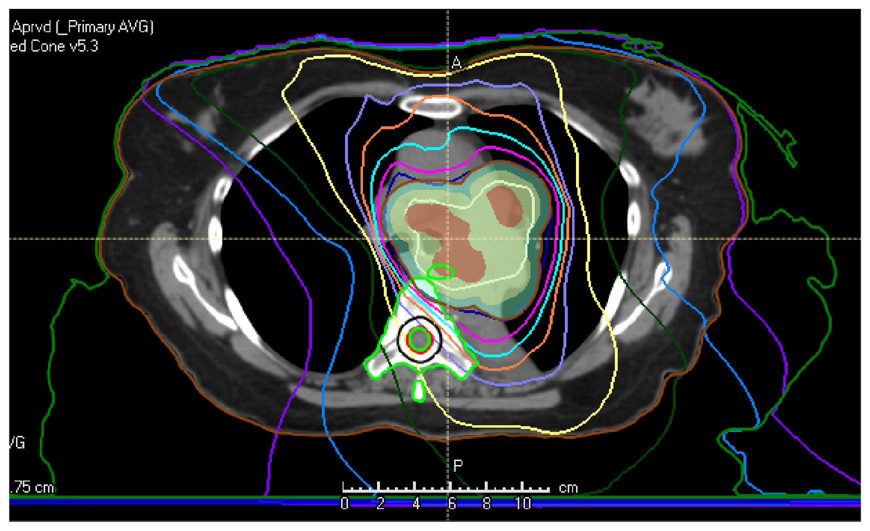
Currently, our institution uses two degrees of gantry spacing between CPs. This study investigates the benefits and feasibility of increasing gantry spacing to four degrees between CPs.

Methods

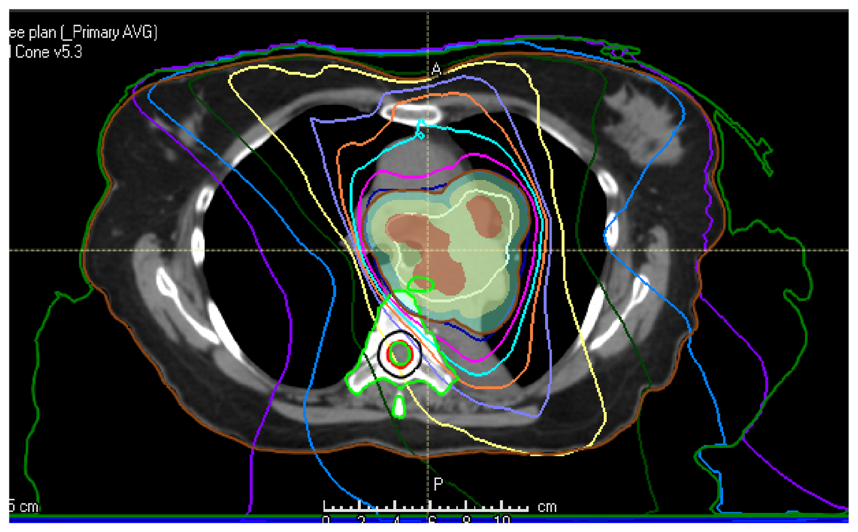
Sixteen cases treating various treatment sites were chosen which had clinically approved plans with two-degree spacing between CPs in RayStation. These plans were reoptimized with four-degree gantry spacing that meets or exceeds the target and organ at risk (OAR) goals achieved by the clinical, two-degree VMAT plan.

For each case the two- and four-degree plans were compared using dose distributions, dose-volume histogram (DVH) plots, dose statistics, and total monitor units.

Thoracic (THOR)

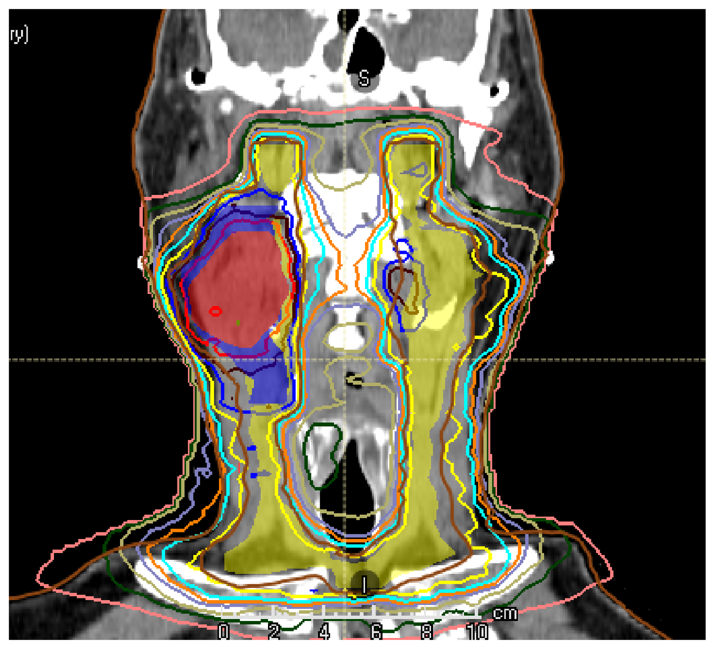


Clinically Approved 2˚ Plan

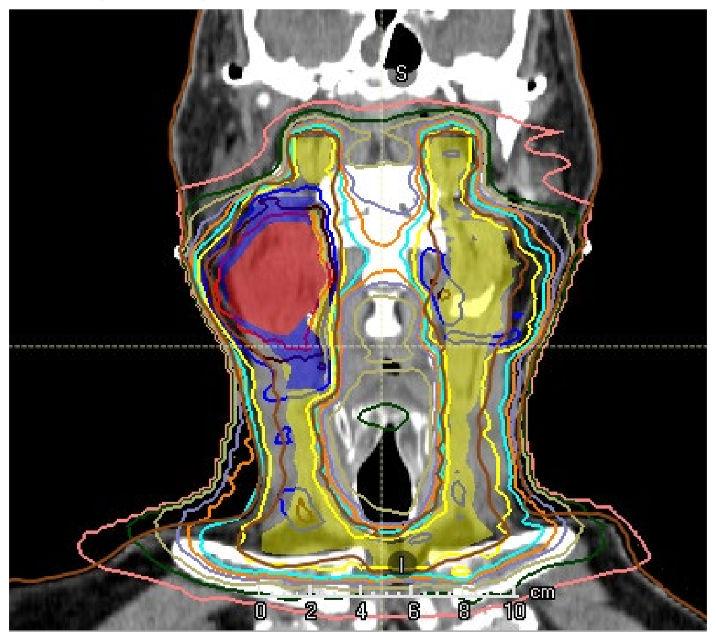


4˚ Plan (Planned by: Joshua Nguyen)

Head and Neck (HN)



Clinically Approved 2˚ Plan



4˚ Plan (Planned by: Leanna Ta)

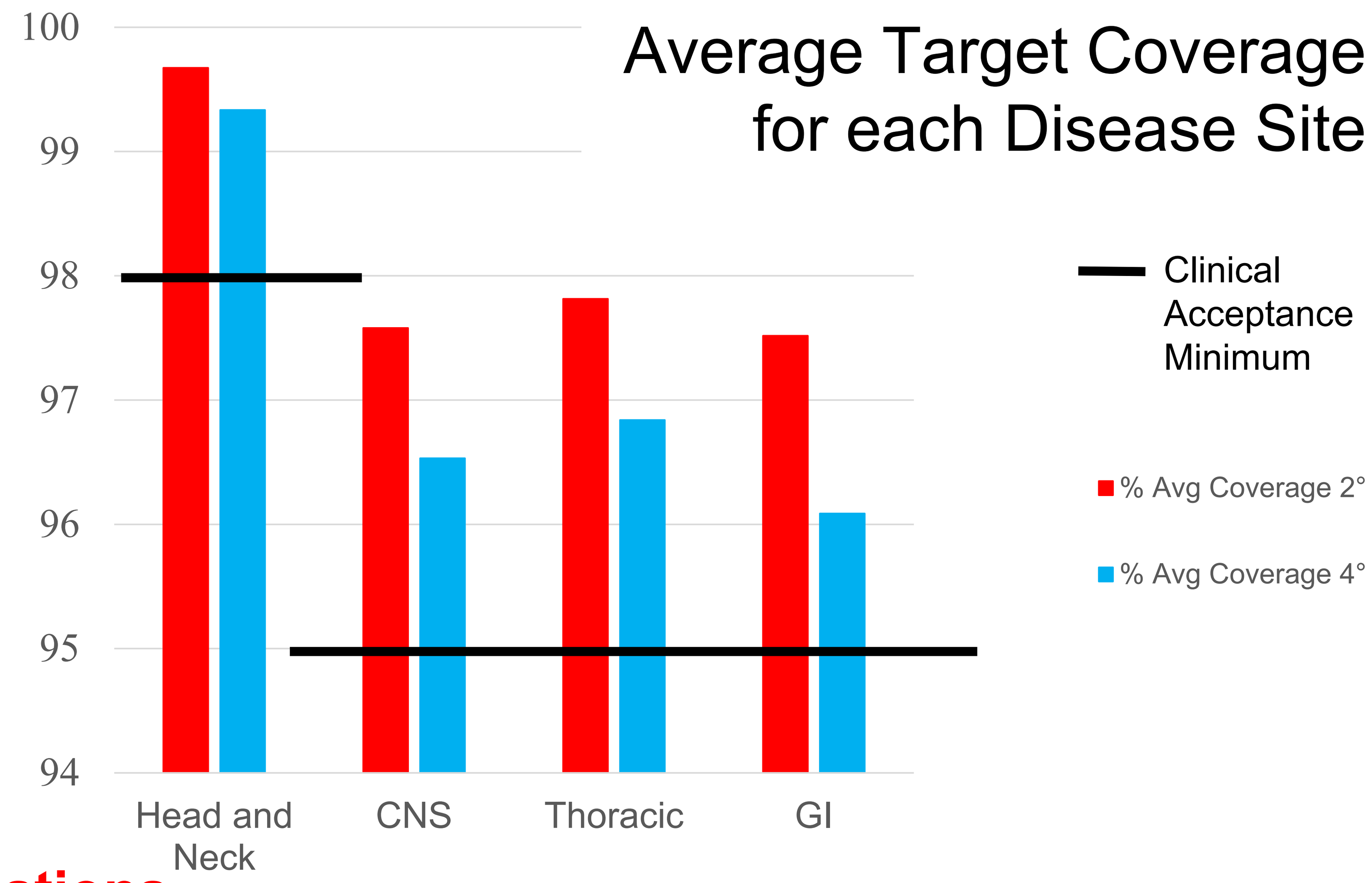


Table 1

ID % Difference between 2° and 4°				
Site	**Case 1**	**Case 2**	**Case 3**	**Case 4**
HN	5.32%	0.29%	1.62%	-22.81%
CNS	-0.23%	0.7%	3.29%	-3.41%
THOR	-3.28%	6.02%	-0.67%	2.98%
GI	1.67%	4.48%	-3.63%	12.63%

Table 2

ID % Difference between 2° and 4°			
Site	**2˚**	**4˚**	**% Diff Avg**
HN	564.75	587.7	-4.063%
CNS	539.43	512.49	5.0%
THOR	851.16	736.54	13.46%
GI	485	502.62	-3.63%

The listed values are the average MUs of the four cases per site***

Table 3

Homogeneity Index (HI) Comparison			
Site	**2˚**	**4˚**	**% Diff Avg**
HN	0.116	0.115	-0.862%
CNS	0.121	0.125	3.306%
THOR	0.076	0.088	15.789%
GI	0.096	0.113	17.708%

The listed values are the average HIs of the four cases per site***

Calculations

- Integral Dose[2] (ID) = $\frac{fsBodyNew\ Avg\ Dose\ (cGy)}{100}\ x\ \frac{fsBodyNew\ Volume\ (mL)}{1000}$
  - fsBodyNew = $fsBody_{clinically\ approved} - [all\ PTVs + pCTV + moats]$
- Homogeneity Index[1] (HI) = $\frac{D_2 - D_{98}}{D_{50}}$
  - D_2 = maximum dose received by 2% of volume
  - D_{98} = maximum dose received by 98% of volume
  - D_{50} = maximum dose received by 50% of volume

Results

For all cases, the resulting four-degree plan achieved similar target coverage and OAR constraints as the clinical, two-degree plans. In 11 of 16 cases the number of MUs prescribed in the four-degree plan were less than the corresponding two-degree plan.

Conclusions

These findings suggest that a gantry spacing of four degrees between CPs does not compromise OAR constraints or target coverage and could be used for all clinical VMAT planning moving forward. The reduction of computational workload allows clinically acceptable treatments plans to be developed in less time while requiring fewer computational and personnel resources

References

1. Murtaza, G., Cora, S., and Khan, E. U. "Validation of the relative insensitivity of volumetric-modulated arc therapy (VMAT) plan quality to gantry space resolution," J. Rad. Res., **58**(4), 579–590. (2017). https://doi.org/10.1093/jrr/rrw114
2. Raturi, V. P., Motegi, A., Zenda, S., Nakamura, N., Hojo, H., Kageyama, S. I., Okumura, M., Rachi, T., Ohyoshi, H., Tachibana, H., Motegi, K., Ariji, T., Nakamura, M., Hirano, Y., Hirata, H., and Akimoto, T. "Comparison of a Hybrid IMRT/VMAT technique with non-coplanar VMAT and non-coplanar IMRT for unresectable olfactory neuroblastoma using the RayStation treatment planning system-EUD, NTCP and planning study," J. Rad. Res., **62**(3), 540–548. (2021). https://doi.org/10.1093/jrr/rrab010