HyperArc planning for fractionated stereotactic radiotherapy of pituitary tumors

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INTRODUCTION

Conformal dose distributions, combined with lower whole-brain and OAR doses aide in the successful radiotherapy for pituitary tumors. It is common to treat pituitary adenoma using single-fraction 20 Gy SRS with a stereotactic frame, however fractionated SRS, such as 25 Gy in 5 fractions, may reduce complications due to patient motion or setup error near the sensitive region surrounding the pituitary. More importantly, fractionated radiotherapy allows for normal tissue repair between fractions. For these reasons, conventional fractionation, such as 54 Gy in 30 fractions, is a common regimen for pituitary radiotherapy, and is the standard of care in our clinic. However, an emerging technique in SRS planning is HyperArc (HA), in which the stereotactic mask system is used with pre-defined couch kicks to deliver linac-based radiosurgery in less time with more leniency in initial patient setup.

OBJECTIVE

In treatment of pituitary tumors, our goal is to retain the benefit of normal tissue repairs and leniency in setup provided by multiple fractions, such as 54 Gy in 30 fractions, while using HyperArc for its ease of planning and delivery in addition to its more conformal dose distribution.

METHODS

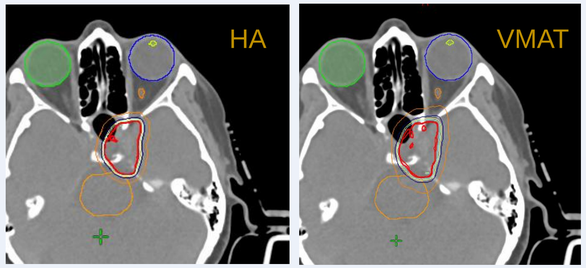
- Twelve pituitary cases treated using 30-fraction VMAT on a Truebeam Edge were replanned using HyperArc planning on Eclipse v15.6
- Conformity index (CI), Paddick conformity index (PCI), gradient index (GI), and heterogeneity index (HI) are used for plan comparison(1)
- Secondary dose calculations using Mobius and IMRT QA measurements were performed and evaluated using Gamma criteria for the HA plans
- Patient setup and delivery were timed for all HA and VMAT plans for comparison

EQUATIONS

$$CI = \frac{V_{RI}}{TV} \qquad PCI = \frac{TV_{RI}}{TV} * \frac{TV_{RI}}{V_{RI}}$$

$$GI = \frac{V_{50\%}}{V_{100\%}} * \frac{V_{RI}}{TV} \qquad HI = \frac{D_{\max}}{D_{\min}}$$

V_{RI} is the volume covered by the prescribed dose and TV is the target volume. TV_{RI} is the target volume covered by the prescribed dose. $V_{50\%}$ and $V_{100\%}$ are the volumes covered by the 50% and 100% isodose volumes, respectively. D_{max} and D_{min} are the maximum and minimum doses.

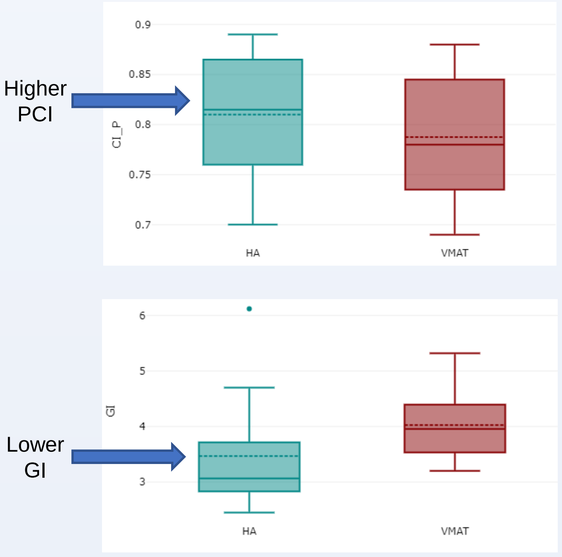


RESULTS

The average CI is 0.900 for HA and 0.946 for VMAT. Average PCI is 0.810 for HA and 0.788 for VMAT. Average GI is 3.242 for HA and 4.026 for VMAT. Average HI is 1.232 for HA and 1.179 for VMAT. Two-tail t-test for paired means shows that the differences in the averages are statistically significant ($p<0.05$) for PCI, GI, and HI ($p=0.026$, 0.022, and 0.013, respectively), but not for CI ($p=0.094$).

The average 3%/3mm Gamma passing rate for Mobius secondary calculations was 99.8%, with a minimum of 99.1%. The average 2%/2mm Gamma passing rate for portal dosimetry was 98.7% with a minimum of 95.2%.

The average HA delivery time was 4:04. The average VMAT delivery time was 7:07.

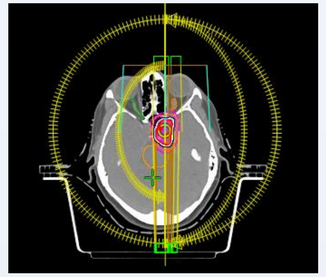


CONCLUSIONS

Statistically significant PCI and GI improvements indicate potentially superior coverage and sparing of organs at risk. Significant HI is likely due to the larger maximum doses for HA plans, however these maximum doses are still reasonable. On average, the conformity indexes are comparable between VMAT and HA plans.

Delivery accuracy is a potential concern due to the lower doses and doses rates used in these fractionated cases, as HA was designed for SRS where high doses and high dose rates are delivered. IMRT QA using portal dosimetry and film as well as secondary calculations using Mobius confirmed there are no significant delivery issues with the HyperArc plans.

The improvement in plan quality, deliverability, and delivery time suggest successful implementation of HyperArc planning for standard fractionated pituitary radiotherapy.



REFERENCES

(1) Cao T, Dai Z, Ding Z, Li W, Quan H. Analysis of different evaluation indexes for prostate stereotactic body radiation therapy plans: conformity index, homogeneity index and gradient index. Prec Radiat Oncol. 2019;3:72-79.

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