Cureus

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Abstract

Dosimetric Comparison of Protons versus Photons for Treatment of Pituitary Adenoma

Shivani Sud [1] , Thomas Botticello [2] , Andrzej Niemierko [3] , Jillian Daly [2] , Helen Shih [4]

1. Radiation Oncology, University of North Carolina at Chapel Hill, Chapel Hill, USA 2. Radiation Oncology, Massachusetts General Hospital, Boston, USA 3. Radiation Oncology, Massachusetts General Hospital, Harvard Medical School, Boston, USA 4. Radiation Oncology, Massachusetts General Hospital

Corresponding author: Shivani Sud, shivani.sud@unchealth.unc.edu

Categories: Radiation Oncology
Keywords: pituitary adenoma, proton radiation therapy, volumetric modulated arc therapy

How to cite this abstract
Sud S, Botticello T, Niemierko A, et al. (March 21, 2019) Dosimetric Comparison of Protons versus Photons for Treatment of Pituitary Adenoma . Cureus 11(3): a368

Abstract

Objectives: To compare the dosimetric advantages and limitations of protons (PRT) versus photons (XRT) in stereotactic radiosurgery for pituitary adenomas.

Methods: Nine patients with pituitary adenomas were selected among patients receiving single-fraction stereotactic proton radiation therapy (PRT) between 2016 and 2017. These cases were re-planned with XRT volumetric-modulated arc therapy (VMAT) with 2.5mm and 5mm multileaf collimators (2.5XRT and 5XRT, respectively). PRT using a dedicated passive scattering stereotactic proton unit with collimated and range compensated ports was delivered via three equally or unequally weighted isocentric fields. XRT VMAT plans were constructed with up to 6 partial arcs to minimize dose to organs at risk (OAR) and avoid direct irradiation or exit dose through the eyes. Plans were generated using the original total treatment dose delivered in one fraction.

Results: Plans were evaluated for clinical target volume (CTV) dosimetry and estimated clinical toxicity. Average target volume was 2.51ml (range 0.57 - 7.88) treated to an average dose of 17.5 Gy(RBE) (range 15-20). There was no statistically significant difference in V100% (91.0%, 93.3%, 95.3%), V95% (93.9%, 95.9%, 97.2%) or V90% (96.3%, 97.3%, 98.3%), Homogeneity index (1.11, 1.12, 1.11) or Gradient index (1.12, 1.08, 1.05) between PRT, 5XRT, 2.5XRT, respectively. 5XRT offered equal or superior V90%, V95% or V100% compared to PRT for 7, 5 and 8 of 9 cases, respectively. 2.5XRT offered equal or superior V90%, V95% or V100% compared to PRT for 9, 9 and 8 of 9 cases, respectively. The Dmax%, highest percent of prescription dose to a 0.1ml volume of CTV, was lower with PRT compared to 5XRT and 2.5XRT (99.7%, 112.2% and 110.9%), $p<0.001$. The Conformity index was significantly higher for PRT (1.97) than 5XRT (1.63, $p= 0.046$) and 2.5XRT (1.63, $p= 0.017$). The maximum dose to OAR, highest dose in Gy delivered to a 0.1ml volume, was significantly lower with PRT compared to 5XRT and 2.5XRT for optic nerves (4.72, 5.73, 5.67), cochlea (0.01, 1.53, 1.49) and hypothalamus (1.71, 3.94, 3.77), $p<0.002$. The maximum dose to OAR did not significantly differ for the eye globe, optic chiasm, temporal lobes, brain stem or whole brain. The average whole brain volume receiving 12Gy was higher for PRT than 2.5XRT (4.69ml versus 4.14ml, $p <0.05$), however, there was no significant difference in the whole brain volume receiving 16Gy, which is predictive of radiation necrosis.

Conclusions: PRT, 5XRT and 2.5XRT demonstrate comparable target volume dosimetry. VMAT typically provides equal or superior CTV coverage but with higher Dmax%. PRT has a higher >1

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Published 03/21/2019

conformity index indicating that the irradiated volume is greater than the CTV. The maximum dose to OAR including critical proximal structures such as the optic nerve and hypothalamus was significantly lower with PRT. The V16Gy was comparable between modalities, however, the V12Gy was lowest for 2.5XRT. In clinical scenarios where dose to critical OAR is limiting, PRT may offer superior organ sparing.