Hippocampal Sparing Radiotherapy in adults with Primary Brain Tumours: A comparative planning and dosimetric study using IMPT, IMRT and 3DCRT.

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Introduction

The majority of patients with primary brain tumours are treated with radiotherapy for local tumour control. Impaired neurocognitive function (NCF) following brain irradiation is positively associated with radiation dose to the temporal lobes and, more specifically, with dose to the hippocampi.

We assessed the feasibility of hippocampal sparing in adults with primary brain tumours using Intensity Modulated Proton Therapy (IMPT) and compared this with Intensity Modulated Radiotherapy (IMRT) and 3D-Conformal Radiotherapy (3DCRT).

Methods and Materials

20 patients were identified, and each patient underwent a radiotherapy planning CT scan and 2 MRI scans. A preoperative diagnostic MRI scan was fused with the planning CT and used for target delineation and a dedicated 3T Planning MRI scan at the time of planning was fused with the CT for accurate hippocampus delineation.

3 hippocampal sparing plans were generated for each patient with specific prescriptions (54Gy/30 fractions, 60Gy/30 fractions and 59.4Gy/33 fractions) using IMPT, IMRT and 3DCRT. Hippocampal sparing was defined as median dose to contralateral hippocampus ≤25Gy without compromising target coverage and organ at risk dose constraints. The IMPT and IMRT plans were created using the Philips Pinnacle³ TPS while the 3DCRT plans were created using the Oncentra Masterplan TPS.

The IMPT plans were robustly optimized to account for both range and setup uncertainties (3.5% range uncertainty and +/-5mm setup uncertainties in all directions).

Results

Hippocampal sparing was achieved in 19 patients (95%) with IMPT, 16 patients (80%) with IMRT and 13 patients (65%) with 3DCRT. The largest median hippocampal dose reduction was seen with IMPT, with a mean median hippocampal dose of 4.8Gy (range:0.0Gy-24.9Gy), 14.6Gy (range:1.9Gy-21.7Gy), and 16.2Gy (range:2.3Gy-25.0Gy) for IMPT, IMRT and 3DCRT respectively. Hippocampal sparing IMPT failed in one case with the largest tumour volume (650cc) where 2/3 of the hippocampus overlapped the target volume.

Conclusion

IMPT as compared to IMRT and 3DCRT plans showed a trend towards significant and effective hippocampal sparing in adult patients with primary brain tumours. We are currently evaluating this in a larger patient cohort and comparing IMPT with VMAT.

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Figure 1: a. 3D View of the Hippocampus
b. Anatomy of the Hippocampus

Figure 2: a. Diagnostic vs Planning MRI Scan
b. RTOG Atlas vs Planning MRI Scan for this study

Figure 3: IMPT Robust Optimization

Figure 4: Dose Distribution and Error Volume Histogram (DVH) for IMPT, IMRT and 3DCRT for Patient Head05

Figure 5: Median Hippocampal Dose for 6 Patients

Figure 6: Median Hippocampal Dose For all 20 Patients