Multiparametric Processing of Serial MRI during Radiation Therapy of Brain Tumors: 'Finishing with FLAIR?'


Departments: 1Department of Radiation Oncology, University of Pennsylvania School of Medicine, Philadelphia, PA, 2Department of Radiology, University of Pennsylvania School of Medicine, Philadelphia, PA

Purpose/Objective(s): Radiation therapy (RT) is the standard of care for many intracranial tumors. Changes induced by RT in tumor and brain can be assessed by magnetic resonance imaging (MRI), but how specific imaging characteristics change over time with increasing RT dose and the significance of such changes remain less understood. Advances in information processing and software development may facilitate comprehensive characterization of such RT-induced changes. We report results using widely available open-source software tools to analyze serial MRI of patients undergoing cranial RT.

Materials/Methods: Patients with intracranial tumors were enrolled in a clinical study of serial MRI scans performed prior to the start, weekly during, and then one month after completion of RT on the same 1.5T scanner. At each session, T1 (pre and post-contrast), T2, T2 FLAIR, diffusion weighted imaging (DWI), and DSC perfusion MRI were performed. Each image was preprocessed through the following steps: 1) field inhomogeneity correction with the MINC N3 package, 2) rigid registration to a reference T1-precontrast image with FLIRT, 3) removal of the skull and other extraneous matter with FMRIB BET software. A model-based automatic segmentation and registration tool (Gooya A, Biros G, Davatzikos C. IEEE Trans. Med. Imaging 2011; 30(2): 375-390) was then applied, followed by co-registration with the RT dose map. Finally, to measure changes between different time points, DRAMMS software was used to generate deformation maps resulting from the corresponding FLAIR images.

Results: T2 FLAIR, DWI and to a lesser extent DSC showed increasing signal in the region of maximal RT dose. For example, a patient undergoing RT for a bilateral frontal lobe tumor showed progressive increases in FLAIR signal, culminating in a 7.8-fold increase in the FLAIR-enhancing volume from before treatment to after treatment (p < 0.05). Interestingly, specific regions within the tumor showed an increase in FLAIR signal early during RT before subsiding, while other areas showed enhancement only late in the course. The results obtained with other MR sequences will be presented and discussed.

Conclusions: Patients receiving focal RT for intracranial tumors showed increased MR signal detectable as early as after 10 Gy, with further increases in signal at escalating doses to 60 Gy. To our knowledge the results obtained may be the first detailed characterization of weekly changes in MRI parameters during a course of fractionated RT. Open-source software can be utilized to efficiently calculate changes in the parameters over time. These methods may allow an assessment of specific parameters that predict treatment success, side-effects, or other clinically relevant endpoints such as edema or blood-brain barrier integrity.