Study of contrast-enhanced T1-w MRI markers of cerebral radiation necrosis manifested in head-and-neck cancers, primary, and metastatic brain tumors: Preliminary findings

Prateek Prasanna[1], Pallavi Tiwari[1], Archana Siddalingappa[2], Leo Wolansky[2], Lisa Rogers[2], Tai-Chung Lam[3], Victoria To[3], and Anant Madabhushi[1]
[1]Case Western Reserve University, Cleveland, OH, United States, [2]University Hospitals, Cleveland, OH, United States, [3]Tuen Mun Hospital, Hong Kong, China

Target audience: Neuro-radiologists, MR imaging researchers, brain tumor researchers.

Purpose: Cerebral radiation necrosis (RN) is the most severe form of irreversible radiation-induced injury caused due to aggressive radiation in primary, metastatic brain tumors, as well as nasopharyngeal carcinoma. Unfortunately, in primary as well as metastatic brain tumor cases, identification of RN is extremely challenging on conventional MRI due to, (a) its close resemblance to tumor recurrence[2], and (b) presence of recurrence/residual tumor confounding the imaging characteristics associated with RN[1]. The treatment regimens for RN and tumor recurrence are completely different and need to be accurately identified for timely patient management. Currently the only definitive diagnosis of RN is via surgical intervention. There is hence a pressing need for identification of MRI markers for RN in as many as 24% of brain tumor patients[1] who currently undergo unnecessary surgical interventions for disease confirmation. It is established that RN in nasopharyngeal carcinoma is unadulterated with no cancer presence in the lesion; with reported MRI markers identified as increased T1 contrast enhancement in the radiated area with central hypo-intensity and increased edema[2] (Fig 1(a)). In this work, we present the initial results of studying imaging differences of cerebral RN on Gadolinium contrast-enhanced (Gd-C) T1-w MRI obtained from a unique cohort of patients treated for (a) nasopharyngeal carcinoma, (b) Glioblastoma Multiforme (GBM), and (c) metastatic brain tumors. Ability to identify changes in imaging characteristics on "pure" RN with no cancer presence as observed in nasopharyngeal carcinoma, may allow for improved understanding of the changes in imaging characteristics on "mixed" RN on account of cancer presence in brain tumors.

Parameters	Inst A	Inst B	
Tumor type	Nasopharyngeal carcinoma	GBM	Metastatic brain tumors
Matrix size	256 x 256	256 x 256	256 x 256
TR	620	250	250
TE	20ms	2.48ms	2.48ms
# of cases	14	10	8

Table 1: Acquisition parameters for Gd-C T1-w MRI for 2 institutions, fast spin echo sequences used in all cases

Methods: A total of 32 Gd-C T1-w MRI studies were retrospectively obtained from 2 institutions (Table 1). Studies for institution 1 were confirmed cases of "pure" RN from nasopharyngeal carcinoma, while studies for institution 2 were histologically confirmed for >80% RN by an expert neuro-pathologist, obtained for GBM as well as metastatic brain tumors. Post-processing of each dataset involved: (a) correcting for bias field, occurring due to varying magnetic field[3], and (b) harmonizing image intensities to a template intensity distribution[3] to account for inter-site scanner variability, such that different tissue regions were each mapped to specific intensity ranges, thus giving them a tissue region-specific meaning.

Results and Discussion: Fig 1(d) shows the box-and-whisker plots of normalized Gd-C T1-w MR intensities for RN on nasopharyngeal carcinoma, GBM, and metastatic brain tumors. It is interesting to note that the MR intensity ranges for "pure" radiation necrosis appear similar to metastatic brain tumors, as compared to GBM, suggesting similar manifestation of RN characteristics across the two disease types. The similarity in MR intensity values for RN from nasopharyngeal carcinoma and metastatic brain tumors may be accounted to the similar nature of the two conditions. Similar to metastatic brain tumors, RN for nasopharyngeal carcinoma occurs secondary to the original site of treatment. The high standard deviation in intensity values for GBM and metastatic brain tumors may be reflective of the "mixed" RN confounded by presence of other tissue types that coexist within the lesion. The variability in GBM is similarly higher due to the known heterogeneity associated with the disease.

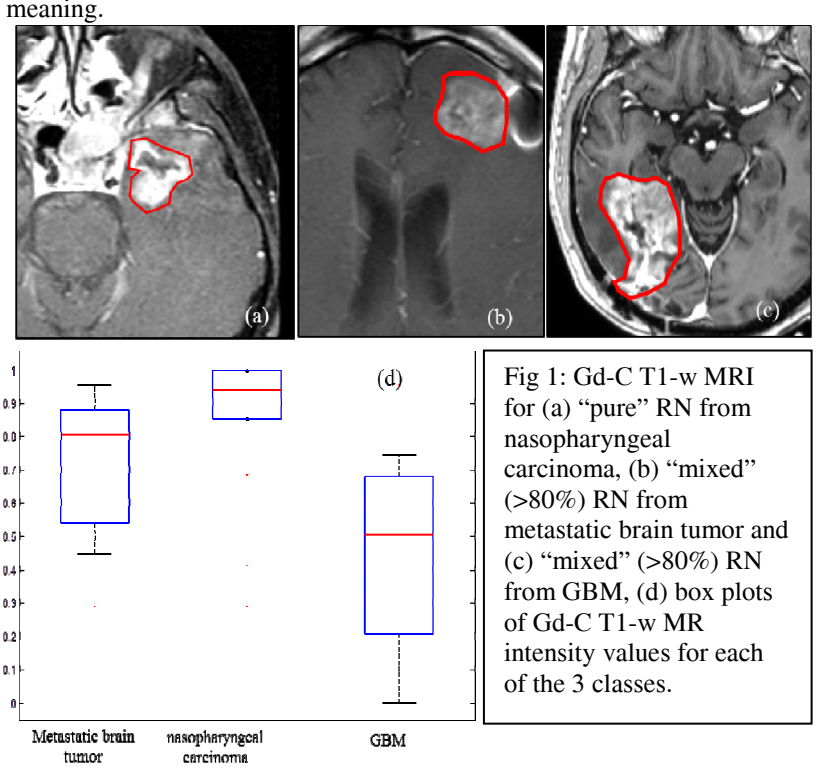

Fig 1: Gd-C T1-w MRI for (a) "pure" RN from nasopharyngeal carcinoma, (b) "mixed" (>80%) RN from metastatic brain tumor and (c) "mixed" (>80%) RN from GBM, (d) box plots of Gd-C T1-w MR intensity values for each of the 3 classes.

Conclusion: We presented the initial results to study Gd-C T1-w MRI characteristics of cerebral RN in patients with nasopharyngeal carcinoma, GBM, and metastatic brain tumors. Understanding MRI characteristics for "pure" cerebral RN on nasopharyngeal carcinoma can potentially allow for identification of non-invasive MRI markers for RN in patients with primary and metastatic brain tumors, currently an extremely challenging problem in management of brain tumor patients.

References: [1]Kumar et al Radiology (2000), [2]Lam et al. Int. J. Rad. Onc. Biol. Phys (2012), [3]Madabhushi et al. Med Phy (2006).