Multiparametric MR studies for Monitoring Treatment Response of Human Head and Neck Cancer

S. Kim[1], L. A. Loevner[1], H. Quon[2], M. Rosen[1], O. Hsu[1], and H. Poptani[1]

[1]Department of Radiology, University of Pennsylvania, Philadelphia, PA, United States, [2]Department of Radiation Oncology, University of Pennsylvania, Philadelphia, PA, United States

Introduction: The availability of non-invasive and reliable methods for prediction and detection of early response of head and neck (HN) tumors will facilitate rational design and optimization of therapeutic strategies. Such indices would spare non-responsive patients unnecessary toxicity and help in reducing patient care costs. The purpose of this study is to evaluate the utility of physiologically-sensitive MRI parameters, such as T_2, apparent diffusion coefficient (ADC), and contrast enhancement, as early indicators of local HN tumor response to chemo-radiation therapy.

Method: Data were acquired from fourteen patients with newly diagnosed squamous cell carcinoma of the head and neck, who were treatment naïve. The institutional review board approved this study, and written informed consent was obtained from all subjects before the scans. All patients had palpable metastatic cervical lymph nodes that were identified by a head and neck radiologist and used as the primary imaging targets. A neck array coil was used for imaging on a 1.5T Siemens Sonata scanner (Siemens Medical Systems, Iselin, NJ). T_2 weighted images (TR/TE = 2 s/13 ms) were acquired initially to locate the tumor. Eight axial slices with an FOV of 26 cm and slice thickness =5 mm were used to cover the tumor region. For T_2 mapping, T_2 weighted images were acquired using a fast spin echo sequence with 4 different echo times; 13, 53, 80, and 110 ms. Diffusion weighted imaging (DWI) was performed using a PGSE/EPI sequence with four b-values; 0, 500, 1000, and 1500 s/mm^2. Prior to the injection of contrast agent, a series of T_1 weighted images were acquired using an inversion recovery prepared turbo FLASH 3D sequence with 5 different inversion times (TI). DCE-MRI was performed using a fast 3D spoiled gradient-echo radial sequence, which provides flexibility to reconstruct images with various spatial and temporal resolutions as described previously [1]. Baseline pre-injection images were acquired for 1 minute. A single dose of Gd-DTPA (Omniscan; Nycomed) with a concentration of 0.1 mM/kg was injected at 1 mL/s into an antecubital vein, followed by saline flush with a power injector (Medrad, Idianola, PA), during which scanning was continued for another 9 minutes. K^{trans} values were measured from the tumor using the Tofts model [2] and the signal from the carotid artery adjacent to the tumor was used as the arterial input function (AIF). Image reconstruction and data analysis software were developed using IDL (RSI, Boulder, CO). The study was repeated three times; before the treatment (pre-x), one week after initiation of treatment (post-1) and the last one after completion of the treatment (post-2) to monitor changes in MR parameters.

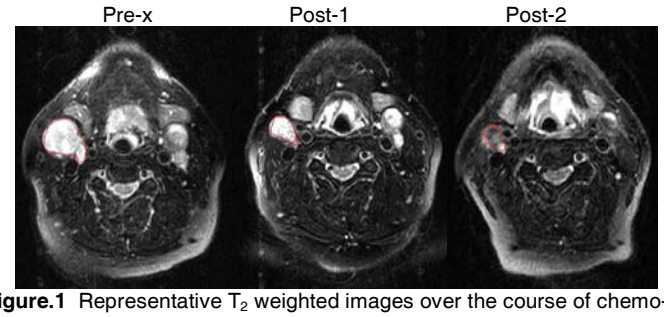

Figure.1 Representative T_2 weighted images over the course of chemo-radiation treatment. The red line is used to delineate the tumor area used for analysis.

Results and Discussion: A representative example of a patient with HN tumor is shown in Fig.1 that demonstrates a gradual decrease in the tumor volume. To assess the sensitivity of tumor volume changes as a marker for therapeutic response, a change in tumor volume between the first and second scan was plotted against the change in tumor volume between the first and third scan. The nodal volume in six patients remained same or slightly increased at the second study, which decreased to below 50% of the initial volume at the third study. Thus, it appears that tumor volume cannot be reliably used for monitoring early response. The mean pre-x ADC value showed a strong correlation (R^2=0.61) with the remaining volume fraction at post-2 as shown in Fig.2(b) suggesting a possible role for ADC in predicting response. No other indices such as variance, skewness, and kurtosis of T_2, ADC, and K^{trans} showed any significant trend.

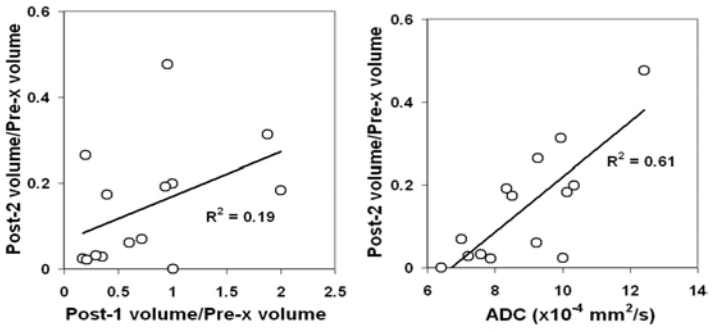

Figure.2 Comparison of final volume fraction with early volume change (a) and pre-treatment mean ADC values (b).

The treatment response was categorized into two groups: complete response (CR) (n=11) with the residual tumor volume at the end of the study being less than 20% of the initial volume and partial or no response (PNR) (n=3) with > 21 % of the initial tumor volume. Fig.3 shows the changes of mean MRI measures following treatment within CR and PNR groups. The PNR group appears to have longer T_2, higher ADC, and lower K^{trans} values than the CR group. However, due to a large inter-subject variability, significant difference between CR and PNR was found only with ADC at post-2 (69% higher in PNR, p=0.015) and K^{trans} at post-1 (180% higher in CR, p=0.041). However, when the changes in these indices were measured within a group, the T2, ADC and K^{trans} in CR group increased initially, but then decreased, while in the PNR group, these values either increased or decreased steadily over time. These preliminary findings in a small cohort indicates the potential of multi-parametric MRI in prediction and monitoring of therapeutic response in head and Neck cancer.

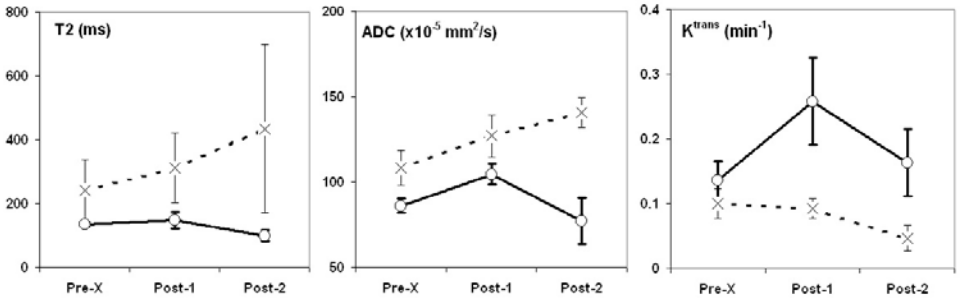

Figure.3 Changes in MRI measures following treatment. The circles and solid lines represent complete responders (n=11) whereas crosses and dashed lines represent partial or non responders (n=3). Error bars represent standard errors.

References: [1] Kim et al, ISMRM 229, 2005.
[2] Tofts et al., JMRI 10:223-232, 1999.

Acknowledgement: This study was funded by the NIH grant RO1 CA102756.