Dynamic Contrast Enhanced and Diffusion Weighted MRI from Primary Tumors and Metastatic Cervical Lymph Nodes in Squamous Cell Carcinomas of the Head and Neck

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Introduction: Dynamic contrast-enhanced MRI (DCE-MRI) derived volume transfer constant ($K^\text{trans}$) and diffusion weighted imaging (DWI) has been used in characterization¹–³, monitoring treatment response¹–³ and in prediction of survival⁴ in squamous cell carcinomas of head and neck (HNSCC) patients. However, majority of these studies have reported $K^\text{trans}$ and ADC values from metastatic cervical lymph nodes²–⁴. In comparison to the metastatic node, $K^\text{trans}$ and apparent diffusion coefficient (ADC) measurements from primary tumor are challenging, as these tumors are generally located in areas prone to artifacts induced by continuous physiologic motion. The current DCE-MRI study was performed using a radial imaging technique along with dynamic K-space weighted image reconstruction contrast (KWIC)⁵ to reduce motion sensitivity and assess the primary tumor mass. In addition, motion correction algorithms⁶ were performed to further reduce motion artifacts in the DCE-MRI and DWI data. Correlation analysis of $K^\text{trans}$ and ADC from the primary tumor and metastatic node was then performed to assess the utility of these methods in the primary tumor site.

Methods: Twenty-eight patients with HNSCC underwent anatomical imaging, DCE-MRI and DWI. DCE-MRI was performed using a fast 3D spoiled gradient-echo sequence, which was modified to acquire eight angle-interleaved sub-aperture images from the full-echo radial data. The imaging parameters were: 256 readout points/view, 256 views (32 views/subaperture, 8 subapertures), fat saturation was applied once every 8 excitations. Spatial saturation was applied every 32 excitations to minimize the flow effect while minimizing the scan time. This data acquisition scheme resulted in a temporal resolution of 2.5 s for each sub-aperture image with full spatial resolution of $256 \times 256$ by using KWIC algorithm.⁵,⁹ Gd-DTPA was injected at a dose of 0.1 mmol/kg body weight at 1 ml/s followed by saline flush, during which scanning was continued for another 9 minutes. DWI was acquired using a pulsed gradient spin-echo/echo planar imaging sequence with three b values: 0, 500, and 1,000 s/mm². Pharmacokinetic model analysis of DCE-MRI data was performed to generate pixel wise $K^\text{trans}$ maps using the generalized kinetic model⁶. Similarly, pixel by pixel ADC maps were also computed. All anatomical images, $K^\text{trans}$ and ADC maps were co-registered using a two-step non-rigid image registration technique to minimize motion artifacts. First 3D registration with affine transformation was performed to minimize global misalignment. Subsequently, a fine 2D registration scheme was applied.⁸,⁹ Furthermore, view dependent phase correction methods were applied to reduce both rotational and translational motions.⁸ Median pretreatment $K^\text{trans}$ and ADC values were computed from regions of interest on the primary tumors and largest nodal masses. Spearman’s correlation analyses were performed for $K^\text{trans}$ and ADC values between primary tumors and nodal masses. Results: Co-registered anatomical images, $K^\text{trans}$ and ADC maps from a representative HNSCC patient are shown in Figure 1. We observed a significantly high correlation ($r=0.684$, $p<0.001$) for $K^\text{trans}$ between primary tumors and nodal masses. Moderate but significant correlation ($r=0.407$, $p=0.031$) was also observed between ADC of primary tumors and lymph nodes (Fig. 2).

Discussion and Conclusion: In spite of greater vulnerability of DCE-MRI being corrupted due to motion from primary tumors, we observed good quality of $K^\text{trans}$ maps in 89.28% of the cases (only 3 of the 28 cases had to be dropped because of severe motion). We used radial pulse sequence to minimize motion artifacts as well as to achieve a high temporal resolution of 2.5 s. Moreover, motion correction methods and non-rigid registration were also used to eliminate the misalignment among the anatomical images and parametric maps. We believe that combination of these two approaches substantially improves the estimation of $K^\text{trans}$ from both primary tumors and nodal masses. Significant correlations of $K^\text{trans}$ and ADC values between primary tumors and nodal masses suggest that both lesions have similar biological and physiological characteristics. As several head and neck cancer patients only have a lesion at the base of tongue (N=0 staging), the ability to achieve high quality $K^\text{trans}$ and ADC maps from these regions may aid in evaluating diagnostic and prognostic role of DCE-MRI and DWI in primary tumors.