Quantitative Analysis of DCE-MRI Kinetic Parameter Deviation Induced by Dual-flip-angle T1 Mapping in Head and Neck
Jing Yuan1, Steven Kwok Keung Chow1, David Ka Kwai Yeung1, Anil T Ahuja1, and Ann D King1
1Imaging and Interventional Radiology, The Chinese University of Hong Kong, Shatin, NT, Hong Kong

Introduction: T1 mapping is essential for DCE-MRI kinetic model analysis. Multiple-flip-angle (MFA) method [1] is preferable for DCE T1 mapping due to its superior signal-to-noise ratio (SNR) and time efficiency. Dual-flip-angle (DFA) [2] reduces the FA numbers to 2 to maximize the time efficiency, however, potentially decreases the T1 measurement accuracy and leads to errors in kinetic model analysis. Although good T1 accuracy by DFA has been reported in brain with optimized flip angles, it may not be readily used for head and neck (HN) DCE-MRI where low SNR, low spatial resolution, tissue heterogeneity and susceptibility typically present. Therefore, we aimed to experimentally evaluate whether DFA could obtain accurate kinetic parameter estimation compared to MFA for DCE-MRI in HN in this study.

Methods: 23 patients with HN squamous cell carcinoma received DCE-MRI at 3T, with T1w spoiled gradient echo sequence. Informed consents were obtained. Gd-DOTA (0.1mmol/kg) was injected intravenously at 2.5mL/s using a power injector pump, followed by a 20-ml saline flush (2.5mL/s). TR/TE=3.9ms/0.9ms, FA=15º, FOV=230mm, matrix =128x128, thickness=4mm, SENSE factor =4, dynamics=185, and temporal resolution=2.59s/dynamic. Pre-contrast images were acquired with four FAs of 2º, 7º, 12º and 15º for T1 mapping based on the suggested values in literatures [3]. Other imaging parameters were identical to DCE acquisition. MFA and DFA T1 maps were calculated with all four FAs, and FA pairs of [2º, 7º], [2º, 12º], [2º, 15º], [7º, 12º] and [7º, 15º] by the least-square fitting of the theoretical equation for spoiled gradient echo signal intensity (Fig. 1). kp, Ktrans and vp maps for extended Tofts model were generated based on MFA and DFAs using an automated extracted arterial input function (AIF) [4]. A literature arterial blood T1 of 1550ms at 3T was used to compensate the reduced T1 measurement due to the in-flow effect. Hematocrit was set as 0.42. kp, Ktrans, and vp by MFA and DFAs were compared for primary tumors (PTs), salivary glands and muscles. A Kruskal-Wallis test was performed (significant p-value level 0.05).

Results: The DFAs of [2º, 7º], [2º, 12º], and [2º, 15º] overestimated, while [7º, 12º] and [7º, 15º] underestimated Ktrans and vp significantly in PTs, muscles and salivary glands (Fig. 2). [2º, 15º] obtained the smallest but still significant overestimation for Ktrans and vp in PTs, 32.1% and 16.2% respectively. Kp estimates by DFAs were relatively closed to the MFA reference, without significant difference from the MFA reference except for kp estimate by [2º, 7º] in salivary glands. T1 mapping error induced by DFAs seemed to have the greatest influence on the estimate of Ktrans in PTs and salivary glands, and vp in muscles.

Discussion: Although T1 mapping accuracy could be improved by the optimized flip angles such as [2º, 15º], the T1 map difference could still be significant due to the limited SNR and susceptibilities for HN DCE-MRI images. Inaccuracy of T1 mapping could propagate through tracer concentration into kinetic model fitting and lead to significant errors in kinetic parameter estimates. kp is insensitive to T1 because it is only dependent on the time-intensity curve pattern instead of the absolute T1 values. If scan time permits, multiple flip angles rather than dual flip angles are suggested for T1 mapping in DCE-MRI studies to ensure accurate quantitative pharmacokinetic model analysis.

Acknowledgement: This work is supported by HK GRC grant CUHK4660088 and SEG_CUHK02.