Multi-Slice Parametric Mapping in Prostate DCE-MRI

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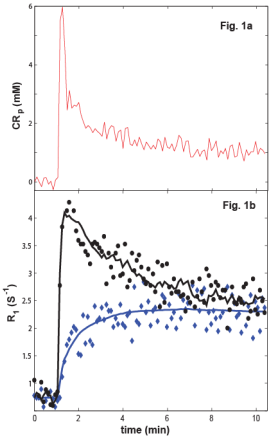
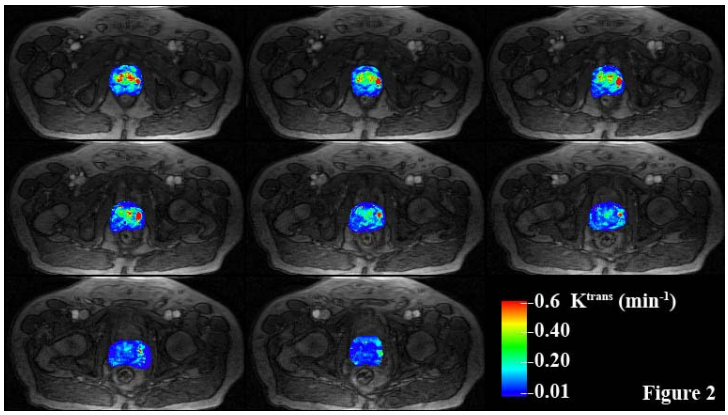
Introduction: Pharmacokinetic analysis of data generated using Dynamic-Contrast-Enhanced MRI (DCE-MRI) has proven to be a valuable tool in the evaluation of the vascular pathophysiology of prostate adenocarcinoma. With improved hardware, multi-slice parametric mapping has become feasible and could provide valuable insight to complement conventional T_2*-weighted images. In this study multi-slice parametric mapping was performed with DCE-MRI data using both the standard model (SM) and the first generation shutter-speed model (SSM1). Parametric maps were then compared with biopsy results.

Method: Prostate ^1H_2O MRI data were acquired on 18 subjects with a Siemens TIM Trio (3T) system under an IRB-approved protocol. RF transmitting was through the whole body coil and RF receiving was with a combination of Spin Matrix and flexible Body Matrix RF coils. The DCE-MRI sequence employed a 3D TurboFLASH sequence with a 256*144*16 matrix size and a 360*203 mm^2 field of view, resulting in an in-plane resolution of 1.4 * 1.4 mm^2. Other parameters are: slice thickness: 3 or 3.2 mm; TR/TE/FA: 5.0 ms/1.57 ms/15º, imaging intersampling interval: 6.28 s. A CR bolus (Prohance; Bracco Inc.) of 0.1 mmol/kg was administered ~30 s after commencing the DCE-MRI sequence. All patients subsequently underwent standard ten core prostate biopsy performed using ultrasound guidance.



Results: Fig. 1a shows the Arterial Input Function (AIF) measured from a femoral artery, amplitude was adjusted using the obturator muscle as reference tissue. Single pixel R_1 time-course data from lesion (black circles) and normal prostate (blue diamonds) tissue are shown in Figure 1b, and the color matched solid curves show the corresponding SSM1 (3) fitting results. Multi-slice parametric mapping was achieved for 11 out of the 18 subjects studied. Severe subject motion during contrast media injection, as well as subject weight, limited chances for successful mappings from the remaining subjects. The vascular physiology of the prostate and prostate malignancy can be evaluated by pharmacokinetic analysis of DCE-MRI data. The blood vessels within prostate malignancies tend to be more permeable than those within benign tissue (1). Vascular permeability is typically represented by the variable K^{trans} (2). Figure 2 shows a multi-slice K^{trans} (SSM1) color map overlaid on post-injection axial pelvic DCE images. Multi-slice parametric mapping demonstrates a region of high relative K^{trans} values in the left peripheral zone of the prostate (right side of image) in 6 contiguous image slices. This is concordant with the surgical pathology report which demonstrated adenocarcinoma in four core biopsy samples taken from the left prostate base, left mid prostate, and left prostate apex. Multi-slice mapping allows for evaluation of the entirety of the prostate gland facilitating definition of the extent of tumor within the gland. Additionally, expanding the ROI studied beyond the anatomic margins of the prostate gland may allow for evaluation of extracapsular spread of disease thereby assisting in appropriate staging of prostate cancer. Fig. 1b shows R_1 [$\equiv (T_1)^{-1}$] (a measure of Gd concentration) DCE time-courses obtained from two regions of interest in the peripheral zone of the prostate. The blue curve was generated from a region of the peripheral zone not suspected of harboring malignancy based upon relatively low regional K^{trans} values on multi-slice mapping. The black curve was generated from an ROI within the region of relative high K^{trans} values in left peripheral zone thought representative of malignancy. The rapid uptake and washout seen in this curve is typical of prostate malignancies. This further supports concordance of multi-slice mapping and the results of surgical pathology.

Discussion: For the small subject group we have, SSM1-returned average intracellular water lifetime of less than 0.3 s, somewhat lower than others have reported (4). This makes the difference between SM1 and SSM1 small. However, elevated K^{trans} is still more noticeable in the lesion area when using SSM1. In Figure 2 a region of relative high K^{trans} values is seen in the left lateral peripheral zone in 5 slices. This correlates well with the pathologic report and on additional subjects similar results have been seen. In light of these observations and those reported in the literature, it seems clear that pharmacokinetic analysis of DCE-MRI data has the capacity to be a valuable clinical tool in the detection and evaluation of prostate malignancy. With new MRI sequences, such as TWIST (Siemens), now readily available, multi-slice parametric mapping will become feasible and allow for evaluation of the entirety of the prostate and malignancy therein. This is a necessity should this technique be adopted for routine clinical use.



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Reference: **1.** Choyke, Dwyer, Knopp,. *J magn Reson Imaging* 17:509-520 (2003) **2.** Tofts, Brix, Buckley, *J Magn Reson Imaging,* 10:223-232 (1999). **3.** Yankeelov, Rooney, Li, Springer *Magn Reson Med.* **50**:1151-1169 (2003). **4.** Lowry, Zelhof, Liney, Gibbs, Pickles, and Turnbull, *Invest. Radiol,* **44:** 577–584 (2009).