Simulation of Optimized Time-Resolved Segmented Elliptical-Centric 3D TRICKS for Abdominal MRA

Oliver Wieben , Walter F. Block, Charles A. Mistretta

Departments of Electrical & Computer Engineering, Medical Physics, and Radiology, University of Wisconsin-Madison, Madison Wisconsin, USA 53792-3252

INTRODUCTION: The use of 3D TRICKS [1] for breath-hold abdominal MRA involves a tradeoff of spatial resolution for temporal resolution [2]. This work aims to simulate a sequence that should provide a vessel-segmented time-resolved series of increased resolution. The method separates k-space into eight elliptical annuli of equal volume, labeled TRICKS regions A-G as the k-space radius increases. During contrast passage the time-resolved TRICKS images are formed. Our group has recently developed a system that can be used to display and analyze data in real-time [3]. Real time detection of the signal permitting ongoing flip angle optimization [4] is assumed. Following detection of venous opacification, the A sections are reduced from 2 sec to 1 sec permitting acquisition of higher spatial frequencies. Continued acquisition of the A sections provides information for continued flip angle optimization and MTF correction (contrast re-weighting).

METHODS: The time frames are used for the segmentation of arteries, veins, and the parenchyma based on their contrast uptake curves using VTRAC [5]. The simulation assumes a 33 s scan, thus allowing the sampling of 160 phase encodes and 40 slices with a TR of 5.1 ms and a frame rate of 3 seconds. The simulation was based on the DSA image shown in Figure 2 and perfomed in the k_y-k_z plane. The signal enhancement curves were derived from a PR TRICKS exam of a volunteer [6] (Fig. 1). The DSA image was weighted with arterial enhancement. A second image slice modeled the renal parenchyma with 2 circular objects. Simulations were performed assuming various scan delays for the TRICKS and traditional elliptical centric [7] acquisitions. MIP images were generated using the arterial and parenchymal slice.

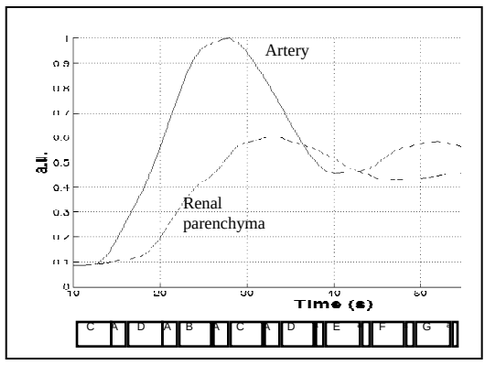

Fig 1 Signal enhancement in the renal artery (solid line) and the renal parenchyma (dashed line).

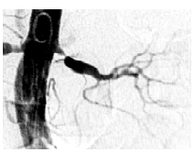

Figure 2- DSA image used for simulations. Simulated MR images were assumed to have readout in AP direction to show the effects of contrast modulation in the ky-kz plane

Noise was added and an arterial contrast curve was measured from the acquired TRICKS A sections. The inverse curve was used to weight the k-space data to achieve a flat contrast weighting (MTF restoration). With such a curve it is also possible to optimize flip angle based on real time estimates of blood T1.

Results: Figure 3 shows simulated conventional EC and modified EC TRICKS examinations performed scan initiation 5 s before (a), on (b) and 5 s after the arterial peak The TRICKS examinations are assumed to have been segmented using the VTRAC algorithm which segments out the representation of the renal parenchyma from the central 1/4 of k-space but retains the signal from the outer 3/4. The parenchymal enhancement can dominate the small renal vessels. The extent of this depends on timing.

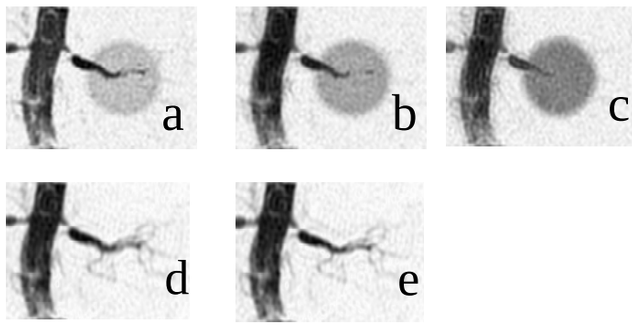

Figure 3 Simulated EC scans with time delays of –5 (a), 0 (b) and 5 (c) s relative to the arterial peak. Simulated TRICKS scans with A sections I time with (d) and delayed 5 seconds (e) relative to the arterial peak. Round circle indicates parenchymal enhancement.

Figure 4 shows the effect of flip angle optimization and MTF correction.

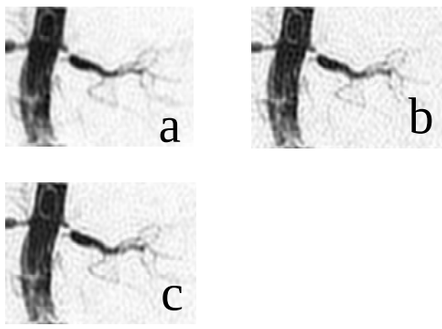

Figure 4 TRICKS images with flip angle optimization (a), MTF correction (b), flip angle optimization + MTF correction (c).

Conclusions The combined effects of EC TRICKS encoding, real time flip angle optimization, MTF correction, and segmentation should provide a time-resolved series with increased spatial resolution relative to conventional TRICKS. The technique should provide improved visualization of small vessels in the renal parenchyma and reduce dependence on timing.

References

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