

Robust Renal MRA using Breath-hold, IR-prep, Dixon bSSFP at 3T

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INTRODUCTION: Non-contrast-enhanced MR angiography has regained popularity since the early 90s due to developments in hardware, discovery of nephrogenic systemic fibrosis (NSF), and high cost of gadolinium-based contrast agents in certain countries [1]. The population most susceptible to NSF are patients with severe renal dysfunction; this work aims to develop and evaluate a fast, robust method of diagnostic imaging for these patients who have a contraindication to contrast-enhanced (CE) MRA. We compare, in patients, the use of an IR-prepared balanced steady-state free-precession (bSSFP) Dixon sequence [2], which achieves **3D imaging of the renal arterial vasculature within a breath-hold (20-30 seconds)**, to a commercially available technique Inhance IFIR (GE Healthcare) [3] at 3T.

METHODS: IR-prep, Dixon bSSFP has several advantages: relative motion-insensitivity due to breath-hold, robust fat suppression especially at 3T, and the high T_2/T_1 contrast and SNR efficiency of bSSFP. A novel k -space scheme allows for high spatial resolution and coverage (Fig. 1). The main differences between our technique and Inhance IFIR are that (1) Inhance IFIR is respiratory-gated instead of breath-held, and (2) uses a fat-selective inversion pulse instead of Dixon for fat suppression.

Study: Nine patients referred for abdominal MRI were recruited and scanned using 3T systems (MR750, GE Healthcare, Waukesha, WI). All patients were examined according to our institution's IRB guidelines. Four acquisitions were added to the protocol as shown in Table 1. Common imaging parameters were: TR 4.7 ms; TI 1.4 s; flip angle 60°; FOV 32×26 cm; matrix 256×180; 44-50 slices; slice thickness 1.4 mm; readout bandwidth ±125-147 kHz; 800 views-per-segment; auto-calibrated parallel imaging (ARC effective acceleration 2×); 2× slice interpolation. The images were anonymized and scored by two radiologists on 5-point scales; visualization of the main and segmental renal arteries (1: non-diagnostic, 2: limited, 3: diagnostic, 4: good, 5: outstanding), and overall image quality (1: unsatisfactory, 2: poor, 3: average, 4: good, 5: excellent). Statistical analyses were made using the Kruskal-Wallis test and Mann-Whitney test with Bonferroni correction.

RESULTS: A total of 38 scans were acquired from nine patients: some IR-prep, Dixon bSSFP scans were repeated or missed due to technical error or patient considerations, and three scans were unsuccessful (as the breath-hold was performed on inspiration instead of expiration, resulting in poor image quality / fat-water swaps). Figure 2 plots results from radiologists rankings; group pairs that are significantly different (using Bonferroni-corrected $p < 0.016$) are denoted by a star. All scans provided diagnostic visualization of the main renal artery. As expected due to motion, the free-breathing scan performed the worst. The agreement between both radiologists was fair ($\kappa = 0.27$). Figure 3 shows MIPs from a 65 y.o. patient.

DISCUSSION: ECG-gated, breath-hold, IR-prep, Dixon bSSFP provided comparable overall image quality and visualization of renal arteries to Inhance IFIR (which has been shown to have good agreement with CE MRA [3]). These high quality angiograms were routinely obtained in our quick, 20-30-s scan. Improvements to fat-water separation reconstruction in the presence of poor B_0 homogeneity will further increase the reliability of the technique.

CONCLUSION: A robust, breath-hold sequence has been evaluated to provide **diagnostic quality renal MR angiograms** comparable to a commercially available sequence, with **much shorter scan time** and without compromising spatial coverage and resolution. The shorter scan time may permit wider integration into abdominal MR protocols.

ACKNOWLEDGEMENTS: Funding by GE Healthcare & NIH RR009784.

REFERENCES: [1] Miyazaki, Radiology 248:20-43, 2008. [2] Saranathan, ISMRM p3774, 2010. [3] Glockner, JMRI 31:1411-8, 2010.

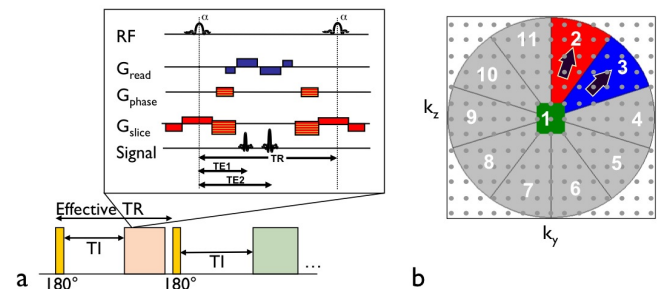


Figure 1: (a) Pulse sequence diagram of IR-prep, Dixon bSSFP. (b) k -space coverage: the central square is acquired after the first IR pulse, followed by the pie segments in the order shown (~5-6 segments or IRs are usually used instead of the 11 shown).

1	Inhance IFIR	Resp.-gated	Ungated	2-5 min
2	IR-prep, Dixon	Breath-hold	Ungated	20-30 sec
3	IR-prep, Dixon	Free-breathing	Ungated	20-30 sec
4	IR-prep, Dixon	Breath-hold	ECG-gated	20-30 sec

Table 1: Scans added to patient's protocol for comparing IR-prep, Dixon bSSFP to a commercially available Inhance IFIR sequence.

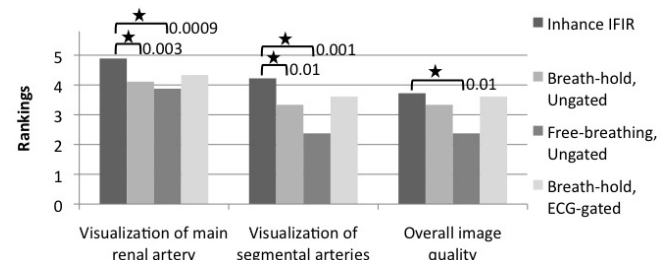


Figure 2: Average scores of artery visualization and overall image quality. Significant differences are represented by the star with p -values. No significant difference was found in any category between Inhance IFIR and ECG-gated, breath-hold, IR-prep Dixon bSSFP.

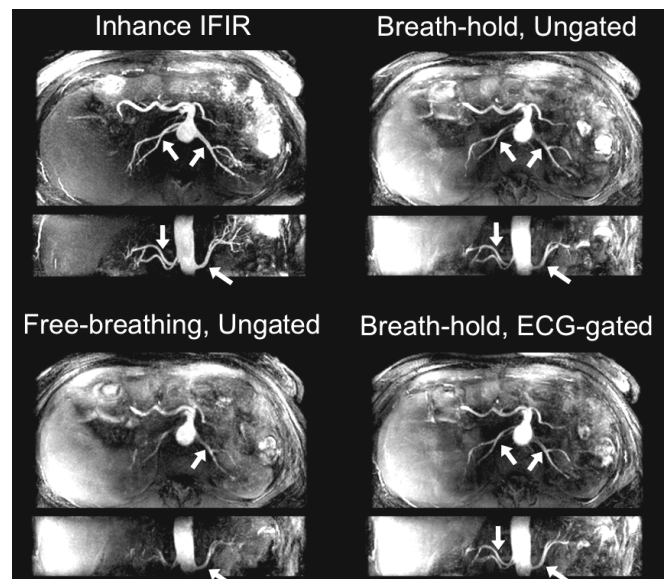


Figure 3: Axial and coronal MIPs from a patient showing good depiction of the main renal arteries (arrows) from Inhance IFIR (3+ min) and IR-prep, Dixon bSSFP (30 s).