Diagnostic Quality Assessment of the bSSFP Dixon Method for NCE MRA

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Introduction: Patients with renal artery stenosis (RAS) are at risk of renal insufficiency (*i.e.*, low estimated glomerular filtration rate, eGFR < 60 mL/min/1.73 m^2) [1], and therefore may be at increased risk of nephrogenic systemic fibrosis linked to gadolinium-based MR contrast agents [2]. The balanced steady-state free precession (bSSFP) Dixon method [3,4] has the capacity for flow-insensitive non-contrast-enhanced (NCE) renal MR angiography (MRA) [5]. Our hypothesis is that the bSSFP Dixon method [4,5] produces diagnostically equivalent NCE renal angiograms compared to conventional contrast-enhanced (CE) renal MRA.

Methods: Ten patients were approached at the time of their clinically indicated 1.5 T CE renal MRA scan and asked to take part in the 3.0 T NCE renal study (8/10 patients agreed to participate). The CE MRA images were collected using a standard coronal protocol from five consenting patients on a 1.5 T clinical MR scanner (Sonata/Avanto, Siemens Medical Solutions, Erlangen, Germany) using a body transmit/receive coil and contrast injection (Gadovist[TM], 15 ml at 1.4 ml/s with 30 ml saline flush). Within a week of their CE scan, the NCE images were collected using a modified 3D axial bSSFP pulse sequence with an elliptic centric phase-encode ordering [6] on a 3.0 T clinical MR scanner (Signa VH/*i*; General Electric Healthcare, Waukesha, WI) using a body transmit/receive coil [5]. The bSSFP Dixon method acquisition parameters were TR = 3.4 ms, TE = 1.7 ms, $\alpha = 25°$, and the centre-frequency offsets were -100 Hz and +100 Hz [5]. The patients were instructed to perform a 15-20-second end-expiration breath-hold during the start of each acquisition, followed by free breathing for the remainder of the acquisition (total scan time ~30 seconds). Water-only (*i.e.*, fat-suppressed) images were generated by complex addition of the ±100 Hz offset images. Both the CE and NCE MRA images were processed using standard angiography software. A vascular radiologist inspected the CE and NCE MRA images for lesion identification and scored both data sets for quality in several renal vascular areas: aorta, ostia, proximal and distal renal arteries, and branching vessels (scoring on a scale of 1 to 5, with 1 being unacceptable and 5 being excellent). A Wilcoxon signed rank test (WSRT) was performed to assess scoring equivalence between examinations.

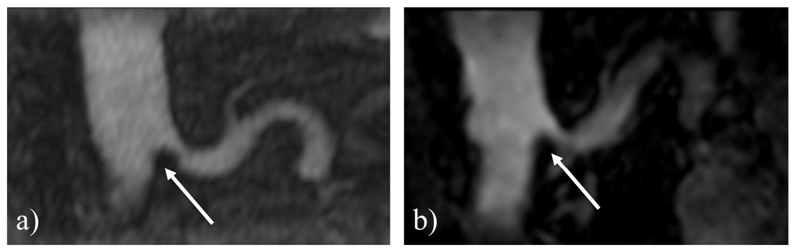

Figure 1: Sample oblique reformatted images from Patient 1 from the left renal artery collected with (a) 1.5 T CE MRA, and (b) 3.0 T bSSFP Dixon NCE MRA. The larger vessel is the descending aorta, along with the left renal artery with RAS (arrows).

Table 1: Comparison between 1.5 T CE MRA and 3.0 T NCE MRA results from all five patients (legend: LRA= left renal artery; RRA=right renal artery; Ost=ostium; Prox=proximal; Dist=distal; Bran=branches; $\tilde{x}$*=median,* q_l*=lower 25%,* q_u*=upper 75%). A vascular radiologist performed scoring on a scale of 1 to 5 (1=unacceptable, 5=excellent). The p-value was determined through a WSRT.*

		CE MRA			**NCE MRA**			***p***
		$\tilde{x}$	q_l	q_u	$\tilde{x}$	q_l	q_u	
LRA	**Ost.**	5.0	5.0	5.0	5.0	4.5	5.0	0.51
	Prox.	5.0	5.0	5.0	5.0	4.5	5.0	0.51
	Dist.	4.0	3.0	5.0	3.0	2.8	3.0	0.11
	Bran.	2.5	1.8	3.3	1.0	1.0	1.0	0.06
RRA	**Ost.**	5.0	5.0	5.0	5.0	4.3	5.0	0.46
	Prox.	5.0	5.0	5.0	5.0	3.5	5.0	0.29
	Dist.	4.0	3.0	5.0	2.5	1.8	3.3	0.16
	Bran.	2.0	1.8	3.5	1.0	1.0	1.3	0.13
Aorta		5.0	5.0	5.0	5.0	4.8	5.0	0.51
Overall		5.0	4.0	5.0	4.0	2.8	4.0	0.07

Results: Figure 1*a* displays the processed CE renal MRA images from Patient 1 with left RAS. Figure 1*b* presents the processed bSSFP Dixon NCE MRA image from the same patient, also demonstrating the left RAS. The data analysis summary from qualitative scoring and WSRT in the eight patients is given in Table 1.

Discussion and Conclusions: The bSSFP Dixon NCE MRA results were similar to the CE MRA results, as confirmed by the WSRT. In all vascular territories, the CE and NCE examinations were statistically similar ($p \geq 0.05$). Both techniques identified left RAS in Patients 1 and 2. A left RAS was identified in Patient 3 in the CE examination but was undetected in the NCE examination. Conversely, a left RAS was identified in Patient 6 in the NCE examination, but not in the CE examination. A major limitation to both techniques is the need for a long end-expiration breath-hold required for sufficient anatomical coverage and high spatial resolution. One suggestion for decreasing the scan time (thus, making the breath-hold more effective) is accelerated data acquisition using parallel imaging techniques. We conclude that these results support the hypothesis that the bSSFP Dixon NCE MRA technique produces diagnostically equivalent images compared to CE MRA. Eliminating the need for contrast agents could have a significant impact on investigation of RAS with MR.

References:

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