SELF-GATED FREE-BREATHING NON-CONTRAST RENAL MRA

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Introduction:

Free-breathing bSSFP non-contrast MR angiography (NC-MRA) with slab-selective inversion preparation has been used for bright blood renal MRA without the need for potentially nephrotoxic contrast agent [1-3]. It typically uses regulated breathing, respiratory bellow, or navigator-gating to alleviate breathing motion artifacts. However, regulated breathing requires additional patient training and does not suit certain patients. The use of respiratory bellows increases patient preparation time and is not reliable. Navigator setup needs an additional scout scan, adds planning time, requires high operator expertise, and sometimes causes signal loss in the region of interest due to saturation bands. Recent breath-hold techniques have high efficiency, however, are not applicable to patients who cannot perform extended breath-hold [4]. Self-gating (SG) techniques have shown promise in eliminating motion artifacts in carotid imaging [5]. In this work, a novel SG technique was developed in an attempt to overcome the limitations of the aforementioned methods in order to simplify and facilitate the clinical application of free-breathing renal NC-MRA.
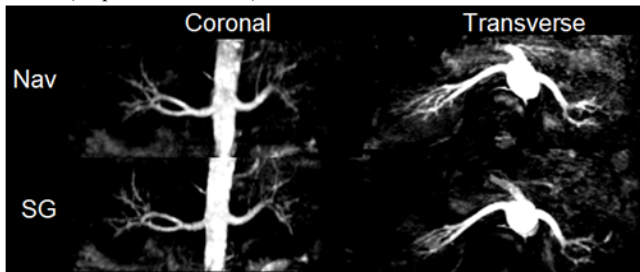
Methods:

Sequence: An additional readout line without partition and phase encoding is inserted at the beginning (for centric encoding) of each 3D bSSFP readout block (**Fig. 1**) for SG acquisition. The impact on SNR efficiency due to the additional line is minimal (<2%). Fourier transform of the SG readout line is the 1D projection of the entire imaging volume in the readout direction (left-right), which serves as the 'fingerprint' of the current respiratory phase. The reference projection profile is defined in a two-heartbeat breath-hold pre-scan which acquires 30 SG readout lines. In each subsequent TR, the cross-correlation coefficient (CC) is calculated between current projection profile and the reference profile. Respiratory motion of the imaging volume will be detected if the CC value is less than the pre-defined threshold and image data will be rejected and re-acquired in the next TR. In case of prolonged data rejection, the threshold will be updated in order to maintain scanning efficiency. An error message will display if CC values drop significantly indicating possible bulk motion.

Fig. 1. Pulse diagram of SG NC-MRA

Acquisition: Imaging was performed on a 3T clinical scanner (MAGNETOM Verio, Siemens) with spine matrix coil and a 6-channel body coil. A total of seven volunteers (4 male and 3 female) were recruited for this study with IRB approval. The imaging parameters included: segment TR = 700-900 ms; TI = 550-750 ms; acquisition time = 4-6 min (all three parameters depend on subject heart rate); TE/TR = 1.9/3.8 ms; 3D transverse acquisition with readout in left to right direction; FOV = 400x250 mm^2, matrix = 304x192, 2.2 mm slice thickness (interpolated to 1.1 mm), yielding isotropic resolution = 1.1x1.1x1.1 mm^3; GRAPPA = 2; bandwidth = 780 Hz/pixel; flip angle = 90. To evaluate the performance of the SG method, navigators were also acquired in the scans (monitor only). For comparison, conventional navigator-gated bSSFP MRA images were acquired immediately afterwards using same parameters.

Fig. 2. Representative monitoring navigator signal (a) and SG CC values (b). A high agreement was observed between the two.

Results:

The navigator signal and SG CC values were highly correlated (n = 7, R = 0.94-0.97, $p < 0.05$, **Fig. 2**), indicating the feasibility of SG for respiratory gating. The 3D datasets from both self-gated and navigator-gated scans were reviewed on a workstation. Both qualitative and quantitative evaluations were performed and the results are summarized in **Tab. 1**. Both gating methods provided excellent depiction of the intra- and extra-renal arteries (**Fig. 3**). No statistically significant difference was found between the two methods regarding SNR and CNR, as well as qualitative reviewer scores (all p values > 0.05).

	SNR		CNR		Reviewer Score (6)
	Intra	Extra	Intra	Extra	
Nav bSSFP	33.1±10.7	43.7±8.7	28±10.2	38±9.1	4.7±0.5
SG bSSFP	31.4±8.6	43.3±7.4	30.7±8	37±6.5	4.8±0.4
p-value	0.31	0.33	0.13	0.26	0.36

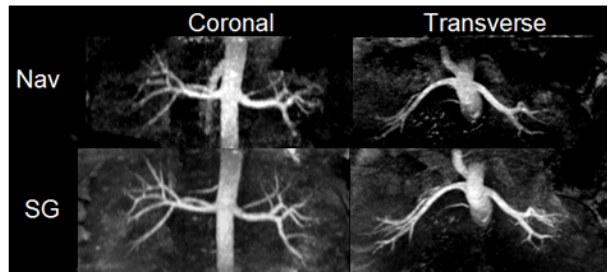**Tab. 1.** Image quality comparison between navigator-gated and self-gated bSSFP renal NC-MRA.

Fig. 3. MIP images of navigator-gated and self-gated bSSFP renal NC-MRA from two healthy volunteers with different amount of inflow.

Conclusion:

Preliminary results of SG bSSFP NC-MRA have demonstrated comparable image quality to conventional navigator techniques but much simplified imaging planning. Further study is warranted to determine its robustness and potential clinical role in patients.

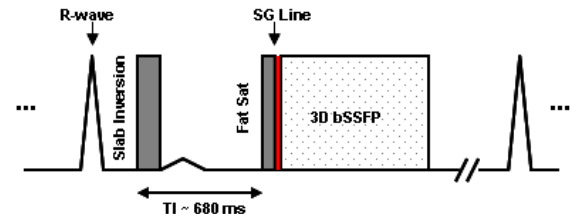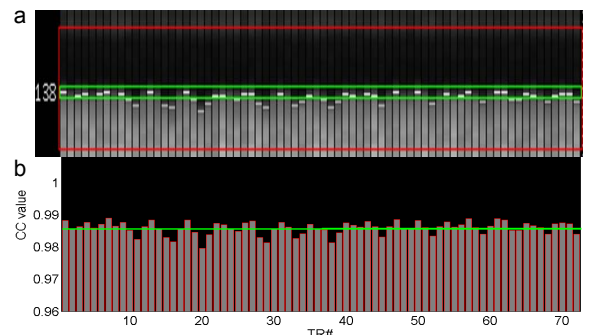[1] Miyazaki M, et al., Radiology 08. [2] Braendli M, et al., AJR 03. [3] Katoh M, et al., Kidney Int. 04. [4] Edelman RR, et al., MRM 10. [5] Fan Z, et al., ISMRM 10.