Free breathing three-dimensional steady-state free procession (SSFP) non-contrast enhanced coronary magnetic resonance angiography at 3T: comparison to gradient-echo sequence

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Target Audience: Physicians, Physicists, MR technologists

Background and purpose: Coronary magnetic resonance angiography (CMRA) is of proven value for the non-invasive assessment of coronary arteries. Steady-state free procession (SSFP) has been accepted as the method of choice for CMRA at 1.5 T because of its high signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR), and its excellent visual estimation capability, compared with gradient-echo sequences [1]. However, the SSFP sequence is sensitive to field inhomogeneities, which increase with the magnetic field strengths; this has prompted a return to fast gradient-echo imaging (FGRE) sequences for CMRA at 3.0 T [2]. Whether SSFP is suitable for CMRA at a high field strength remains uncertain. Since multitransmit technology has recently improved B1 inhomogeneity, we conducted an initial feasibility study using a 3T commercial scanner comparing free breathing three-dimensional non-contrast enhanced CMRA using SSFP and that using FGRE.

Methods: Volume targeted non-contrast CMRA scans were obtained in 14 healthy volunteers during free breathing with respiratory navigation using a commercial Phillips Inginea 3T MR scanner, digital broadband system, and a phased - array torso coil (dS Torso coil). The image of RCA and LAD were acquired separately. We evaluated the image quality, visible vessel lengths, vessel diameter , and vessel sharpness between following two sequences ; a 3D SSFP sequence (TR/TE = 4.2 ms/2.1 ms; FA = 60°; acquisition window = 50ms; FOV = 320 mm x 320 mm; matrix = 219 x256; voxel size = 0.8 mm x 0.8 mm x 0.8 mm; SENSE = 2 in the foot-head direction; SPIR fat saturation) with T2-preparation and a 3D FGRE sequence (TR/TE = 4.3 ms/2.0 ms; FA = 15°; acquisition window = 50ms; FOV = 320 mm x 320 mm; matrix = 219 x256; voxel size = 0.8 mm x 0.8 mm x 0.8 mm; SENSE = 2 in the foot-head direction; SPIR fat saturation) with T2-preparation. The image quality was compared using a visual estimation score base on a four-point scale (1 = poor/not visible, 2 = fair, 3 = good, 4 = excellent) and the visible vessel length, vessel diameter, and vessel sharpness were statistically compared using a paired t-test with a P-value < 0.05 considered significant.

Results and Discussion: All the scans were successfully completed using both sequences. Image quality (RCA SSFP vs. FGRE $P = 0.06$, LAD SSFP vs. FGRE $P = 0.32$), vessel diameter (RCA SSFP vs. FGRE $P = 0.73$, LAD SSFP vs. FGRE $P = 0.36$) , and vessel sharpness (RCA SSFP vs. FGRE $P = 0.83$, LAD SSFP vs. FGRE $P = 0.06$) were not significantly different between the sequences, with an equally good image quality, but the vessel lengths of RCA using SSFP sequence are significant longer than those using FGRE sequence (RCA SSFP vs. FGRE $P = 0.01$, LAD SSFP vs. FGRE $P = 0.47$). New equipment with a digital broadband system and multitransmit technology improved the image quality of SSFP as well as the FGRE CMRA, and could be used to visualize dedicated coronary artery trees using a high field commercial scanner.

Conclusion: The resulting measurable improvements in the image quality using non-contrast SSFP coronary MRA performed using 3T commercial scanner are likely to lead to more accepted clinical applications.

Reference: [1] Weber OM, Martin AJ, Higgins CB. Magn Reson Med. 2003; 50(6): 1223-8. [2] Fuchs F, Laub G, Ohtomo K. Eur J Radiol. 2003; 46:494-502

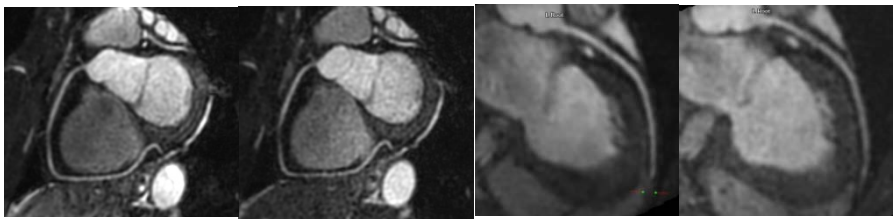

Figure1 a) RCA SSFP b)RCA FGRE c) LAD SSFP d) LAD FGRE
Reformatted image of the LAD and RCA obtained using (a, c) SSFP and (b, d) FGRE

Table 1 Mean and standard deviation of vessel length, diameter, sharpness and image quality score between SSFP and FGRE

	RCA		LAD	
	SSFP	FGRE	SSFP	FGRE
vessel length (mm)	135.3 ± 32.6	130.6 ± 32.5	121.1 ± 22.7	119.9 ± 25.1
vessel diameter (mm)	3.19 ± 0.89	3.12 ± 0.81	3.06 ± 0.55	3.26 ± 0.54
vessel sharpness	0.45 ± 0.13	0.44 ± 0.12	0.46 ± 0.09	0.40 ± 0.08
visual score	2.86 ± 0.77	3.28 ± 0.47	3.07 ± 0.47	3.00 ± 0.56