The validity of a Free Breathing Motion Corrected Phase Sensitive Inversion Recovery Sequence in the detection of Delayed Myocardial Enhancement at 3T.

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Purpose: Myocardial delayed enhancement (DE) imaging is a reference standard to evaluate for myocardial scar. Free breathing (FB) single-shot steady-state free precession (SSFP) and breath held (BH) segmented TURBO FLASH (TFL) sequences are currently used to evaluate delayed enhancement (DE) of the myocardium, typically with an integrated second heart beat reference acquisition enabling a phase-sensitive inversion recovery (PSIR) reconstruction. Single-shot SSFP DE images often demonstrate reduced contrast to noise compared to segmented TFL DE at 3T (1) and are imperfect solutions for patients with difficulty breath-holding. Free breathing (FB) motion corrected (MOCO) single-shot SSFP DE with averaging has been shown to be equal or superior in detecting myocardial infarction at 1.5T, particularly in vulnerable patients(2). The purpose of this study is to investigate the feasibility of DE imaging using FB MOCO SSFP at 3T. We hypothesize that image quality, diagnostic confidence, and accuracy of FB MOCO SSFP DE imaging will be superior to FB SSFP and BH TFL DE techniques.

Methods: 22 consecutive patients (6F, 16M aged 28–77 years, mean 51.6) referred predominantly for aortic root/valve disease (n=6, 37%), heart failure (n=5 , 23% %) or hypertrophic cardiomyopathy (n=3, 18%) underwent cardiac MRI on a 3T scanner. DE imaging was performed 10 – 25 minutes following the administration of IV gadolinium. 9 patients underwent FB MOCO PSIR SSFP, FB PSIR single shot SSFP and BH PSIR TURBOFLASH. The remaining 13 patients underwent FB MOCO PSIR SSFP and FB PSIR single shot SSFP. Images were graded by an experienced cardiovascular radiologist for image quality on a 5-point Likert scale and DE sequences were qualitatively analyzed for the presence of myocardial scar using the 16-segment AHA model. In patients with delayed enhancement, diagnostic confidence was also graded on a 3-point Likert scale.

Results: FB MOCO SSFP DE images were successfully obtained in all patients. Average image quality scores were 4.30+/-SD 0.73, 4.00 +/- SD 0.73 and 4.13 +/- SD 0.83 for FB MOCO PSIR SSFP, FB PSIR single shot SSFP and BH PSIR TFL respectively (Figure 1). 7 patients (32%) demonstrated delayed enhancement in patterns of atypical scar (n=4), vascular scar (n=1), hypertrophic cardiomyopathy (n=1) (Images 1-3) and myocarditis (n=1), each with universally high diagnostic confidence of 3. 4 patients who showed DE only underwent FB MOCO PSIR SSFP and FB PSIR single shot SSFP and showed 6 and 4 DE segments respectively. 3 patients who showed DE underwent FB MOCO PSIR SSFP, FB PSIR single shot SSFP and BH PSIR TURBOFLASH and showed 18, 14 and 17 DE segments respectively.

Discussion: All three DE techniques demonstrated excellent image quality and perfect diagnostic confidence. Superior image quality on FB MOCO SSFP DE images compared with FB SSFP is hypothesised to relate to the rejection of the 40% most motion degraded images, giving rise to sharper myocardial margins while the application of averaging increases the signal to noise ratio. While initial experience produced higher image quality on FB MOCO PSIR SSFP than either other sequence, this was not statistically significant (p=0.201, 0.587), although this does confirm non-inferiority in this small sample.

Conclusion: FB MOCO SSFP demonstrated similar image quality and identical diagnostic confidence compared with BH TFL DE imaging and superior image quality compared to FB SSFP DE imaging while improving the detection of myocardial segments with scar compared to both techniques. Our initial experience suggests that FB MOCO DE imaging rivals BH TFL DE imaging at 3T for the assessment of myocardial scar.

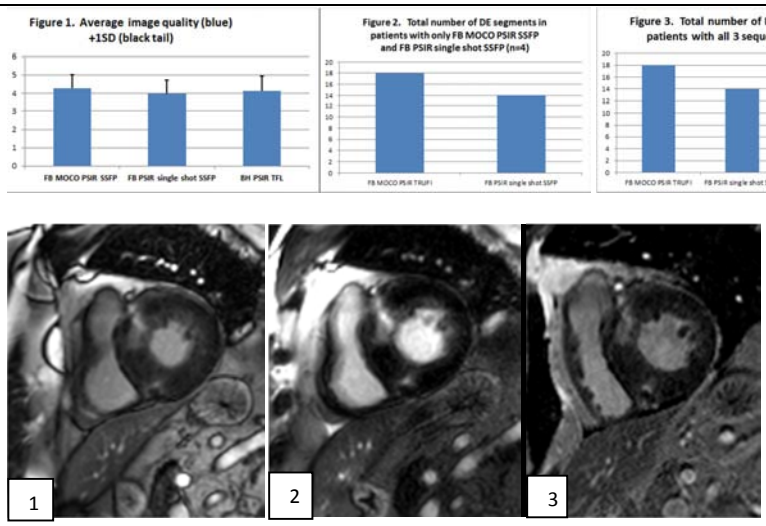

Figure 1: Average Image quality and in each technique (with one standard deviation marked above). **Figure 2:** Total number of DE on only SSFP sequences. **Figure 3:** Comparison of total segments with DE in patients with DE who underwent all 3 sequences. **Figure 4:** t-test analysis confirms no statistically significant difference between groups. **Images 1-3**; (L to R) 3T images of FB MOCO PSIR SSFP, FB PSIR single shot SSFP and BH PSIR TFL. The images demonstrate high image quality and delayed enhancement at the superior and inferior septal insertions with myocardial thickening in keeping with hypertrophic cardiomyopathy.

1. Oshinki JM et al., Jnl CVMR. 2010, 12:55 2. Kellman P et al., Magn Reson Med. 2002;47:37.