Free breathing (FB) motion corrected (MOCO) SSFP delayed enhanced imaging of left ventricular scar in patients with non-ischemic cardiomyopathy.

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Purpose: Free breathing (FB) single-shot SSFP and breath hold (BH) TURBO FLASH (TFL) sequences are currently used to evaluate delayed enhancement (DE) of the myocardium, typically with a phase sensitive inversion recovery (PSIR) approach (1). However, many patients are unable to perform adequate breath-hold for diagnostic quality images to be acquired. Free breathing (FB) motion corrected (MOCO) PSIR SSFP with averaging has been shown to be equal or superior in detecting myocardial infarction, particularly in vulnerable patients (2). For FB MOCO PSIR SSFP sequences to replace current techniques in the detection of DE, they must also be sensitive to non-ischemic type delayed enhancement.

Methods: 45 consecutive out-patients (16F, 29M age 25-83 years, mean 57.8) referred for cardiac MRI predominantly for evaluation of heart failure (n=28, 62.2%) or aortic valve/root disease (n=14, 31.1%) underwent MRI on a 1.5T system (MAGNETOM Aera, Siemens, Erlangen, AG). Delayed enhancement sequences performed 10-25 minutes post gadolinium injection included FB MOCO PSIR SSFP, FB PSIR single shot SSFP and BH PSIR TF. All MOCO images were used for averaging. Depending on the degree of deformation, different weight was applied using an optimal image combination algorithm (3). BH TFL was not always performed on patients who did not show DE on BH single shot SSFP images. Images were graded by an experienced cardiovascular radiologist for image quality (scale of 1 to 5) and diagnostic confidence (3 point Likert scale). They were also scored for the presence of DE and qualitatively analysed for the number of segments showing DE using a 16 segment model.

Results: Image quality for FB MOCO, BH TRUFI and BH TFL was 4.51, 4.34 and 3.95 respectively **(Figure 1)**. 14 of 45 patients (31.1%) demonstrated non-ischemic DE on all 3 sequences. In this subgroup, diagnostic confidence for FB MOCO PSIR SSFP, FB PSIR single shot SSFP and BH PSIR TFL were 2.81, 2.71 and 2.52 respectively **(Figure 1)**. The total number of involved segments for the 3 techniques were 86, 83 and 82 respectively **(Figures 2-4)**. In segments demonstrating discrepant findings between the 3 sequences, image quality and diagnostic confidence was equal or higher on FB MOCO PSIR SSFP compared with FB PSIR single shot SSFP or BH PSIR TFL.

Discussion: The higher image quality on FB MOCO PSIR SSFP compared with FB PSIR single shot SSFP is hypothesised to relate to the rejection of the 40% most motion degraded images, giving rise to sharper myocardial margins. The increased image quality compared with BH PSIR TFL is hypothesised to relate to poor breath holding ability during the latter.

Conclusions: FB PSIR MOCO SSFP demonstrated improved image quality, higher diagnostic confidence and greater number of detected segments of DE than both FB PSIR single shot SSFP and BH PSIR TFL. All patients with DE on either FB PSIR single shot SSFP or BH PSIR TFL were identified on FB MOCO. While larger numbers are required, initial findings suggest that FB MOCO is equal or superior to FB single shotSSFP and BH TFL in detecting non-ischemic DE and could replace them in clinical practice.
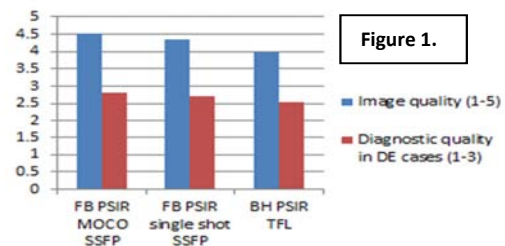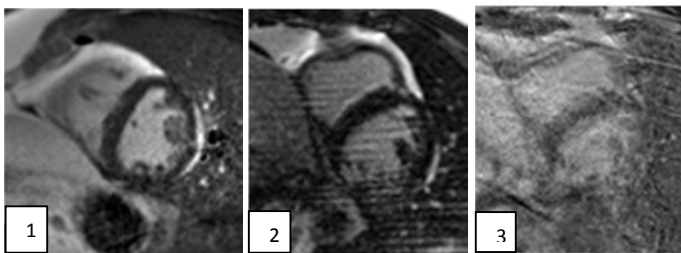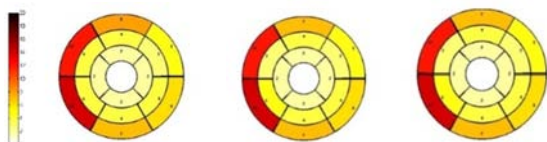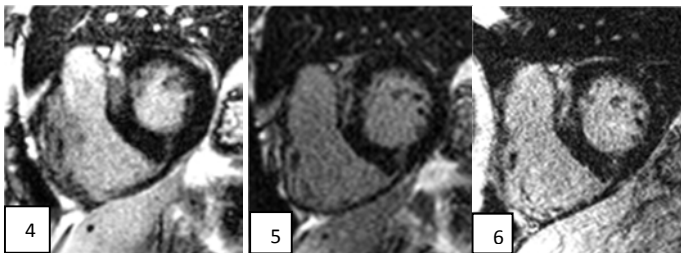

Figure 1: Image quality and diagnostic confidence of the 3 sequences. **Images 1-3:** (L to R) Short axis FB PSIR MOCO SSFP, FB PSIR single shot SSFP and BH TFL, showing image qualities of 5, 4 and 3 respectively. **Images 4-6:** (L to R) Short axis FB PSIR MOCO SSFP, FB PSIR single shot SSFP and BH TFL. Each clearly demonstrates anteroseptal and inferoseptal delayed enhancement in a patient with hypertrophic cardiomyopathy. **Figures 2-4:** (L to R) Color bar and heat maps of total segments showing DE in all subjects for FB PSIR MOCO SSFP, FB PSIR single shot SSFP and BH TFL. There is very strong correlation between the 3 techniques with slightly greater total DE detection on FB PSIR MOCO SSFP.

1. Kellman P et al., Magn Reson Med. 2002;47:37. 2. Piehler KM et al., CircCardiovasc Imag. 2013; 6:42 3. Chefd'hotel C et al., ISBI 753-756(2002).