The Optimisation and Validation of Cardiac Mass and Function at 3 Tesla.

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INTRODUCTION

The technical and regulatory problems of 3 Tesla clinical imagers have been solved. Neuroimaging has been demonstrated across a range of applications to be generally improved at 3T, but it is unknown whether 3T provides a better field strength than 1.5T for cardiac imaging. The measurement of cardiac mass and function is a key cardiac evaluation and 1.5T MRI using SSFP provides the gold-standard approach for this evaluation. Existing studies of SSFP at 3T have shown SNR increases from 20% to 150%[1,2] and have raised concerns over ECG triggering and SSFP artefacts.

METHODS

Images were acquired on a 1.5T (~63 MHz) Siemens Sonata and a 3T (~123 MHz) Siemens Trio, 25A software, and were equipped with identical high performance gradients, and similar cardiac array coils. Image contrast parameters (i.e. excitation flip angle) were optimised on 5 volunteers using SSFP and FLASH methods, using other parameters that have been optimised for 1.5T exams.

A further 10 normal volunteers (5m, 5f, mean age 28±5 years) with no history of cardiac disease, hypertension or cardiac risk factors and a normal baseline ECG were evaluated at 1.5T and 3T with both FLASH and SSFP methods. Careful ECG positioning, slice positioning, and frequency piloting was followed by the acquisition of a short-axis stack of images using each of the 4 methods (1.5T SSFP, 3T SSFP, FLASH 3T, FLASH 1.5T). Images were evaluated using a grading system. Images were segmented (Argus, Siemens) to assess the clinically required cardiac parameters of the right and left ventricle.

RESULTS

Maximising the flip angle subject to SAR limits improves the SNR of SSFP sequences at both field strengths (see fig.1). Flip angles of 20° and 60° were used for the FLASH and SSFP sequences respectively at both field strengths. In some cases at 3T, the excitation angle was limited by SAR, with the lowest excitation achieved being 54° in the smallest volunteer. SNR increases were shown at 3T for SSFP (48% myocardium, 30% blood) (fig.1) and FLASH (19% myocardium, 13% blood).

Scoring of image quality showed 1.5T SSFP to be the best, followed by 3T SSFP, 3T FLASH, and 1.5T FLASH was graded the worst, with the improvements in SNR of SSFP being counteracted by small amounts of image artefact.

No image artefact prevented volume or function analysis, and there were no significant differences in functional parameters between 3T SSFP and 1.5T SSFP. Similarly, FLASH measurements agreed between the two field strengths. SSFP and FLASH gave systematic differences at both field strengths as is known at 1.5T[3]. ECG waveforms were affected by the increased field strength but triggering presented no problems in this study.

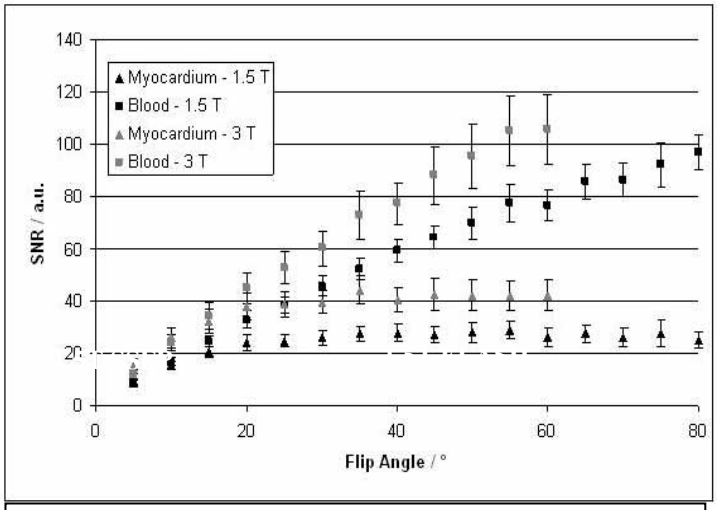

Figure 1: Variation of SNR in the myocardium and blood at 1.5T and 3T for the SSFP sequence

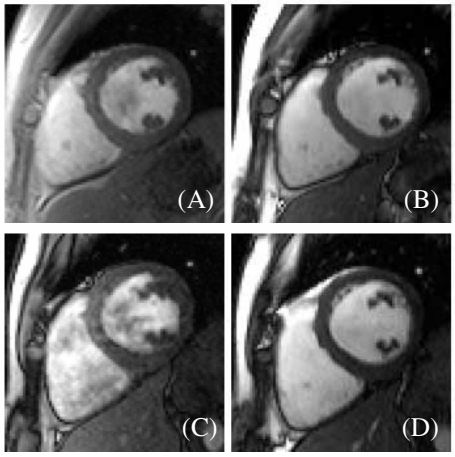

Figure 2: End-diastolic short-axis images with 3T FLASH (A), 3T SSFP (B), 1.5T FLASH (C) and 1.5T SSFP (D) from a healthy male volunteer.

DISCUSSION AND CONCLUSION

Cardiac imaging at 3T can be used for function and mass assessment, but currently does not provide superior results to the 1.5T gold standard. 3T FLASH methods are superior to FLASH methods at 1.5T and showed no increase in artefact levels. Therefore, in patients who are unable to be imaged with SSFP, 3T provides a small improvement in FLASH images. 3T cardiac images may be further improved by continued sequence and parameter optimisation using additional SNR to directly address image quality. The cardiac function exam at 3T provides neither a reason to purchase a 3T (over a 1.5T) nor a reason not to purchase a 3T. It is possible to perform a functional cardiac examination accurately at 3T, with errors that are not dominated by those relating to image quality.

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