Comparison and optimization of myocardial tagging at 1.5T and 3T

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Introduction

A common problem with myocardial tagging at 1.5T is the relaxation of tagged magnetization in the diastolic phases such that the tags in the muscle are no longer visible. When a gradient echo sequence is used, the tag persistence is largely dependent on the T_1 of the myocardium, and flip angle. In general, tissue T_1 increases with increase in field strength. The T_1 of myocardium has been reported to be about 1115 ms at 3T [1], while it is approximately 900 ms at 1.5T. With longer myocardial T_1, tag persistence is expected to be better at 3T than at 1.5T.

Higher flip angles reduce tag persistence because the magnetization is rapidly brought into steady-state. However, although the tag persistence may be improved with low flip angles, the overall image signal-to-noise ratio (SNR) is reduced. Since the SNR is doubled at 3T, the flip angle that is used at 3T can be reduced while maintaining adequate SNR. This reduction in the flip angle can then contribute to longer tag persistence**.**

The purpose of this study was to compare myocardial tagging at 1.5T and 3T, and evaluate whether there was any improvement in tag persistence at 3T.

Methods

Seventeen healthy volunteers (n=17, 10 male, 7 female, ages 24 to 60, mean age: 43.2 years) and 3 patients were imaged at both 1.5T and 3T (Siemens) to compare the image quality and tag persistence. The mean heart rate for the healthy volunteers was 69.2 ± 11.2 beats per minute. The first 6 volunteers were imaged at only one field strength to optimize the protocols with respect to slice thickness, tag thickness, and readout bandwidth. After optimization, these parameters were kept constant for the remaining volunteers (n=11). Since one of the major factors determining tag persistence is the flip angle, it was varied from 4 deg. to 16 deg., in increments of 2 deg., at both field strengths in the 11 volunteers. For each flip angle, the SNR, tag contrast-to-noise ratio (CNR), and relative myocardium-to-tag contrast (RCMT) were evaluated. The RCMT was calculated as: (Signal of untagged myocardium – Signal of tag)/(Signal of untagged myocardium). All measurements were performed in the anterior, lateral, inferior, and septal walls, and then averaged for each volunteer. A prospectively triggered gradient-echo sequence was used for imaging. The imaging parameters were as follows: TR/TE = 5.2 ms/3.7 ms, FOV = (250-300) x 340 mm, matrix = (135-162) x 256, slice thickness = 6 mm, tag thickness (grid tags) = 8 mm, readout bandwidth = 185 Hz/pixel, temporal resolution = 46 ms.

Results

A comparison of the tagging images acquired in a healthy volunteer at 1.5T and 3T are shown in Fig. 1. Note that the conspicuity of the tags is greatly reduced in the diastolic phase in the image acquired at 1.5T. At 3T on the other hand, the tags are clearly visible in the myocardium in all phases. From the first 6 volunteers used for optimizing the imaging parameters, a slice thickness of 6 mm, tag thickness of 8 mm, and a readout bandwidth of 185 Hz/pixel were found to be suitable. The choice of the flip angle for the patients was based on the data acquired in the 11 volunteers. At 1.5T, the optimal flip angle was found to be 12 deg. while that at 3T was found to be 8 deg, after the overall image quality, SNR, and tag conspicuity (RCMT) were compared. In the last 11 volunteers, the comparison of SNR and RCMT with flip angles of 12 deg. and 8 deg. at 1.5T and 3T respectively are shown in Fig. 2. Note that the blood SNR is higher at 3T despite the lower flip angle. The RCMT was also found to be much higher at 3T than at 1.5T. The difference was more pronounced in the diastolic phases than in systole.

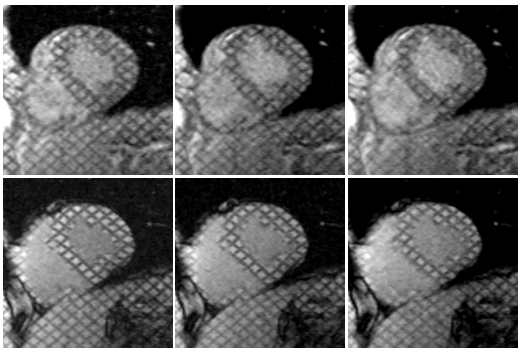

Figure 1. Comparison of tagging at 1.5T (top row) and 3T (lower row) in the same volunteer. Variation of SNR, blood-tissue contrast and tag-persistence is evident. Images at 3T demonstrate a clearly visible grid pattern even late in the cardiac cycle whereas the tags are faded at 1.5T.

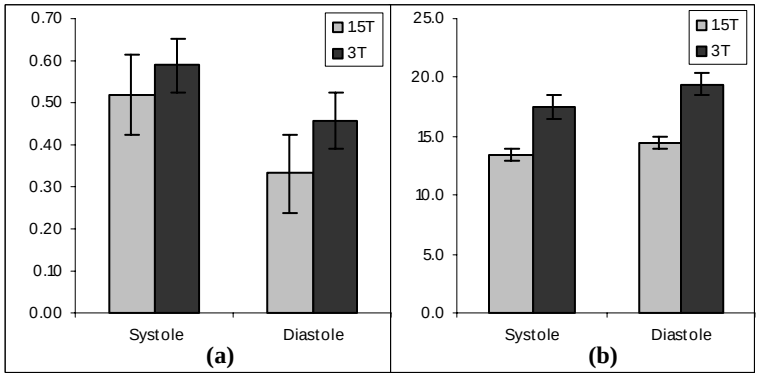

Figure 2. (a) SNR and **(b)** RCMT comparison at 1.5T and 3T. The SNR and RCMT both are higher in the systolic as well as diastolic phases at 3T as compared to 1.5T.

Conclusion

Results show that myocardial tag persistence is improved at 3T. The longer T_1 and lower flip angle at 3T are responsible for the increase in tag persistence. Although a lower flip angle is used at 3T than at 1.5T, the SNR is still higher than at 1.5T. In conclusion, myocardial tagging is improved at 3T compared to 1.5T.

References

1. Noeske R, Seifert F, et al. MRM 2000; 44:978-982.