Accuracy and reproducibility of four T1 mapping sequences: a head-to-head comparison of MOLLI, ShMOLLI, SASHA, and SAPPHIRE

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Accuracy and reproducibility of four T_1 mapping sequences: a head-to-head comparison of MOLLI, ShMOLLI, SASHA, and SAPPHIRE

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Background

Quantitative myocardial T_1 mapping provides in-vivo tissue characterization for assessment of cardiomyopathies. Pre and post-contrast T_1 maps can be used to calculate the extracellular volume fraction (ECV) to detect diffuse myocardial fibrosis. Several imaging approaches have recently been proposed for measuring T_1 values [1-4], but no head-to-head comparison has been reported to cross-examine their accuracy and reproducibility. In this study, we compared both T_1 maps and ECV measurements from the following techniques: Modified Look-Locker Inversion Recovery (MOLLI) [1], Shortened MOLLI (ShMOLLI) [2], Saturation recovery single-shot acquisition (SASHA) [3], and SAturation Pulse Prepared Heart rate independent Inversion-REcovery sequence (SAPPHIRE) [4].

Methods

The four T_1 mapping methods were implemented on a 1.5 T Phillips scanner using a b-SSFP readout (TR/TE/α = 3.1/1.5 ms/70°, FOV = 360 × 337 mm2, voxel size = 1.9 × 2.5 mm2, slice thickness = 8 mm, SENSE factor = 2). In a phantom experiment, the four methods were each repeated 10 times and were compared to the gold standard T_1 measurements obtained using spin echo acquisitions (15 inversion times from 100 ms to 3000 ms). In-vivo analysis experiments was performed in 8 healthy subjects (38 ± 19 y, 4 m), and in 10 patients (56 ± 14 y, 6 m). Pre-contrast imaging was performed twice with the four methods. Healthy subjects were removed from the bore between the two pre-contrast scans to simulate a separate exam. Post-contrast T_1 mapping was performed twice at 15 and 30 mins post-injection. T_1 maps were reconstructed offline using an in-house platform and were analyzed by a blinded observer. In all T_1 maps, the septum and the blood pool were manually delineated, and an ECV value was then computed from each pre and post-contrast T_1 map pair. For each method, T_1 measurement variations between the two sets of pre-contrast images and ECV measurement variations generated from the second pre-contrast T_1 and each of the two post-contrast T_1 data were examined.

Results

SASHA and SAPPHIRE were more accurate but less reproducible than MOLLI and ShMOLLI for T_1 mapping

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in phantom experiments. MOLLI was more reproducible than ShMOLLI and SAPPHIRE was more reproducible than SASHA. There was a trend for MOLLI and ShMOLLI to be more reproducible than SASHA and SAPPHIRE for pre-contrast T_1 mapping in all subjects. There was no statistical significant difference in ECV measurement reproducibility among the four methods in both healthy subjects (One-way ANOVA, p = 0.51) and patients (p = 0.35). However, MOLLI and ShMOLLI yielded large errors in the derived ECV values due to error propagation of T_1 measurements.

Conclusions

Both SASHA and SAPPHIRE T_1 sequences yield excellent accuracy, but with lower reproducibility compare to MOLLI and ShMOLLI. Reproducibility of ECV measurements is similar with all methods, but MOLLI and ShMOLLI demonstrated large systematic errors.

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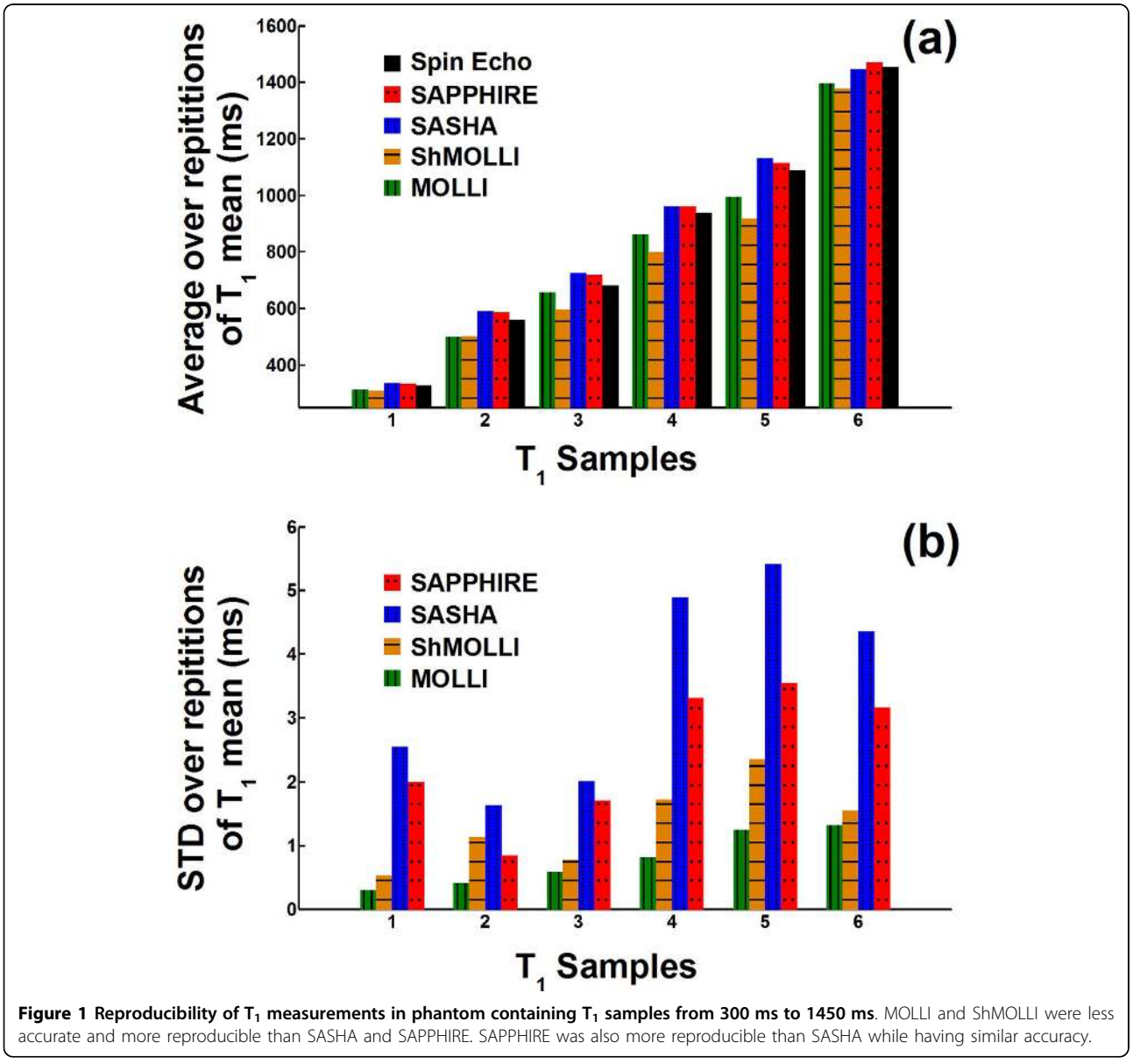

Figure 1 Reproducibility of T_1 measurements in phantom containing T_1 samples from 300 ms to 1450 ms. MOLLI and ShMOLLI were less accurate and more reproducible than SASHA and SAPPHIRE. SAPPHIRE was also more reproducible than SASHA while having similar accuracy.

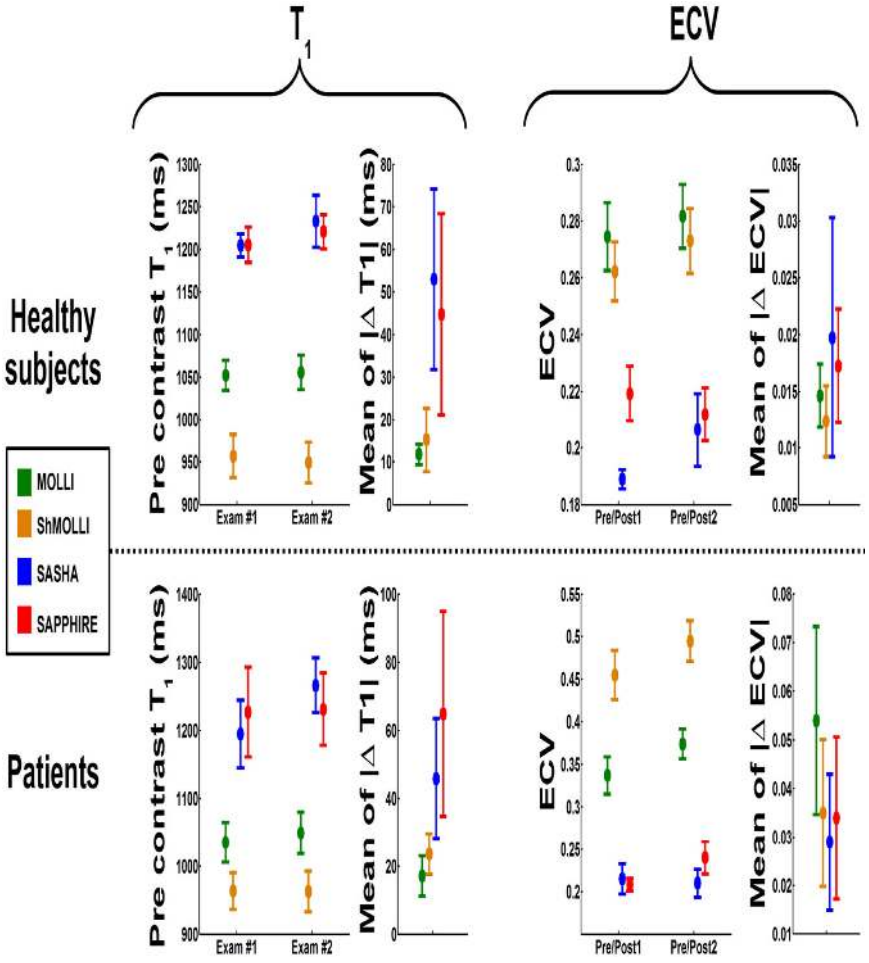

Figure 2 Reproducibility of T_1 and ECV measurements in healthy subjects and patients. MOLLI and ShMOLLI tend to be more reproducible than SASHA and SAPPHIRE for pre-contrast T_1 mapping. No statistical significant difference was found among the four methods in term of reproducibility of ECV measurements.

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