

Estimation of fat fraction considering T2* decay in liver after SPIO injection

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Introduction

The incidence of Non-alcoholic fatty liver disease (NAFLD) is increasing. Fat fraction estimation is very important for this disease, especially if non-alcoholic steatohepatitis (NASH) is suspected. Estimation of fat fraction is affected by T2* decay, and because liver diseases are often accompanied by iron accumulation causing T2* shortening, it is important to take this effect into account (1). The aim of this study was to determine the accuracy of fat fraction estimation combined with T2* estimation depending on the number of echoes acquired with a multi-echo gradient echo sequence with breath holding.

Method

11 volunteers with fatty liver of various degrees were scanned on a 1.5T Achieva system (Philips Healthcare, BEST, NL) with eight channel phased array body coil after obtaining informed consent. Scan sequences included dual echo T1-weighted fast field echo (TR=100ms, TEs=2.15/4.2ms, FA=70, 204x256 matrix, scan time=18.2sec) and multi-echo fast field gradient echo (mFFE: TR=48ms, TE=2.15ms, FA=20, ΔTE=2.15, 10 echoes, 128x128 matrix, scan time=19.7sec) before and after superparamagnetic iron oxide particles (SPIO) administration. Scans were repeated at 1,3,5,7 and 10 minutes after SPIO injection. Fat fraction was calculated using custom developed tool (IDL 6.1) with the following methods:

Dual echo data: Fat fraction = $(S_{in} - S_{out}) / 2 * S_{in}$

mFFE data : $S(te) = [(S_w * e^{-te/T2^*})^2 + (S_f * e^{-te/T2^*})^2 + 2 * S_w * S_f * e^{-te/T2^*} * \cos(\Delta\omega te)]^{1/2}$,

Fat fraction = $S_f / (S_w + S_f)$

For mFFE method, fat fraction maps were generated after signal fitting using different number of echoes (3,4,6,8, and 10 echoes).

Fat fraction maps from dual echo data and mFFE data were compared before SPIO injection and for each acquired time point after injection. For each time point fat fraction ratio (FFr) maps were calculated as post-contrast data divided by pre-contrast data and average values across time points from manually placed ROIs (excluding big vessels) was used for comparison.

Results

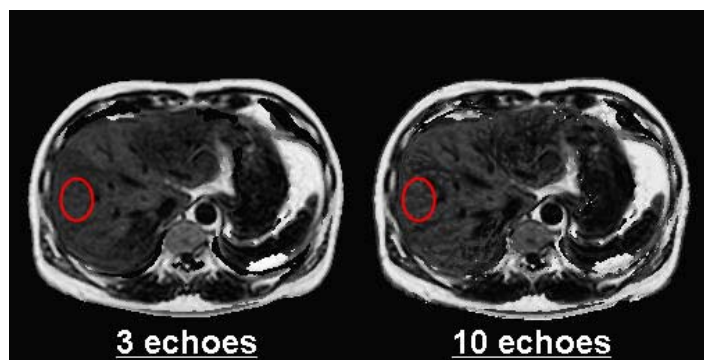
A total of 12 ROIs were used for comparison. FFr by dual echo method was 0.32 ± 0.28 , by mFFE method using 3 echoes (1.03 ± 0.11), 4 echoes (1.00 ± 0.07), 6 echoes (1.04 ± 0.05), 8 echoes (1.12 ± 0.08) and 10 echoes (1.32 ± 0.05) (Fig.1). With Dual echo method, fat fraction is clearly underestimated because of unaccounted T2* decay, while with mFFE, the ratio stays close to expected 1.0. The variance of mFFE data is significantly smaller compared to dual echo (Wilcoxon's signed rank test, $p < .0001$). For different number of echoes, only data from 10 echoes was significantly larger than other datasets ((Wilcoxon's signed rank test, $p < .0001$).

Discussion

Accurate estimation of fat fraction accounting T2* decay is possible using mFFE method in the liver, even in patients with iron accumulation. In case of very short T2*, signal at long TE is too small, consequently fat fraction estimation will be less accurate when using all echoes for fitting. Considering that abdominal imaging requires breath holding, i.e. short scan times, and that the results for 3, 4, 6, and 8 echoes are not significantly different, the use of smallest number of echoes is justified. More echoes would be necessary for more complex signal modeling (ex. considering multiple T2*), but it is unlikely that acquisition of more than 6 echoes will be useful in practice.

Reference

(1) Huanzhou Yu, et al, JMRI, 2007; 26: 1153-1161



Fat fraction image (10min after SPIO injection)

Left : using 3 echoes for fitting, FFr = 15.9%,

Right : using 10 echoes for fitting, FFr = 18.4%

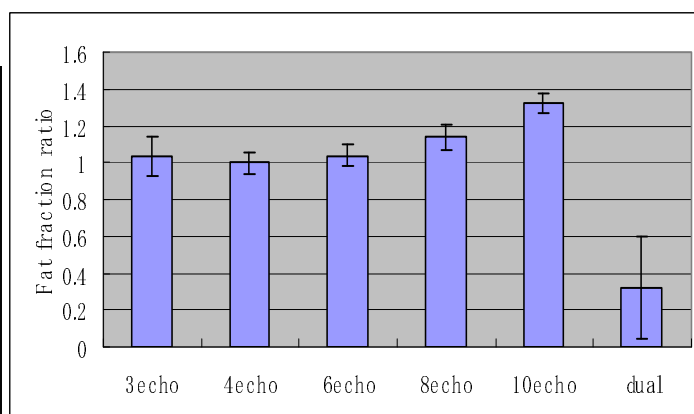


Fig.1 Fat fraction ratio

Comparison with each result that using different number of echoes for fitting