TE-averaged PRESS for breast spectroscopy - increased flexibility by using fractional NEX averaging

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Introduction

MR Spectroscopy (MRS) is used as a clinical tool in diagnosing and characterizing breast cancer. A resonance at 3.2 ppm referred to as total choline-containing compound (tCho) is used as a cancer biomarker. TE-averaged PRESS (1) is a common technique for single voxel breast spectroscopy (SVS) to remove potential sideband artifacts due to oscillations of the B_0 field during the beginning of the acquisition (2-4). To cancel the sidebands by destructive interference data is acquired at different echo times. Best results are achieved by a large number of echo times (NoET), e.g. NoET = 64 or 128 (3).

For clinical use it is preferable to adapt the total number of acquisitions in SVS to voxel size in relation to the lesion size to achieve acceptable SNR. The conventional approach only allows discrete increments of acquisitions per echo time (averages) for all echo times. While keeping NoET fixed this results in large increments in possible total acquisition times.

This study will present an acquisition scheme where the number of averages varies across the bandwidth of acquired echo times. The effect of this fractional NEX (number of excitations) averaging method on SNR and sideband artifacts was investigated.

Methods

Two different fractional NEX acquisition schemes were implemented. In case the total number of acquisitions is not a discrete multiple of NoET the additional acquisitions beyond the next smaller discrete multiple of NoET are done starting with the shortest echo time (minimum scheme) or centric around the average echo time (centric scheme). Each acquisition is stored individually in the raw data file.

Data processing was implemented in MATLAB (MathWorks, Natick, MA, USA) consisting of line broadening and zero filling, zero order phase correction, first order phase correction using a cross-correlation method to compensate for frequency shifts and averaging. After HSVD water removal a Voigt lineshape model was fitted to the peak at 3.2 ppm (tCho).

Phantom experiments were done using a MRS phantom (MRS HD Sphere, GE Healthcare, diameter = 18 cm, Cho concentration ~ 3 mM) on a whole body 3T scanner (GE Healthcare, Milwaukee, WI, USA) with standard quadrature head coil.

TE-averaged PRESS parameters were: average TE = 125 ms, ΔTE = 2.384 ms, NoET = 64, TE range from 50 – 200 ms, NEX between 1 and 8. T2 relaxation time of choline was determined from full data set (8 NEX * 64 NoET = 512 acquisitions). In addition two data sets with NEX = 0.15 yielding 10 acquisitions were reconstructed from the original data set to demonstrate the potential size of the sideband artifact. This was done for both acquisition schemes (minimum, TE range from 50 – 71.5 ms; centric, TE range from 114.25 – 135.75 ms).

Results

Exponential fit of choline signal at 64 different echo times result in T2 of choline of 172 ms which is in good agreement with the value T2 = 175 ms given by the manufacturer (figure 1). The signal intensity of choline signal relative to NEX (between 1 and 2) is higher for the minimum scheme than it is for the centric scheme (figure 2). This is due to the higher signal at shorter echo times that were acquired more often in the minimum scheme.

Figure 3 shows good suppression of the sideband artifact due to the TE-averaging (0.15 NEX versus 1 NEX) and only small artifacts for fractional NEX larger than 1. The simulated data of NEX = 0.15 is just shown for comparison of sideband artifact. The amount of sideband artifact decreases with increasing NEX for non-integer NEX acquisitions due to the decreased weight of those fractional NEX components where sideband artifacts have not fully cancelled out. The difference between both schemes is low for fractional NEX larger than 1.

Discussion

It has been demonstrated that the proposed fractional NEX averaging schemes for TE-averaged PRESS provide full flexibility to adjust total acquisition time and therefore SNR to lesion size in breast spectroscopy without changing the range of echo times by using just NEX as parameter in a user friendly way. Both schemes have negligible effect on sideband artifact. The minimum scheme gives slightly larger SNR.

Instead of equivalently averaging across the whole range of echo times, it is also possible to implement a weighted average (averaging per echo time) which has the advantage of keeping the artifact for NEX $\geq$ 1 constant while losing some of the SNR gain (figure 4).

References

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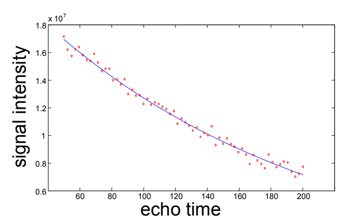

Figure 1: choline signal intensity vs. echo time. Exponential fit gives T2 of 172 ms.

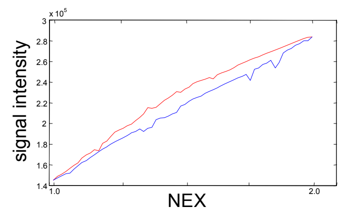

Figure 2: choline signal intensity vs. NEX (minimum scheme, red; centric scheme, blue)

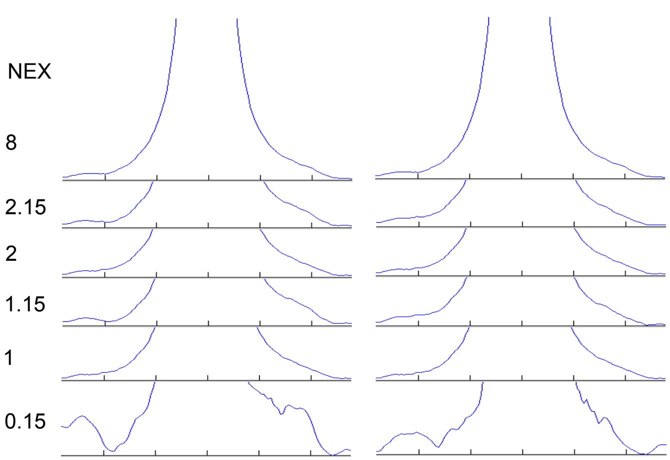

Figure 3: sideband artifact around water peak for different NEX values. (left) minimum scheme, (right) centric scheme

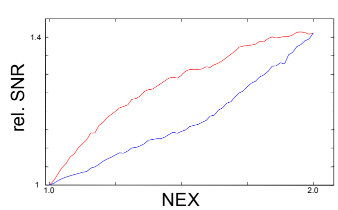

Figure 4: relative SNR of choline signal vs. NEX (equivalently averaging, red; weighted averaging, blue)