The effect of Interleaved Navigator Scans on the result of human in-vivo MR-Spectroscopy at high fields

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Introduction

With the wider availability of magnetic resonance scanners of 3T and higher magnetic resonance spectroscopy in humans at high fields are increasingly utilized to study brain metabolism in healthy and pathological states. Quality of spectra in magnetic resonance spectroscopy is strongly affected by temporal signal instabilities during the acquisition. Beside hardware imperfections, e.g. drifts of the main magnetic field in super conducting magnets, subject dependent variances like movements during the scan, introduce unwanted inconstancies. These effects limit the accuracy of the measured spectra and can even lead to wrong interpretations or useless results. Various correction approaches for NMR and in-vivo MRS at field strengths up to 2T have been published in recent years [1-4]. This study utilizes interleaved navigator scans (INS) in order to correct spectroscopic data at a standard clinical 3T whole body system.

Method

The MR data were obtained on a 3 T whole-body system (Magnetom Trio, Siemens Erlangen, Germany) using a standard quadrature head coil. For localization a T1-weighed 3-D-data set was acquired using a MPRAGE (Magnetization Prepared Rapid Acquisition Gradient-Echo Imaging) sequence. A standard PRESS (point-resolved spectroscopy) sequence was used as a template to integrate the interleaved reference scan acquisition scheme [1]. Measurements were carried out using the following parameters TE=30ms / 135 ms, TR=3000ms, 96 acquisitions, [20mm x 20mm x 20mm] voxel size. Individual averages were saved separately for further post processing. Each experiment starts with a water suppression scheme automatically adjusted by the system. The PRESS acquisition scheme was unchanged compared to the template sequence and followed by the repetition of the water suppression scheme omitting RF pulses to obtain a non water suppressed navigator signal with identical gradient history. The PRESS block for generating and acquiring the navigator signal uses a reduced excitation flip angle of 20°.

The volunteer examinations consisted of 4 repetitions. The first post processing step consisted in either just conventionally averaging all acquisitions without further processing or data correction using the corresponding reference scan prior averaging. Data correction was done in two ways as a simple frequency shift by the frequency difference calculated from the navigator data or by time domain deconvolution of the acquired data with the navigator data [1].

Each repetition of the volunteer data sets was processed for themselve as well as averaged over all repetitions. This first part of the processing was done using routines implemented in Matlab (The MathWorks, Natick, Massachusetts). For the final analysis of the data the software package LCmodel [5] was used. As parameter of spectral quality the s/n and FWHM (full width at half maximum) values provided by the LCmodel analysis were taken.

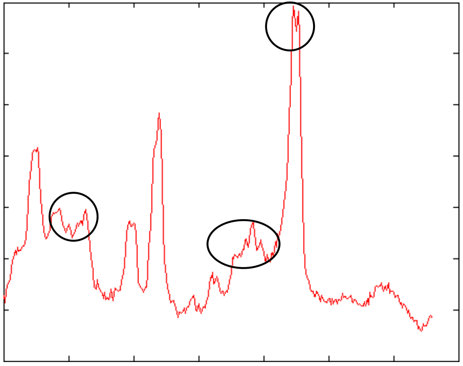

Fig. 1a (left)
Averaged real part spectrum of 4*96 acquisitions.

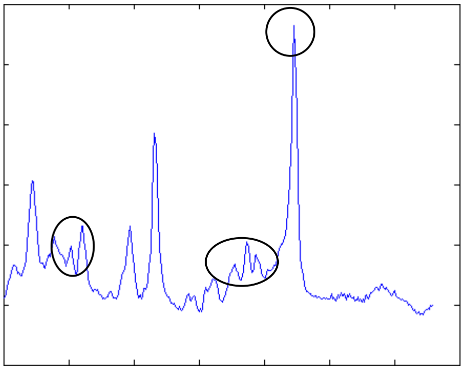

Fig. 1b (right)
The same data as in Fig. 1a after deconvolution processing using the corresponding reference scans.

Results

The sequence was tested on phantoms to assure proper functionality (data not shown). Results of the in-vivo examinations are shown in figure 1 and 2. Figure 1 shows the comparison of a volunteer study averaged with and without correction. The results without correction show clear effects of presumably head movements, which becomes manifest in double peaks and peak broadening, the most prominent are emphasized by circles. In comparison the corrected spectra show none of these unwanted effects.

Figure 2 displays the S/N and FWHM comparison of results achieved with and w/o correction. The S/N values in all volunteers are at least equal or improved for each repetition. While for the conventional PRESS acquisition there are huge variations in FWHM between the scans, both the frequency and the deconvolution corrected scans show homogeneous FWHM values within small standard deviation.

Discussion

Interleaved navigator scans can be used to significantly improve the quality and reliability of human in-vivo MRS data on clinical high field systems.

The approach using interleaved navigator scan acquisition requires no additional acquisition time and no noticeable increase of duration for data processing. INS proofed to increase spectral quality at any circumstances was system instabilities and / or subject movements are present. The cost of an increased minimal selectable TR is negligible since protocols to achieve good spectral quality use already TRs above 2500ms. In the ideal case of the absence of any instabilities, data acquired using the INS scheme will be identical as without. Preconditioned the implementation directly on the scanner there will be no noticeable difference for the operator except of a better outcome. The fully automatic setup is most important for the introduction into the clinical environment. Further improvements may be achieved introducing smart algorithms to reject single heavily distorted averages.

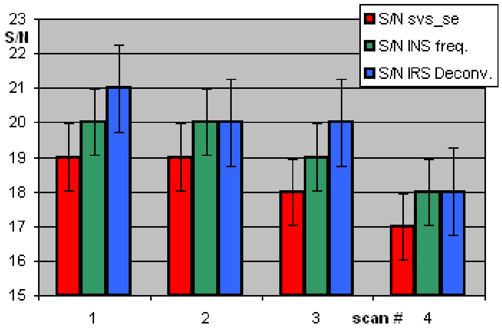

Fig. 2a (left)
S/N comparison of 4 acquisitions during a volunteer experiment.

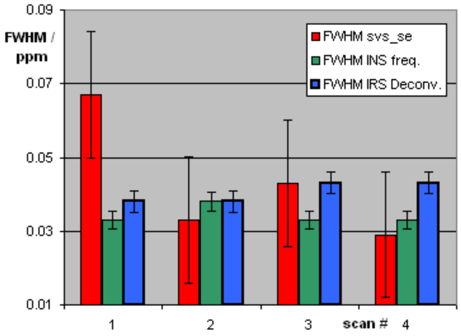

Fig. 2b (right)
FWHM comparison of the same data sets shown in figure 2a.

References

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