MR Spectrocopy of Arbitrarily Shaped Single Voxel Using Segmented, Blipped-Planar 2D-Selective RF Excitations with Weighted Averaging

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Introduction

In conventional MR spectroscopy based on cross-sectional RF excitations, the interpretation of measured metabolite concentrations often is hampered by partial volume effects. Because the target regions usually deviate from the cuboidal measurement volume, surrounding tissue must be included or only a part of the target region can be covered which both reduce the sensitivity and specifity of the method. The application of spatially two-dimensional selective RF (2DRF) excitations [1] that are able to excite arbitrarily shaped, two-dimensional regions, is a promising approach to reduce these partial volume effects as has been demonstrated [2,3]. One of these methods [3] involves a segmented 2DRF excitations based on a blipped-planar trajectory with only one line per segment to minimize the echo time and avoid chemical shift displacement artifacts in the blip direction. Although the spatial selectivity achieved so far is promising [3], the signal-to-noise ratio (SNR) per volume is considerably reduced compared to the conventional localization technique. In this work, it is demonstrated that using weighted averaging of the individual segments with a flip angle adaptation [4] considerably increases SNR performance.

Methods

In a conventional spin-echo single-voxel MRS pulse sequence, the initial excitation was replaced by a segment of a 2DRF excitation based on a blipped-planar trajectory [3]. This sequence must be repeated with the different segments until all segments of the 2DRF trajectory were covered to obtain the desired arbitrary profile. If more averages than segments are desired, previous approaches used the same number of averages for each segment. However, because some of the segments, in particular in outer *k*-space, have rather low RF peak amplitudes, i.e. flip angles, this method is rather insufficient. In the present approach, the flip angles of segments with low flip angles were adapted to avoid or minimize averaging [4]. Rather than performing multiple averages of weak signals generated by low flip angle 2DRF segments, the flip angle of these segments was increased to obtain the same signal amplitude in as few averages as possible.

Measurements were performed on a 3T whole-body MR system (Siemens Magnetom Trio) with a twelve channel head coil. The desired excitation profile was the shape of the corpus callosum (see Fig. 1) realized with a 2DRF excitation covering 7 segment with one k-space line each and a resolution of 5x5 mm^2 yielding side excitations in a distance of 35 mm which were eliminated by one of the two refocusing RF pulses.

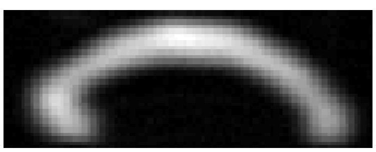

Figure 1: Excitation profile of the segmented 2DRF excitations acquired in a water phantom. The profile was defined using the shape of the *corpus callosum* on a sagittal T1-weighted MR image of a healthy volunteer.

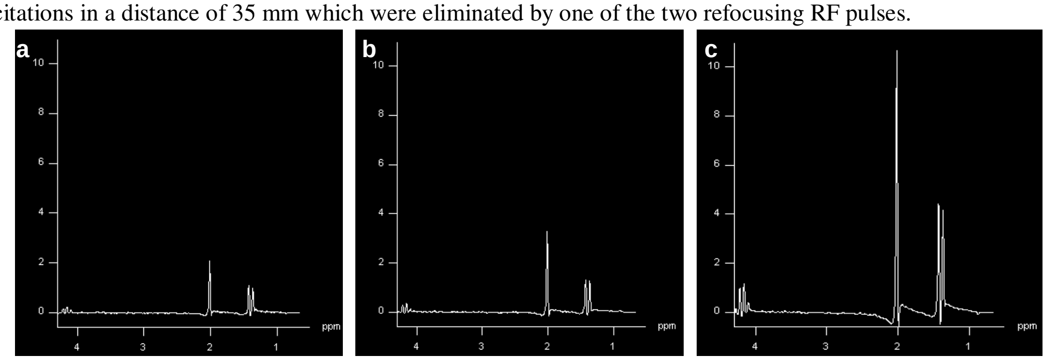

Figure 2: Short-echo-time MR spectra (TE 30ms, TR 3000 ms) of a spectrocopy phantom containing NAA and lactate acquired with (a) cross-sectional RF excitations (63 averages) defining a square of 8x8 mm^2, i.e. the largest square fitting into the *corpus callosum* profile, and (b,c) with segmented 2DRF exciting the full *corpus callosum* profile shown in Fig. 1 with (b) standard averaging, i.e. 9 averages for each of the 7 segments, and (c) weighted averaging with 31 averages for the central *k*-space segment and a total number of 61 averages. The scaling is identical for all spectra, i.e. different peak amplitudes rather good reflect SNR differences.

Results and Discussion

The excitation profile of the 2DRF excitation measured in a water phantom is shown in Fig. 1. The smallest cuboid fitting into the corresponding corpus callosum has a base area of 8x8 mm^2. It represents the volume-of-interest for an acquisition with cross-sectional RF excitations if signal contributions from regions outside of the corpus callosum must be avoided. A corresponding spectrum obtained in a phantom is shown in Fig. 2a. Using segmented 2DRF excitation and the excitation profile shown in Fig. 1, yields a spectrum with a NAA peak amplitude increased by about a 60% if the same number of averages is used for each segment (Fig. 2b). Using the weighted averaging approach with the flip angle adaptation yields an about 3.5-times higher NAA peak amplitude (Fig. 2c) compared to standard averaging although the total number of averages is almost identical (61 vs. 63). This increase rather good reflects the ratio of the number of averages used for the central k-space segment which is 31/9≈3.4.

It should be noted that the SNR per volume even for the weighted approach is inferior to that of cross-sectional RF excitations which mainly is due to the lower flip angle required to avoid profile distortions. Thus, if cuboids are the target volume of MRS, cross-sectional RF excitations are still the gold standard. However, as soon as curved or non-convex regions are desired, the presented approach may be an alternative that can offer full volume coverage without contributions of surrounding tissue.

References

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