Establishing T2-Contrast in True FISP Imaging

Robin HEIDEMANN1, Mark GRISWOLD1, Claudia HILLENBRAND1, Dietbert HAHN2, Axel HAASE1, Peter JAKOB1

1Universität Würzburg, Physikalisches Institut, EP5, Würzburg, Germany; 2Institut für Röntgendiagnostik, Würzburg, Germany;

Introduction

The true FISP imaging method [1] offers an excellent SNR with short acquisition times, which makes it interesting for many applications. The main drawback of this sequence is the mixed contrast which is proportional to $T_2/T_1$. Since pure $T_2$-contrast is of clinical relevance, $T_2$-weighted true FISP imaging would be very useful in certain clinical applications. In this work we demonstrate the feasibility of introducing $T_2$-contrast in the true FISP imaging method using the CAT principles [2].

Methods

In vivo examples from healthy volunteers were obtained on a Siemens Vision 1.5 T whole body clinical scanner (Siemens Medical Systems, Erlangen, Germany). Spin echo images of axial slices were acquired to obtain the $T_2$-weighted images. After the completion of the spin echo experiment, a true FISP image at the same slice position was acquired in an independent experiment. The following imaging parameters were used: FOV 170 x 230 mm, slice thickness 5 mm, resolution 192 x 256.

Spin echo: $T_R = 2000$ ms, $T_E = 99$ ms, total acquisition time $T_{tot} = 384$ s.

True FISP: $T_R = 6.32$ ms, $T_E = 3$ ms, flip angle 70°, $T_{tot} = 1.2$ s.

According to the CAT principle, data combination was performed by using spin echo data from the center of k-space and true FISP data from the outer parts of k-space. In order to investigate the potential/pitfalls of this approach, data sets with a varying number of spin echo data lines in the center of k-space were generated, retrospectively.

In order to reduce discontinuities at the transition zones between spin echo and true FISP data, which cause ringing artifacts in the resulting image, a dedicated reconstruction algorithm was developed. This algorithm allows one to adapt the true FISP data to the spin echo data in phase and magnitude:

(i) Phasing was performed with a calculated phase map of the zerofilled low resolution spin echo image. This phase map was used in an iterative POCS-type algorithm to adapt the phase of the CAT image to the spin echo phase. After each iteration step the original spin echo data were restored in the CAT data set.

(ii) Scaling was done after phase adjustment. By dividing the absolute values of the spin echo data by the absolute values of the true FISP data, line by line, scaling vectors were calculated. An overlap between the spin echo and the true FISP data with only five lines was used. The amplitudes of the true FISP data were rescaled with an averaged scaling vector.

Results

In order to demonstrate the benefits of using the CAT-approach to achieve standard $T_2$-contrast in true FISP images, Fig. 1 shows the results. The total acquisition time of a 192 x 256 spin echo image (see Fig. 1a) was six minutes. Fig. 1b shows a true FISP image with the same resolution as the SE-image, with an total acquisition time of two seconds. From the high resolution spin echo image a low resolution image (Fig. 1c) with 64 phase encoding steps, zeroﬁlled to the same nominal resolution is reconstructed for comparison. To achieve the high resolution true FISP image with standard $T_2$-contrast (see Fig. 1d), a combination of the low resolution spin echo image with the high spatial frequency data of the true FISP image was used. It can be seen from the enlarged details, that resolution of this true FISP image is nearly the same as in the high resolution spin echo image, with almost preserved $T_2$-contrast.

Discussion

In this study it was demonstrated that it is feasible to achieve standard $T_2$-contrast in true FISP images by combining true FISP signals with the low spatial frequency signals of a spin echo image. The CAT approach with the above described phasing and scaling procedures leads to artifact free combinations between spin echo data from the center and the true FISP data from the outer parts of k-space.

Compared to the high resolution spin echo image, the acquisition time of this true FISP CAT image is reduced by a factor of 3, while the same resolution is achieved and the $T_2$-contrast is almost preserved.

The drawback of this method is that the $T_2$-contrast is not exactly the same as in a pure spin echo image, and fine details of the true FISP image appear in the CAT image. The implemented phasing and scaling procedures allows one a flexible and artifact free combination of spin echo and true FISP information.

The primary focus of this study was to demonstrate the feasibility of achieving a standard $T_2$-contrast in true FISP images. To enable data consistent even in the case of motion during the image process, reducing the acquisition time will be the next goal. Future work will use the combination of true FISP data with turbo spin echo data to achieve shorter acquisition times.

References