Controlled aliasing in 3D parallel imaging (2D CAIPIRINHA)

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Introduction

A new approach to improve image quality in partially parallel 3D MRI is presented. Aliasing artifacts are manipulated by modifications of the gradient tables in the 3D phase encoding direction in order to achieve improved conditions for the final image reconstruction procedure. In contrast to conventional 3D parallel imaging methods, like 2D SENSE [1], superimposed partitions with essentially identical coil sensitivities can be separated by using reordered coil sensitivity information, according to the modification of the gradient tables.

Theory and Methods

In order to control aliasing artifacts the gradient tables in 3D phase encoding are modified as depicted in Figure 1. An additional offset of every second phase encoding step in one phase encoding direction shifts overlapping partitions with respect to each other. This can significantly improve subsequent parallel imaging reconstruction procedures as shown previously in multi-slice CAIPIRINHA experiments [2]. For comparison g-factor maps were calculated using simulated sensitivity maps of an 8 element spiral array [3]. In vivo MR experiments were performed on a 3T whole body scanner (Magnetom TRIO, Siemens, Erlangen, Germany) using an 8-channel head array for signal reception. All image reconstructions were done using conventional parallel imaging algorithms in combination with reordered coil sensitivity information.

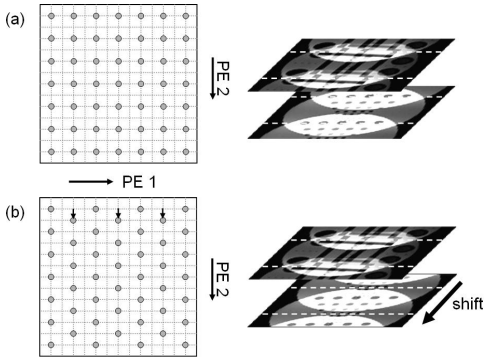

Fig 1: Reduced 3D acquisition scheme in two phase encoding (PE) dimensions of **(a)** a conventional 2D SENSE experiment (R=2x2) and **(b)** a CAIPIRINHA-type experiment (R=4). Every second PE 1 step is modulated with an additional offset (in PE2) off the gradient table. Folded slices are shifted with respect to each other.

Results

Figure 2 shows a comparison of the calculated g-factor maps of an accelerated (R=4) (a) 2D SENSE R=2x2 (b) 1D SENSE (R=4) and (c) a 2D CAIPIRINHA (R=4) experiment. It can be seen that CAIPIRINHA offers increased SNR performance compared to normal 2D SENSE Figure 3 shows the results of two corresponding superimposed partitions of a 3D in vivo head experiment. Again 2D CAIPIRINHA results in superior image quality.

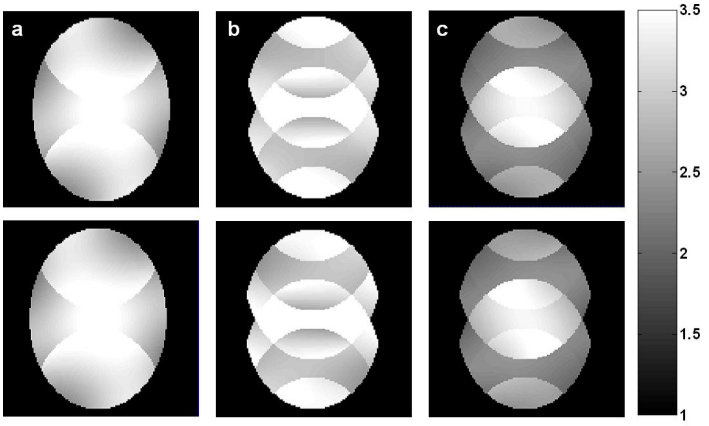

Fig. 2: Simulated g-factor maps of an 8 element spiral array. Corresponding unfolded partitions are shown (top row and bot row) obtained with **(a)** a 2D SENSE (R=2x2), **(b)** a 1D SENSE (R=4) and **(c)** a 2D CAIPIRINHA (R=4).

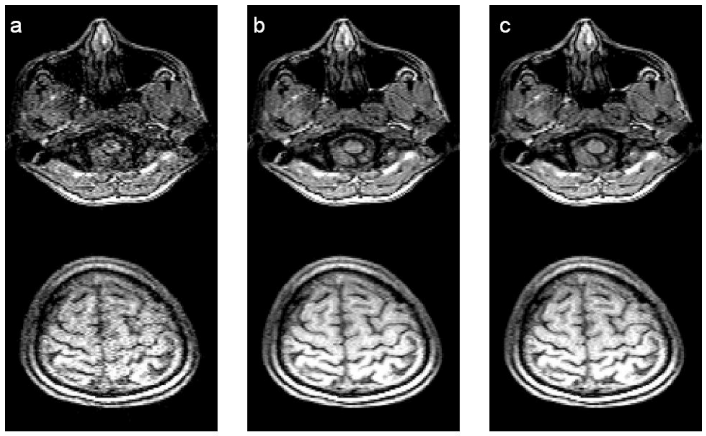

Fig 3: Comparison of two corresponding partitions after **(a)** 2D SENSE (R=2x2), **(b)** 1D SENSE (R=4) and **(c)** 2D CAIPIRINHA (R=4).

Discussion

The simulations of the g-factor maps indicate that CAIPIRINHA has the potential to exploit variations of coil sensitivities along multiple dimensions in a more efficient way than standard 3D parallel imaging techniques. The in vivo head 2D CAIPIRINHA (R=4) experiment shows a significantly improved image quality compared to conventional 2D SENSE (R=2x2), while a reduction in one phase encoding direction (R=4) resulted in a comparable image quality. In general 2D CAIPIRINHA provides more relaxed requirements in 3D parallel imaging.

References

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[2] Weiger M et al. MAGMA 2002; 14:10-19
[3] Müller M et al. Proceedings ESMRMB 2003, 156

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