Single-Slab 3D TSE with CAIPIRINHA Acquisition Mode

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Introduction: The CAIPIRINHA (controlled aliasing in parallel imaging results in higher acceleration) technique has been successfully applied to 3D imaging [1]. By shifting the phase encoding strategy, CAIPIRINHA can provide an optimal phase encoding pattern with minimum g-factor, which leads to higher SNR in comparison to the traditional GRAPPA. In this work, we demonstrate the feasibility of using CAIPIRIHNA technique for potential scan time reduction in single-slab 3D TSE (SPACE) imaging.

Methods: The CAIPIRINHA scheme was implemented on a commercial version of single-slab 3D TSE (SPACE) sequence. Since K-space reordering [2] is a critical part of 3D TSE sequence, a new concept "block" is introduced to simplify the process. The block size is defined in terms of the total acceleration factor for both phase encoding directions (before phase encoding shift). K-space reordering scheme is implemented on "block" level (Fig.1 red box), in which the phase encoding shift for different CAIPIRIHNA patterns will not increase the reordering complexity. In addition, a separated GRE calibration scan and image domain GRAPPA reconstruction algorithm [3] were used for further saving time.

Experiments and Results: The study was performed on a Siemens MAGNETOM Aera 1.5T scanner with 16 channel head/neck coil. Experimental data were obtained on healthy volunteer using traditional and modified sequence respectively. The imaging parameters are in the following: FOV =240mmx240mm, TE/TR = 8.2600ms, turbo factor = 36, echo spacing = 4.2ms, 1.0mm isotropic resolution, readout bandwidth = 630Hz/pixel, slices per slab =192. Total acceleration factor of 3-6 was tested to explore the potential acceleration benefits from different sampling patterns (*Fig. 2*). A separated GRE reference scan was used to acquire calibration data for parallel imaging reconstruction. Fig. 3 shows comparisons of the same slices for total accelerations of 3-6. The images acquired with delicate CAIPIRINHA pattern (a-2, b-4 and c-2) show higher SNR and more detailed information in comparison to those of traditional GRAPPA pattern (a-1), (b-1-2-3) and (c-1).

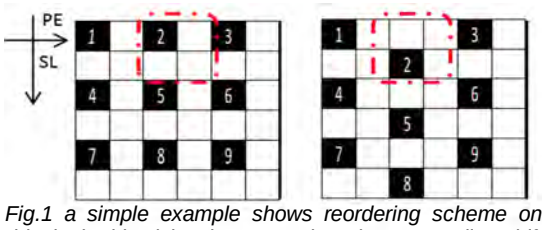

Fig.1 a simple example shows reordering scheme on "block" (red box) level. It notes that phase encoding shift won't bring additional complexity to reordering process.

Discussion: SPACE is a time-consuming sequence, which limits its clinical application. The combination with GRAPPA is not always satisfied due to the SNR loss in particularly for higher acceleration factor. In this study, it demonstrates that CAIPIRINHA with optimized block reordering scheme could effectively reduce measurement time while keeping high SNR. It notes that the optimal sampling pattern is depended on the coil sensitivity map and the anatomy structure of the subject. Each sampling pattern therefore needs to be optimized for different applications. In conclusion, CAIPIRINHA patterns combined with well-designed reordering is feasible for SPACE sequence, which could be widely used for routine clinical applications in the future.

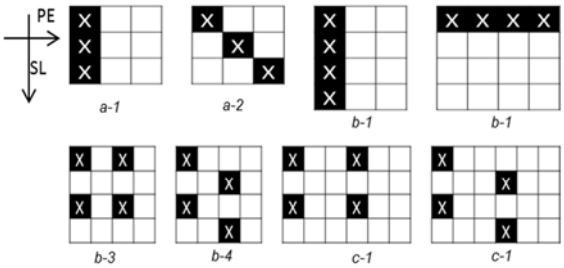

Fig.2. Illustration of parallel acquisition patterns in phase encoding plane. CAIPIRNHA pattern is implemented by shifting phase encoding on GRAPPA pattern.

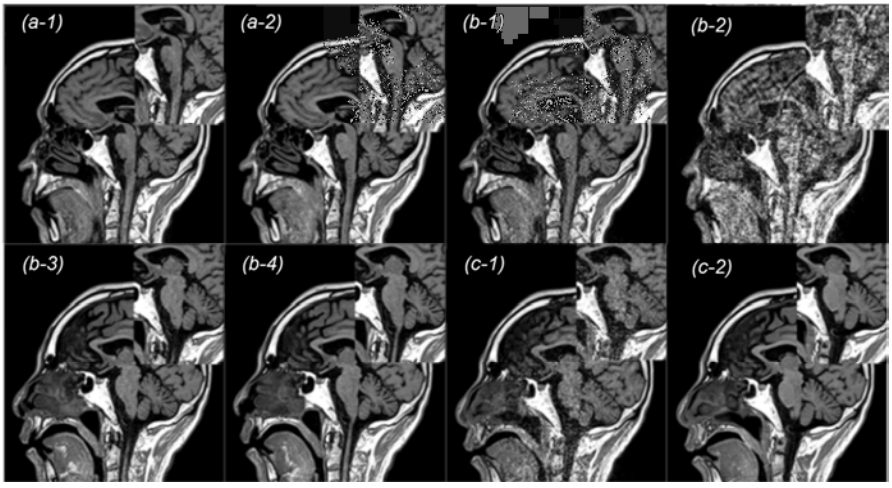

Fig.3. Comparison of images acquired with different acceleration factors, patterns shown in Fig.2 respectively. (a-1) and (a-2) had total acceleration factor = 3 and total scan time = 4:30mins; (b-1-2-3-4) had total acceleration factor = 4 and total scan time = 3:30mins; (c-1) and (c-2) had total acceleration factor = 6 and scan time = 2:50mins. Magnified structures are also displayed on the top-right corner of each image.

Reference:

[1] Breuer F, et al. MRM 2006; 55;549-556.
[2] Li GB, et al, ISMRM 2009 p2003
[3] J. Wang et al, ISMRM 2005 p13