Variability of Contrast and Spatial Parameters in Multi Contrast Imaging

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Introduction

During the last years moving table techniques for extended FOV imaging became more and more popular. Starting with angiography [1], clinical application expanded to other fields like screening for tumor metastases [2] or diagnostics of musculoskeletal diseases [3]. Sequences that acquire multiple datasets with different contrasts simultaneously within a single measurement procedure can help rendering future multi task examination protocols more time efficient and comfortable. For this purpose a novel acquisition technique called multi contrast imaging was recently presented [4]. This study discusses the boundary conditions and degrees of freedom coming along with this method in terms of contrast and spatial structure of the data. Based on exemplary measurements on healthy volunteers, a sequential and an interleaved acquisition pattern are compared. Image contrast was modified using different TRs, TEs and flip angles. Variations in terms of the spatial data structure were achieved by means of different spatial sampling along the z-direction.

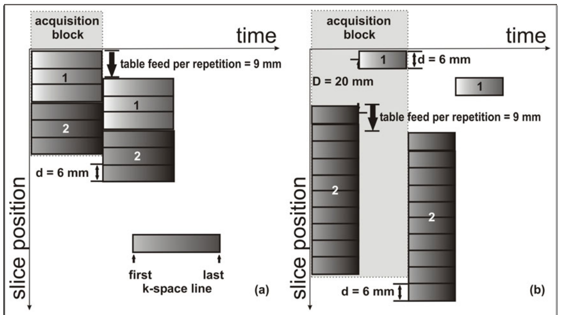

Fig 1: Sequential (a) and interleaved (b) multi contrast acquisition pattern as used in our experiments.

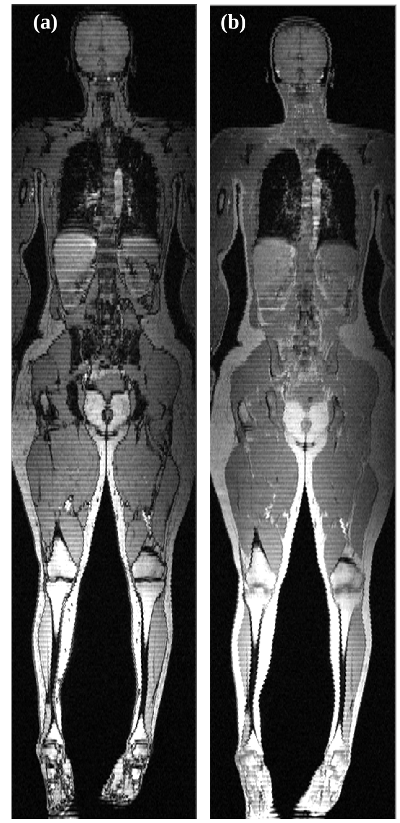

Fig 2: ➡ Coronal reformations obtained with the interleaved setup: (a) TE_1=2.4 ms (out-of-phase), (b) TE_2=4.8 ms (in-phase).

Method

Multi contrast imaging provides the simultaneous acquisition of an extended FOV with multiple contrasts within a single measurement procedure. All steps needed to acquire images of different contrasts are combined into one acquisition block that is repeated during table motion in order to cover the full FOV. Two exemplary sequence setups were used in our experiments (Fig 1): The interleaved pattern shown in Fig 1a acquires images of two different contrasts within the same timeframe. Therefore TR=42.6 ms and the number of phase encoding steps had to be the same for all slices. The acquisition block consisted of a package of 6 slices. Each three of them were recorded with different TEs of 2.4 ms (in-phase) and 4.8 ms (out-of-phase) respectively. The table velocity of 1.0 mm/s was adapted to a table shift of 1.5 slices per repetition resulting in a virtual resolution of 3 mm along the z-direction by reducing partial volume effects. The sequential pattern displayed in Fig 1b acquires a single slice (contrast C_1) and a package of ten slices (contrast C_2) consecutively. With this approach, TR and the number of phase encoding steps can be chosen independently for the two datasets with different contrast. The parameters were set to TR_1=6.3 ms, TR_2=63 ms, F_1=15°, F_2=45°, and TE=2.4 ms. The table velocity of 0.58 mm/s, which was adapted again to a table shift of 1.5 slices per repetition, lead to differences in the virtual resolution of the data along the z-direction of 9 mm for C_1 compared to 3 mm for C_2. Additionally threefold redundant data was acquired for C_2 which allowed increasing SNR by means of belated averaging. All experiments were performed with a spoiled FLASH sequence on a 1.5 T whole body system (Magnetom Sonata, Siemens Medical Solutions, Erlangen, Germany) using local surface coil arrays and a dedicated mobile table setup (AngioSURF, MR-Innovations, Essen, Germany). The total measurement time was 27 min for the interleaved setup and 46 min for the sequential acquisition pattern.

Results

Two coronal reformations obtained with the interleaved setup are shown in Fig 2: The images differ in terms of contrast due to the variation of TE but share the same properties in terms of resolution and general SNR. Fig 3 displays two coronal reformations obtained with the sequential setup: They show differences in contrast due to a different TR and have different spatial data structure. The data from C_1 (Fig 3a) shows a lower virtual resolution along the z-direction compared to C_2 (Fig 3b). Due to the longer TR and belated averaging, the data from the ten slice package (C_2) features also a distinctly higher SNR than the single slice data (C_1). As the slices of the multi slice packages are recorded at different positions in the scanner, the reformatted images suffer from artifacts due to gradient nonlinearities. In Fig 2, they appear as saw tooth like distortions and intensity modulations, particularly in the upper abdominal regions and in the lower limb. In Fig 3b, these artifacts could be extensively removed by the belated averaging procedure.

Discussion

Sequential multi contrast acquisition offers unrestricted freedom in choosing contrast and spatial parameters between different datasets. Depending on the desired TR, a time efficient interleaved acquisition pattern can be applied. However, this requires TR and the number of acquisition steps to be equal for all datasets. The acquisition of datasets with explicitly different spatial resolution might be of interest for dynamic parameter adjustment during the measurement: The high resolution dataset is used for imaging, while the adjustment parameters are calculated from a low resolution dataset.

Fig 3: ➡ Coronal reformations obtained with the sequential setup: (a) TR_1=6.3 ms, low virtual z-resolution; (b) TR_2=63 ms, high virtual z-resolution, 3x-averaging.

References

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