Single breathold multi-contrast 3D abdominal imaging

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Introduction

In abdominal MR-imaging, breathold techniques are often used to avoid image artifacts. Thus, respiratory motion (e.g. of liver and kidneys) is frozen, and also peristaltic motion artifacts are reduced due to the short scan duration. However, for a comprehensive diagnosis, multiple contrasts are often mandatory as obtained via T1w, T2w or fat-suppressed scan protocols [1,2]. If the scans are acquired in different breatholds, spatial misregistration can occur, as the absolute position between consecutive breatholds may vary. Highly accelerated parallel imaging [3,4] helps to reduce the scan time significantly. These techniques allow multiple acquisitions of a large abdominal volume within a single breathold. This offers the possibility combining different contrast protocols (regardless if spin-echo or gradient-echo based) within that time frame. Consequently, the information content can be increased for each voxel and the diagnostic value can be improved. The technical feasibility is demonstrated in this abstract.

Methods& Measurement

Multiple 3D scans with different contrast settings covering a large abdominal volume were acquired in a single breathold on a 1.5T ACHIEVA clinical scanner (Philips Medical Systems). For an efficient usage of the breathold interval, the preparation phases of the different scans were performed beforehand (see Fig. 1), which allowed a nearly continuous scanning with a negligible delay between scans. In a healthy volunteer study, abdominal volumes were acquired using a 32-element cardiac coil with sufficient FH coverage.

Representative for the available protocols, a magnetization prepared (fat-suppressed) segmented T1-weighted field echo sequence (TR/TE/FA= 4.4ms/2.0ms/10°) was performed, acquiring a field of view of 220×220×320 mm^3 (FH×AP×RL) with an isotropic voxel size of $(2.1mm)^3$. Its T1-contrast was supplemented by a balanced 3D SSFP sequence (TR/TE/FA= 3.5ms/1.7ms/60°) with identical scan resolution and geometry, leading to a T2/T1 contrast with a high SNR. Both scans were acquired with a SENSE factor of 6 (3FH×2AP). The resulting scan times of 12.6s and 6.8s allowed a patient-friendly total breathold time below 20s.

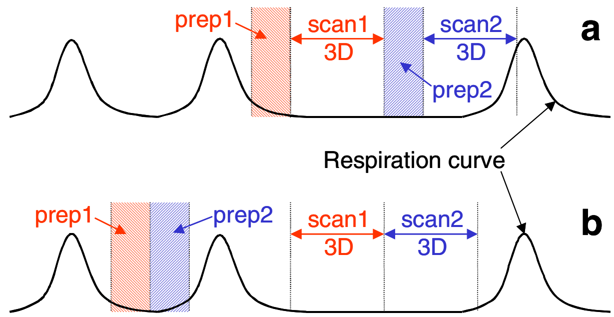

Fig. 1: Modified scan acquisition. Each preparation phase is usually performed directly before the scan during free breathing. Performing two scans in one breathold, the second preparation would lead to an inefficiently long scan duration (a). For this reason, the preparation phases are separated from each scan and performed beforehand (b) for an efficient usage of the breathold period.

Results

Fig. 2 presents a reformatted coronal slice from 3D data of a volunteer. Fig. 2(a) shows balanced SSFP data with its higher SNR, whereas the T1-weighted image in Fig. 2(b) exhibits a contrast much more sensible to liver and kidney. Due to an optimized coil geometry, no SENSE artifacts were observed in any sub-sampled direction (FH and AP). Representative for a more specific combination of the different contrasts, Fig. 2(c) shows a colored overlay of the balanced SSFP data (blue color map) and the T1 weighted data (red color map). Even if this overlay represents only a very simple combination of the two scans, it nevertheless demonstrates the nice match of the two volumes without any transformation or other image post-processing.

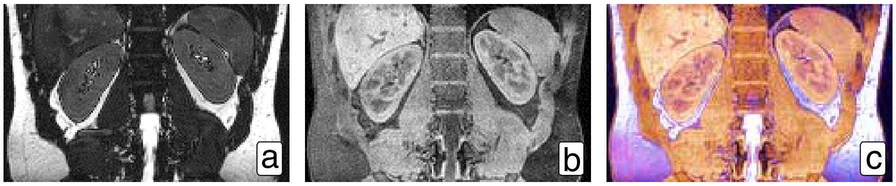

Fig. 2: Reformatted coronal abdominal slice of the 3D datasets, obtained in a single breathold. (a) exhibits the T2/T1-contrast of balanced SSFP, while a fat-suppressed, T1 weighted contrast is shown in (b). It was acquired in a segmented gradient echo acquisition. (c) shows a colored overlay of (a, blue) and (b, red), to demonstrate that a more diversified and comfortable diagnosis might be possible, e.g. by computer aided diagnosis.

Discussion

The basic feasibility of performing multiple 3D scans with different contrasts in one breathold has been demonstrated. The approach showed a very robust and reliable behavior for all volunteers. Due to the enhanced parallel imaging capabilities of the new hardware using 32 receive channels, high image quality was obtained. This enables and supports new scan applications in clinical practice. Larger volumes can be acquired keeping the resolution constant, and 3D imaging may become clinical standard for many applications, e.g. for screening applications. However, 3D techniques lead to a huge amount of data that have to be interpreted by the user. The user himself might, therefore, become a bottleneck in diagnosis. Image processing, combining images with different contrasts, or multivariate statistics may help to identify specific aberrations or diseases. It might even be necessary in the future to perform a computer aided preselection to handle the huge amount of data, where the utilization of different contrasts or different protocol types (like T1W, T2W, DWIBS [5], etc.) can be very helpful. However, in any case, a very good matching of the images is necessary to avoid loss in image content. This match can be achieved with a single breathold acquisition rather easily.

Conclusion

The acquisition of a large 3D volume with separate scans of different contrasts, but within one breathold, is demonstrated in this abstract. The new capabilities of parallel imaging allowed a diagnostically relevant scan resolution. Especially for diagnoses that are based on multiple contrasts, e.g. tumor screening in the upper abdomen [1,5], the single breathold acquisition may enable a more comfortable and accurate diagnosis.

References

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