Dynamic liver imaging using an image-based navigation approach

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Introduction:
Despite the introduction of new acquisition methods like k-t SENSE (1), real time imaging of large volumes (e.g. liver) remains challenging. Nevertheless, the characterization of motion and deformation of the liver due to respiration is of great interest for example in radiotherapy planning. Today's achievable acceleration factors of <10 are not sufficient to acquire 3D data of the liver at appropriate spatial resolution in less than ~200 ms, which is necessary to avoid motion artifacts. A possible solution is to split up the acquisition of the 3D stack into several 2D slices that are acquired over more than one respiratory cycle, and to temporally rearrange the slices retrospectively using a navigation slice. A representative slice of the liver is used as navigator (2). To cover the whole liver during free breathing and improve the temporal resolution using SENSE, a 32 channel coil array was used.

Methods:
Data acquisition:
Balanced 2D SSFP imaging was performed on a Philips 1.5T Achieva System (Philips Medical Systems, Best, The Netherlands) using a 32 channel coil array. Scan parameters were: in-plane resolution: 1.8x1.8 mm^2, T_R/T_E: 3.5/1.74 ms, flip angle: 140°, SENSE reduction factor: 4, Halfscan factor: 0.6. Scan time per slice was 104 ms. To cover the whole liver in a coronal view, 30 slices with a thickness of 6 mm and an overlap of 2 mm were required. The slices were acquired in an ascending order, interleaved with the acquisition of the navigator slices (Figure 1) used for the temporal correlation during post-processing.
Data post-processing:
In post-processing the navigator slices are used to find image slices that show the same state of the liver (Figure 1). Slices with similar preceding and subsequent navigator slices (indicated by the same color) are combined to a 3D stack yielding 3D volumes of the liver at a temporal resolution of approximately 230 ms.

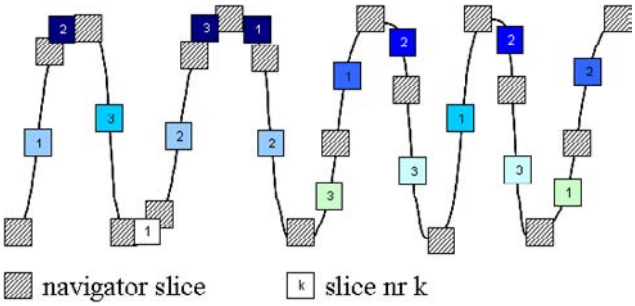

Figure 1 *The acquisition of the image slices during free breathing is interleaved with the acquisition of navigator slices. Image slices that have similar neighboring navigator slices (indicated by the same colors) are stacked together to a 3D volume.*

Results:
In Figure 2 exemplary maximum intensity projections of the 3D volumes at maximum inhalation and maximum exhalation are shown. The size of the coil array (37 x 33 cm^2) offered an excellent coverage of the whole liver during free breathing. The short acquisition time for one slice minimized the motion artifacts caused by the pulsation of the heart.

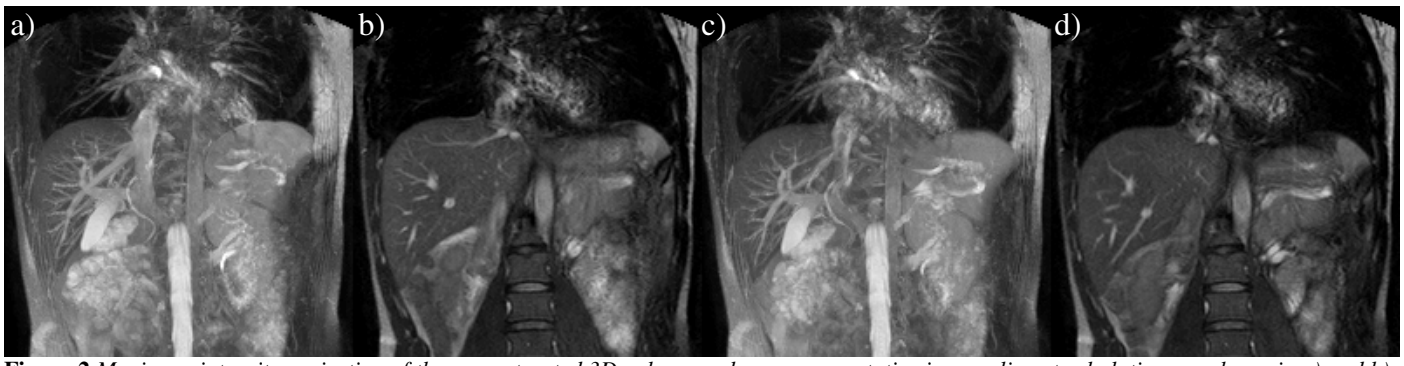

Figure 2 *Maximum intensity projection of the reconstructed 3D volume and one representative image slice at exhalation are shown in a) and b) respectively. The images for the maximum inhaled position are shown in c) and d) respectively.*

Conclusion:
Dynamic liver imaging can significantly benefit from large coil arrays, since both a large coverage and high reduction factors can be achieved. Therefore the acquired images are free of motion artifacts while maintaining a high spatial resolution. Combined with the image-based gating approach proposed in (2), time-resolved 3D images of the complete liver could be reconstructed.

References:
1 Tsao, J. et al. Magn Reson Med. 2003: 50 (5): 1031-1042
2 von Siebenthal, M. et al. MICCAI. 2005: 3750: 336-343