IMPROVED SNR IN RETROSPECTIVE RESPIRATORY SELF-GATED 3D HUMAN LUNG MRI USING IMAGE REGISTRATION

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INTRODUCTION: Respiratory and cardiac motion significantly degrades the image quality in 3D human lung imaging. It has been shown that the *k*-space center signal (DC-signal), in combination with quasi-random *k*-space sampling (QR-sampling), allows for motion artifacts suppression in retrospectively gated high resolution 3D human lung imaging [1]. However, retrospective gating is inefficient because only a part of the acquired data is used for image reconstruction. In this work it is demonstrated that the image quality can be significantly improved by averaging multiple 3D data sets, reconstructed at multiple respiratory phases. To this end the individual data sets are all registered to one respiratory phase (target) using the algorithm described in [2].

METHODS: A 3D gradient echo sequence with repeated DC-signal acquisition [1,3] was implemented on a clinical 1.5T MR-scanner. *In vivo* experiments were performed on healthy volunteers using a six-channel phased-array body matrix in combination with a spine matrix. Imaging parameters: TE/TR/α=1.2ms/3.3ms/7°, matrix size=256x256x44, FOV=500x500x220mm^3, voxel size=2x2x5mm^3, repetitions=8, acquisition time=297s. The dynamic range of the DC-signal was divided into six different gating windows for data acceptance (Figure 1 - left), each representing a different respiratory phase. Retrospective gating results in data sets with ~25 % of missing *k*-space lines, which were reconstructed using iterative GRAPPA [4]. Multiple accepted *k*-space lines were averaged. 3D image registration [2] was performed on the data sets obtained from windows 1 to 4 using the scheme displayed on the right in Figure 1. The end expiration image (window 1) was used as target for registration (blue in the figure). Two adjacent data sets (windows 3 and 4) were first registered and then averaged. The same procedure was then repeated on the resulting image to include also data sets of windows 2 and 1. The image obtained (green in the figure) was finally compared to the case where the same amount of data (windows 1 to 4) was used for the retrospective reconstruction of a single data set (accepting the data acquired above the red line in Figure 1 - left).

RESULTS and DISCUSSION: Different reconstruction strategies were used to generate the same representative partition displayed in Figure 2. Left: only the data acquired within the gating window 1 were used for reconstruction. The partition shows a good suppression of motion artifacts but poor SNR, due to the narrow window width. Additionally, this data set serves as target for 3D image registration. Center: gating windows 1 to 4 were combined to a single window, showing improved SNR but also increased blurring artifacts due to the broader window width. Right: the single data sets reconstructed from windows 1 to 4 were registered and averaged. This results in a data set that combines the benefits from above: increased SNR as well as decreased motion artifacts at the same time. Nevertheless, a loss of resolution can be observed in regions where much motion occurs, for example close to the diaphragm. The window widths increase from 1 to 6 because the same amount of missing *k*-space lines within each window was desired. Hence, it must be considered that including more windows in the reconstruction leads to a loss of resolution because more motion is allowed. In the fact a more significant loss of resolution is observed when combining the full data set from window1 to 6 (not shown). The same reconstruction process can also be applied using the end inspiration data set as target, to improve the scan efficiency.

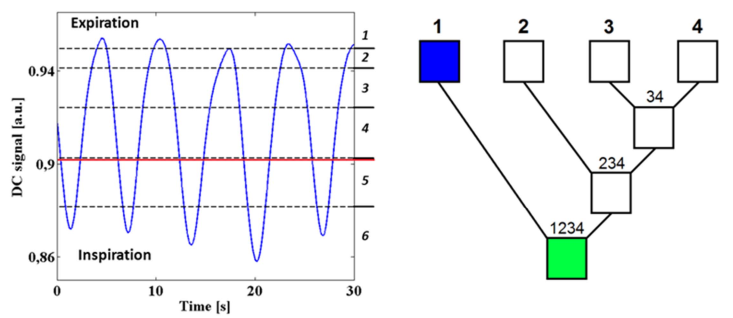

Fig.1 Left: DC signal time course and multiple gating windows (1 to 6). Data from windows 1 to 4 (above the red line) are used for reconstruction. Right: image registration scheme. The data set of window 1 is used as target (blue). Adjacent data sets are registered and averaged until one only image is obtained (green).

CONCLUSIONS: Signal navigation, in combination with parallel imaging and QR-sampling, shows to effectively suppress motion artifacts in retrospective respiratory gating. However, the performance of this method depends strictly on the width of the window used for data acceptance. Narrow windows result in increased motion artifact suppression but also in decreased SNR. Broader windows provide increased SNR as well as increased blurring due to motion. It is shown here that image registration in combination with averaging enables for the reconstruction of data sets with improved SNR, while preserving motion artifact suppression.

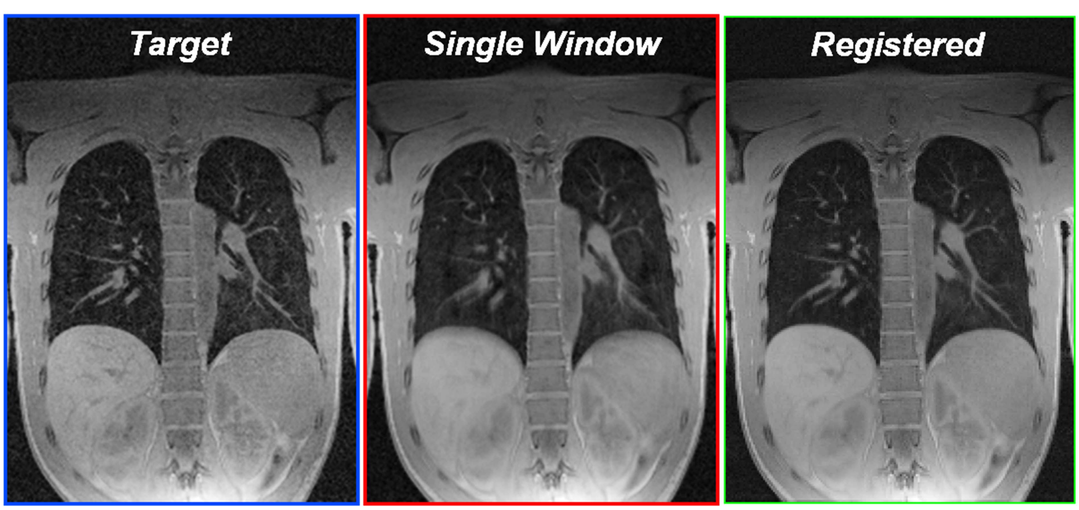

Fig.2 Representative partition of the full 3D set obtained from volunteer examination. Left: end expiration image obtained from the data set of window 1 and used as target for registration. Center: image obtained using the data of windows 1 to 4 for retrospective reconstruction of a single image. Right: image obtained using the data sets of windows 1 to 4 for retrospective reconstruction of four independent images, and then applying registration and averaging.

REFERENCES

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